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Article

Assessing Green Solutions for Indoor and Outdoor Environmental Quality: Sustainable Development Needs Renewable Energy Technology

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Abstract: The survival of humans depends on both natural and manufactured surroundings. Though most people spend their time indoors, there are constantly new challenges to address, and air pollution is one of them. This research considered both outdoor and indoor factors that affected green development agendas. Outdoor factors include fossil fuel combustion, renewable energy supplies, and carbon emissions, whereas indoor factors include industrial waste management, chemical use in production, and green technologies. Against the backdrop of the Indian economy, plagued by severe environmental problems from 1995Q1 to 2020Q4, this research evaluated green alternatives for indoor and outdoor environments. Carbon emissions rise with the use of chemicals in production, with the burning of fossil fuels, and with economic expansion, as shown by the Autoregressive Distributed Lag (ARDL) testing method employed. In contrast, emissions fall when a nation invests in renewable energy technologies and appropriately manages its industrial waste. Granger causality estimations validated the feedback link between industrial chemical usage and carbon emissions while demonstrating a unidirectional causality from chemical use to green energy demand and fossil fuel combustions. Moreover, burning fossil fuels and energy demand causes carbon emissions. Carbon emissions and fossil fuel combustion are produced due to industrial waste handling. The scale of the use of chemicals is expected to have the greatest impact on carbon emissions over the next few decades, followed by industrial waste, renewable energy supply, fossil fuel combustion, and renewable energy technologies. In order to achieve environmental sustainability via emissions reduction, this study proposed policies for a low-carbon economy, renewable energy source encouragement, and sustainable management. Close attention should be paid to clean energy and environmental sustainability by investing in research and development (R&D) to create a long-term sustainable energy strategy that is environmentally benign.

Keywords: carbon emissions; chemical use; industrial waste; renewable energy; green technology; India

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1. Introduction

Demand for fossil fuels has increased due to the rapid industrial revolution and growth in diverse economies across the globe. Widespread fossil fuel combustion results in massive amounts of carbon emissions, which in turn leads to a host of environmental issues [1,2]. The world's economies came together in December 2015 to sign the historic United Nations Climate Change Paris Agreement, which aims to reduce greenhouse gas emissions and address global environmental problems. The average worldwide temperature in 2020 was 1.2 degrees Celsius higher than its pre-industrial level. There has been a recent, urgent call to action to reduce carbon emissions and keep the global average ambient temperature rise as low as possible due to environmental and climate concerns [3,4].

The highest priority should be given to transferring cutting-edge technology and increasing climate funding to economies with the worst environmental deterioration if they improve their climate performance and take effective action to make necessary changes [5,6]. As a result of the revolutionary environmental framework, wealthy nations could reach out to developing nations that were also experiencing severe environmental issues. The outcomes of the 26thConference of the Parties (COP26) reflect India's priorities, and India's clean and climate-resilient economy might be supported by the declaration to increase climate action in the country [7]. Following the COP26 UN Framework Convention on Climate Change in Glasgow, the Indian government has implemented the following nationwide measures [8].

i. Achieve 500GW of non-fossil energy capability.
ii. Renewable sources meet more than 50% of their energy needs.
iii. Reduce anticipated carbon emissions by one billion metric tonnes.
iv. Reduce the country's carbon intensity by 45%, and
v. Achieve net-zero carbon emissions

As a result of rising energy consumption and industrialization, global carbon emissions are expected to peak in the near future. Based on energy, economic, and meteorological statistics, the International Energy Agency [9] predicted that by 2022, emissions would rise to 36.3 Gigatonnes (Gt), a 6% increase from 2020. Jeon [10] argues that the basis of renewable energy consumption (REC) rather than fossil fuels is the significance of environmental sustainability and economic progress. Environmental pollution and carbon emissions associated with manufacturing may be reduced by increasing REC in highly polluting industries and using environmentally friendly technology in production. A major obstacle to a more sustainable future for the planet is the burning of fossil fuels. In low- and middle-income nations, where there is a dearth of resources and ways to reduce these consumption-related pollutants, carbon emissions and air pollutants crucial to climate change are particularly problematic.

Carbon emissions, non-REC, and inefficient use of combustible energy sources are at the heart of the present investigation. Using REC and other sources is a fundamental component of environmental sustainability and an effective means of lowering carbon emissions [11–13]. The current study investigates fossil fuels, REC, combustible energy waste, green technology, chemical use in manufacturing, and carbon emissions based on the following preliminary study research questions. First, does the use of energy derived from fossil fuels affect India's overall carbon emissions levels? This question asks how the energy provided by fossil fuels may meet the requirements of a green and sustainable demand based on the usage of a variety of energy resources in the environment that produce less carbon. In addition, the best way to maximize resources hinges on increasing and developing energy resources (fossil fuels) in their natural setting. Second, how much do REC help India cut its carbon footprint? It explores how REC may be utilized as an effective method to encourage sustainable development in the process of lowering carbon emissions, which leads to sustainably increased resources for energy consumption and growth. Third, does India's inefficient use of combustible energy sources increase its carbon footprint? This inquiry probes how choices for climate change, patterns of growth, and environmental measures are affected by explosive energy use and refuse. More flammable refuse in the environment also contributes to severe economic and environmental harm. Finally, how can changes to India's energy system and cleaner technologies help to lower the country's carbon output? The importance of various energy reforms for the future of environmental sustainability and pollution control by estimating their effects on emissions reduction is pivotal for sustainable development. The study's understanding of the function of energy consumption from fossil fuels within the context of sustainability is based on the research questions suggested. The potential impact of abundant RE, technology and other sources on the decarburization goal is also investigated. In conclusion, the research suggested several measures to reduce carbon emissions to accomplish sustainability aims. In order to do this, the following objectives were set:

- To determine the effects of REC and environmentally friendly technologies on national efforts to reduce carbon emissions.
- To determine how using chemicals, fossil fuels, and economic growth impacts national carbon emissions, and
- To learn more about how refuse that can be burned affects national carbon emissions.

Building RE infrastructure may help a nation reduce its carbon footprint and ensure its environmental sustainability.

2. Literature Review

The review of the literature is sub-divided into three main components:

I. Renewable energy technology and mitigating carbon emissions.
II. The use of fossil fuel energy in pollution damage function; and
III. Industrial waste and its repercussion on the natural environment.

The stated domain helps to reach sustainable solutions to show the way forward to improve indoor and outdoor environmental quality.

2.1. Literature on Cleaner Technologies and Carbon Reduction

Sustainable economic policies that consider the long-term benefits of REC for improving environmental quality have been shown to impact agreed minimum goals positively. With the help of cleaner technology, the decarbonization process was sped up, and the world's average temperature was kept below a certain threshold. Using data from 2003 to 2015, Kocaket al. [14] studied the effects of R&D spending on energy efficiency, alternative energy consumption, and fossil fuels energy of 19 OECD economies on carbon emissions. The results reveal that using REC does not significantly increase the amount of carbon dioxide released into the atmosphere. In addition, research indicates a promising positive correlation between CO_2 emissions and R&D dollars spent on energy efficiency. In addition, there is an inverse correlation between the use of energy derived from fossil fuels and the release of carbon. The research suggested prioritizing the use of REC resources in order to achieve long-term economic development without increasing the cost to society via increased carbon dioxide emissions. Musah et al. [15] used data from 1990 to 2018 to analyze how urbanization, income, and alternative energy use affected carbon emissions in North African nations. The data shows a positive and statistically significant correlation between REC and carbon emissions. In addition, growing cities produce more carbon dioxide over time. The correlation between economic expansion and carbon emissions is positive. Similarly, urbanization leads to economic expansion, while economic growth causes clean energy. Reducing carbon emissions and ensuring the long-term health of our planet may be achieved by switching to RE sources. In a study covering 44 Sub-Saharan nations from 2000 to 2015, Mentel et al. [16] found a correlation between industrial value-added GDP per capita, renewable power use, and carbon emissions. The empirical analysis reveals a negative correlation between the generation of renewable power and the release of greenhouse gases. Furthermore, REC has a moderating influence on both industrial production and CO_2 emissions. Carbon emissions are positively correlated with economic growth. The correlation between GDP expansion and carbon emissions is also U-shaped. A rise in economic complexity indexes and the incorporation of novel environmental welfare policies into development plans and the organizational structure of countries are among the recommendations of the research. Using data from 2000 to 2017, Jiang et al. [17] examined the impact of economic growth and non-renewable and REC on the environment in 28 of the world's most polluted nations. The findings prove that RE sources do not contribute to increased carbon emissions. In addition, using fossil fuels to generate electricity increases the amount of carbon released into the atmosphere. As the economy expands, so do its carbon emissions. Growth in the economy, green energy, and carbon emissions go hand in hand in all emerging nations. In contrast, development, non-REC, and carbon emissions go in the same direction. Increasing funding for green activities is necessary to keep environmental sustainability and speed up the transition to using fewer fossil fuels and more REC to cut down on carbon emissions. Umar et al. [18] analyzed real GDP, fossil fuel energy consumption, and biomass energy consumption to determine their effects on carbon emissions in the United States from 1981Q1 to 2019Q2. The research found a negative correlation between the use of biomass for energy production, economic development, and carbon emissions. In addition, a positive correlation exists between the use of fossil fuels for energy and the release of carbon dioxide. Similarly, there is a causal relationship between real GDP and carbon emissions and the use of biomass and fossil fuels to generate electricity. According to the study's findings, the transportation industry, in particular, must put more attention and resources into creative development if the world will succeed in cutting energy-related carbon emissions.

Using data from 42 countries in sub-Saharan Africa between 1995 and 2011, Apergis et al. [19] found a correlation between per capita gross domestic product, health spending, REC, and carbon dioxide emissions. The empirical research reveals that the relationship between REC and carbon emissions is causal in both directions. In addition, there is negative and two-way causation between healthcare spending and emissions. Carbon emissions are positively correlated with economic growth, and the relationship between RE expansion and increased carbon emissions is also unidirectional. These nations can improve the lives of their citizens, reduce their carbon footprints, and combat climate change by maintaining their per capita growth while investing in healthcare and RE initiatives. In their research on the effects of trade intensity, financial openness, GDP per capita, capital formation, RE use, and CO_2 emissions in Commonwealth independent state economies from 1992 to 2015, Rasoulinezhad and Saboori [20] found mixed results. It has been shown that RE sources have a negative impact on carbon dioxide emissions. Additionally, economic growth and CO_2 emissions both tend to go down. Similarly, there is bidirectional causation from fossil fuel energy use to RE and carbon emissions, as well as from economic development to financial openness and trade openness. The research suggested switching from fossil fuels to RE sources to reduce carbon emissions. Using data from 1996 to 2012, Hu et al. [21] examined the impact of 25 developing nations' international commercial services trade, GDP per capita, and usage of RE on carbon emissions. The data support the EKC theory fora given nation. In addition, RE sources are inversely correlated with carbon dioxide release, and in addition, the exchange of commercial services across borders is inversely correlated with carbon emissions. There is a positive and strong relationship between economic expansions and carbon emissions, and carbon emissions and economic expansion powered by RE sources only go in one direction. The research concluded that low-carbon and accelerated economic development might be achieved if emerging nations promoted commercial services trade and the usage of RE. Studies have shown a negative and statistically significant correlation between the use of RE and carbon emissions [22–24].

The primary hypothesis of the research is as follows, based on the above literature review:

H1: *To maintain environmental sustainability and offer a path to low carbon emissions, the percentage of consumption from RE sources will probably rise as part of the energy transition, and*

H2: *The use of RE sources helps to minimize carbon emissions, which advances environmental goals.*

2.2. Literature on Fossil Fuel Combustions and Carbon Emissions Intensity

Industrial production needs renewable fuels to replace the fossil fuels that damage the indoor and outdoor natural environments. Uzair et al. [25] used data from 1971 to 2014 to examine the connections between economic growth, fossil fuel use, population density, and carbon emissions in India, Pakistan, and Bangladesh. The findings support the U-inverted EKC theory, which states that rising economic prosperity is inversely related to increasing carbon emissions. Carbon emissions are positively correlated with the use of fossil fuels. Further, a higher population density is associated with higher levels of carbon dioxide release. Similarly, a positive and strong long-term link exists between FDI, total exports, and carbon emissions. There is also a short-term causal relationship between economic development and population density, and CO_2 and population density. According to the findings, carbon emissions may be lowered, and environmental sustainability preserved, by adopting efficient technologies and producing low levels of carbon dioxide. It was reported by Rehman et al. [26] that between 1975 and 2019, they found a correlation between Pakistan's GDP per capita, nuclear energy source, power output, and carbon emissions. The empirical research reveals that using RE sources, energy from fossil fuels, and carbon emissions all have a positive, substantial, and long-term relationship with one another. In addition, using fossil fuels for energy increases CO_2 emissions over time. In addition, a rising economy is positively correlated with more carbon output. In order to meet the country's energy needs and reduce carbon emissions, the study recommended that the economy adopt practical, progressive policies aimed at the energy and power sectors. The effects of fossil fuels, GDP per capita, economic complexity, foreign direct investment, RE usage, and environmental quality on the Spanish economy were studied by Adebayo [27] for the years 1970 to 2017. The research found a negative correlation between RE and carbon output over the short and medium term. Furthermore, there is a positive association between fossil fuels and environmental quality in the short to medium term. Furthermore, FDI is inversely related to ecological health. The economy also has a short-, medium-, and long-term impact on environmental quality. Improving environmental assessment instruments to lessen the impact of fossil fuels and locating new instruments to design environmentally friendly RE are needed for sustainable development. Jiang et al. [28] used data from 1995 to 2018 to examine the correlation between fossil fuels, GDP per capita, financial development, urbanization, REC, natural resource use, and carbon emissions in 57 countries along the Belt and Road. The data shows that using RE sources reduces carbon emissions. Moreover, comprehensive natural resources and fossil fuel use positively correlate with carbon emissions. In addition, urbanization tends to increase exports of fuel, which in turn increases carbon emissions. In order to reduce environmental pollution, the study recommends that the governments of these countries have joint conversations about the challenges of rapid urbanization, build the necessary institutions, and reduce their reliance on fossil fuels. Dumoret al. [29] studied the relationship between GDP per capita, fossil energy use, trade, human development, FDI, REC, and carbon emissions in EAC nations between 1970 and 2016. According to the findings, long-term carbon emissions arestrongly related to fossil energy, commerce, human development, and economic growth. Furthermore, the use of fossil fuels, GDP expansion, and carbon emissions are all negatively correlated, and FDI tends to decrease carbon emissions. The study recommended increasing investments in energy-efficient technologies and expanding access to RE sources that do less damage to the environment.

Li and Haneklaus [30] looked at the Chinese economy from 1990 to 2020 to see how several factors, including GDP growth, fossil fuel use, RE adoption, and urbanization, affected the country's carbon emissions. The findings of this analysis support the U-inverted EKC hypothesis that there is a positive relationship between carbon emissions and economic expansion over the medium- to long-term. Furthermore, RE and carbon output have a negative, short-term connection. Carbon emissions are inversely proportional to the use of fossil fuels. In addition, rising GDP tends to go hand in hand with increased CO_2 emissions. As a result of the study's findings, it was suggested that RE be encouraged as part of the energy mix to cut down on carbon emissions in the near term, which is associated with the sector's explosive growth and the introduction of new, cutting-edge technologies. Using data from 1990 to 2013, Hanif et al. [31] examined the connection between 15 emerging Asian nations' fossil fuel use, FDI, economic development, and carbon emissions. The findings of this research provide more evidence of the positive correlation between regional fossil fuel usage and carbon emissions. Furthermore, the positive correlation between FDI and domestic carbon emissions supports the pollution haven theory. Evidence for the EKC theory is also seen in the positive correlation between economic development and carbon emissions in these emerging nations. According to the findings, improving environmental sustainability in a growing region requires less reliance on fossil fuels and the promotion of environmentally friendly new technologies. Mensah et al. [32] used data from 1990 to 2015 to study the correlation between GDP per capita, fossil fuels energy use, oil prices, and carbon emissions in 22 African nations. The empirical analysis indicates a long- and short-term panel causal relationship between fossil fuel energy use and economic development, and between fossil fuel energy consumption and carbon emissions. There is also bidirectional causation to the pricing of nonoil exports and a long-term unidirectional causality from economic expansion to carbon emissions. Furthermore, long- and short-term causal relationships exist between oil prices and economic growth, energy use, and carbon emissions, across all panel nations. Using data from 1960 to 2011, Gokmenoglu and Sadeghieh [33] studied the connection between Turkey's fossil fuel usage, GDP per capita, and carbon emissions. According to the findings, there is a positive short-to-long-term elastic connection between fossil fuel use and carbon output. Furthermore, there is a significant negative relationship between economic expansion and carbon emissions over the long-term. In addition, the combined effects of rising prosperity, fossil fuel use, and improved banking infrastructure result in a 16.97% annual rate of change in the long-term equilibrium level of carbon emissions. The research was submitted covering and regulating the probable environmental impacts of economic indicators and charting a course to low carbon intensity on a tight budget. Using data from 1990 to 2014, Hanif [2] found a correlation between GDP per capita, urbanization, energy consumption from fossil fuels, and carbon emissions in 12 East Asian and Pacific nations. According to the data, the consumption of fossil fuels is correlated negatively with carbon emissions. Furthermore, urbanization is associated with increased CO_2 emissions. In addition, a rising economy is positively correlated with more carbon output. In addition, the EKC hypothesis is true in the area even though there is a U-shaped inversion of the link between carbon emissions and economic development. In order to meet expanding energy demands and broaden the stimulus of governmental policies in lowering carbon emissions, the research suggests promoting RE sources. Bandyopadhyay and Rej [34] analyzed the inverse link between nuclear energy fuels and carbon emissions. Kartal [35] looked at the function of energy fossil fuels usage and found that it raises carbon emissions. The current study's third research hypothesis is based on the above literature review:

H3: *To reduce carbon emissions, increasing the use of fossil fuels is hypothesized to have adverse environmental effects.*

2.3. Literature on Industrial Waste Management, Chemical Use, and Carbon Emissions

Reducing the number of chemicals used in production and making better use of industrial waste will assist in lessening the global impact of carbon emissions. Adding it to the waste recycling process, synthesizing green instruments, and cleaner fuels would significantly benefit the interior and outdoor environment. Ali et al. [36] looked at 2008–2020 data on GDP per capita, combustible energy waste use, and carbon emissions in Balkan countries to arrive at that conclusion. The findings of the research indicate a strong positive correlation between the use of combustible energy waste and economic expansion. Combustible energy waste has also been shown to have a counterproductive impact on greenhouse gas production. Carbon emissions are linked to rising economic activity and the rising use of waste fuels that may be burned. The study suggested prioritizing economic development above unanticipated increases in CO_2 emissions from various industries by using energy generation from basic biowaste and paying greater attention to defining climate and RE policy objectives. By analyzing data from 1980 to 2011, Jebli and Belloumi [37] found a correlation between the real GDP per capita, combustible renewables and waste consumption, sea and rail mobility, and carbon emissions in countries in Tunisia. Long-term carbon emissions are positively correlated with the use of combustible renewables and refuse, according to the results of an empirical investigation. Additionally, both marine and rail transportation contribute to CO_2 emissions. There is also a negative relationship between economic expansion and carbon emissions over the long term. Similarly, real GDP, combustible renewables, refuse consumption, and rail transport all lead to CO_2 emissions in a unidirectional fashion. In contrast, marine and rail travel leads to carbon emissions in both directions in the short term. For the sake of maintaining a high degree of sustainability, the research suggests that carbon emissions be lowered by increased use of renewable and waste energy sources and their novel frameworks and technologies. Studying 80 industrialized and emerging nations, Solarin et al. [38] looked at how changes in biomass energy use affected GDP, fossil fuel use, hydropower generation, urbanization, population growth, FDI flows, and carbon emissions. According to the findings, using both biomass and fossil fuels increases carbon emissions. In addition, urbanization, economic expansion, and population increase are all positively correlated with carbon emissions. Furthermore, hydroelectricity, foreign direct investment, and trade openness negatively correlate with CO_2 carbon emissions. There is also evidence that the EKC and the Kyoto Protocol work to reduce carbon emissions. The research concluded that to reduce carbon emissions and maintain a high degree of sustainability, replacing fossil fuels with other renewable energy sources rather than biomass energy would be preferable.

Utilizing data from 1971 to 2013, Sun et al. [39] investigated the effects of combustible renewables, power generation, trade openness, GDP per capita, urban population, and REC on carbon emissions in Ghana. The data shows a negative correlation between using RE sources, combustible renewables, using electricity generated from fossil fuels, and emitting carbon dioxide. In addition, using fossil fuels increases carbon dioxide output. The rise in urbanization and industrialization has been linked to increased carbon emissions. Additionally, Granger causality does exist in the long run between all study variables. From 1990 to 2011, Larsen et al. [40] reported that the economy of Tunisia was studied for its effects on real GDP per capita, health index, combustible renewables and refuse consumption, rail travel, and carbon emissions. Real production, combustible renewables, and refuse consumption were all shown to have a positive and statistically significant link with health indices over the long term. Moreover, a negative correlation between health indices and rail transportation's carbon emissions may be seen. Moreover, real GDP is causally related to health indices, but only in the short term and in a unidirectional fashion. Combustible renewables and refuse consumption negatively correlate with health indicators unidirectionally. RE investment projects are valuable ideas for contributing to growth and carbon emissions reduction connected to combustible refuse, as well as reducing energy dependency on other energy supply sectors. In a study spanning the years 2001 to2015, Feng et al. [41] found a correlation between carbon efficiency and 55 different nations' service trade, exports, and imports. The empirical research demonstrates a favorable and statistically significant link between service trade and carbon efficiency. Carbon efficiency in many nations and sectors positively correlates with export and import services. Promotional links have also been shown between the monetary crisis and shifts in national leadership on carbon efficiency. The relationship between RE expansion and increased carbon emissions is also unidirectional. The research suggested that promoting carbon efficiency and expanding worldwide free carbon emissions trade in service might help the environment in the long run. From 1980 to 2013, Sun et al. [42] studied 30 nations to determine how openness in the service trade affected energy efficiency, developing service industries, and carbon emissions. According to the findings, an increase in the free flow of services is associated with a lower carbon emissions rate. In addition, the growing importance of the service economy has been linked to an increase in greenhouse gas production. There is a positive correlation between the use of conventional services and the release of greenhouse gases. The gap between industrialized and developing countries regarding energy and carbon emissions efficiency is also subject to a catch-up effect. Low-carbon globalization in less-developed nations should drive energy and carbon emissions efficiency improvements for global prosperity. There was a correlation between GDP per capita, trade in services, and carbon emissions in 47 African nations, as reported by Ibrahim et al. [43]. A positive correlation between the scale effect and carbon emissions was found in the empirical research. In addition, there is N-shaped evidence between GDP per capita and CO_2 emissions and a negative relationship between the technological impact and emissions. To add fuel to the fire, there is a positive and statistically significant correlation between commerce and carbon output in support of the legitimacy of the pollution haven theory. Trade also hurts energy intensity and greenhouse gas emissions. This research suggests that green investment may mitigate the negative environmental impact of economic expansion and the service trade. Using data from 2000 to 2014, Longe et al. [44] found a correlation between national income per person, usage of RE, exports and imports, and environmental deterioration across 21 nations. The empirical research reveals that RE sources are linked to environmental damage. Environmental deterioration is positively correlated with trade and transportation services, and another negative correlation exists between imports and environmental damage. The research recommended enhancing the technology to satisfy the region's sustainability aim better while also ameliorating the mixed impact of commerce and transit services on the environment.

The following are the hypotheses of the research based on the above literature review:

H4: *Growing energy and refuse that may be burned are anticipated to raise environmental and carbon emissions issues.*

H5: *Chemical value-added utilized in production is expected to rise, posing environmental risks, and*

H6: *The natural environmental damage in a nation is expected to rise in proportion to the per capita GDP.*

The study model built on the proposed hypotheses differs from prior studies in several ways. First, the study uses a combination of renewable energy and the combustion of fossil fuels in its carbon mitigation models. This combination has not been fully employed before. Climate change is exacerbated by human activities, which raise the atmospheric concentration of carbon and, in turn, the global average temperature. The use of fossil fuels for the generation of energy and propulsion accounts for a disproportionate share of global CO_2 emissions [45–47]. This is because it provides a fossil fuels framework for reorienting environmentally damaging high-carbon production activities toward those more in line with the goals of the Paris Climate Agreement on climate change. A climate-neutral shift can only be maintained with widespread belief and consensus. Capital inflows must be redirected, and regulators can help make that happen. However, they can be in a precarious position, straddling the line between sky-high hopes and the realities of their limited resources and public policy [48–50]. The reason for this is that it presents a framework for fossil fuels. Second, the research goes beyond its initial focus on environmental technical elements by integrating RE technology as a moderating element that promotes environmental quality in green energy and R&D investment. This increases the research scope and allows it to grow beyond its original focus on environmental technical aspects. The worldwide community must undertake extraordinary adjustments to the human intellect, economy, and means of transportation to reach the aim of keeping the surface temperature rise below 2 °C in the climate change Paris Agreement. It requires fostering innovation to use as-yet-untapped resources such as wind and ocean power [51–53]. Investment in research and development within the energy sector to build RE technologies that will serve as the industry standard to guarantee the highest possible degree of sustainability with the fewest possible adverse effects on the environment is required [54–56]. This is the idea behind the plan. In conclusion, the use of chemicals, the expansion of the economy, and the accumulation of industrial waste all contribute to the pollution problem in India; nevertheless, the effects of this problem on the economy of the country have only been somewhat investigated in earlier research [57,58]. In the framework of the Indian economy, the research was initiated to choose the critical components to establish long-term policies for conserving the natural environment both inside and outside the country.

3. Materials and Methods

3.1. Theoretical Framework

Before beginning work on the econometric model, we first construct the conceptual framework of environmental theories and models used in this research to aid with the model variables.

3.1.1. Values on the Frondel and Schmidt Index

Frondel and Schmidt [59] established this index to illustrate the hazards associated with a country's fuels, fossil and biofuel production, renewable power, and total energy supply. The model considers the interconnectedness of exporting oil supplies and other fossil fuels and energy sources. Indexes xij and xid are used to determine the relative contributions of nation j, the exporter, and country 'i', the supplier of energy resources. Estimating the potential danger to a country's fuel supply is achieved as follows:

$$TRxi = xid\ 2\ rd + \sum xij\ 2\ \mathrm{j}\ \ = 1\mathrm{rj} \tag{1}$$

where, rj is the risk factor, and *rd* is the domestic supply of energy resources.

3.1.2. Energy Security Price Index (ESPI)

Lefevre's [60] ESPI calculates the potential and risk associated with each country's portion of the global energy export market in terms of fossil fuel energy. The fuel-specific indicators are multiplied by the country's total primary energy supply in this model, i.e.,

$$ESPI = \sum(EfTPESf)ESMCpol - fwithESMCpol - f = \sum(rcwcf2c) \tag{2}$$

where; *EfTPESf* is the share of total fuel in the total primary energy supply, *rc* is the potential risk of energy and fuel demand, *wcf* is the share of the export country, and *c* is the net energy potential of the country.

Jansen et al. [61] suggested that this index explains the four indications of long-term energy security:

- Extra components of long-term energy security,
- Long-term political stability,
- Diversification of energy sources and imports concerning imported energy sources, and
- Import volatility

Indicators with values greater than one indicate a diverse and balanced fuel supply.

$$II = \sum(ciIpiLnpi)i \tag{3}$$

where *II* is the energy supply security indicator, *pi* is the share of primary energy source *i* in total primary energy supply, *i* = 1 . . . , *n* is the primary energy source index, and *ci*I is the correction factor to pi for indicator *II*.

3.1.3. Model of Human Interaction with the Environment

Stem [62] created a model of how people engage with their surroundings. There are different ways in which human actions affect the natural world that is accounted for by this model. One such source is the environment, which provides essential materials such as minerals, energy, food, fibers, and water for commercial activity. Continual manufacturing uses natural resources and wears out environmental ones, and using natural resources and generating pollution and refuse are byproducts of industrial production. The disorganized environmental system provides life support to counteract the degrading effects of human activities and lower environmental pollution levels. Finally, the deterioration of the environment negatively influences human wellbeing due to the adverse effects of increased pollution and water scarcity on human health and economic prosperity.

3.1.4. Technology Acceptance Model (TAM)

Davis [63] created the Technology Acceptance Model (TAM) to describe the attitudes of technology users: why some people embrace new tools, while others reject them outright, and what can be done to improve the usability and effectiveness of technological products. Achieving sustainable and green investment decision objectives, improving logistical performance, exporting capabilities, technological progress, resource inputs, and boosting competitiveness are all made possible by the renewable energy TAM extension. Research and development are bolstered, and a more positive outlook on green and innovative systems is fostered, thanks to the growing need for sustainable energy.

3.2. Data Source and Econometric Modeling

The study employed the time series data from 1995Q1 to 2020Q4 collected from World Development Indicators [64]. The study used carbon (CO_2) emissions in metric tonnes per capita as the dependent variable, and the independent variables are given below:

- Chemical use
- Renewable energy consumption
- Fossil fuel energy consumption
- Square of fossil fuel energy consumption
- Combustible renewable and waste
- Renewable energy technology, and
- Real GDP.

Table 1 shows the list of variables for ready reference.

Table 1. List of Variables and Measurement.

Variables	Symbol	Measurement/Units
Carbon emissions	CO_2	Metric tonnes per capita
Chemical used	CHM	% of value added in manufacturing
Renewable energy consumption	REC	% of total final energy consumption
Fossil fuel energy consumption	FFC	% of total energy consumption
Square of fossil fuel energy consumption	SQFFC	% of total energy consumption
Combustible renewable and waste	CRW	% of total energy
Renewable energy technology	RET	Research and development expenditure (Patent applications, residents) × Renewable energy consumption
Real GDP	RGDP	Constant 2015 US$

Source: WDI [64].

Econometric Modeling

The ADF unit root test and the AR(1) model are used to evaluate the stationary time series of the relevant variables, allowing for the identification of one of three possible results. First, the series is stationary at the level; next, it is stationary at the difference, and finally, it is not stationary at the second difference. The ADF equation is shown for quick reference in Equation (4), which reads as follows:

$$\Delta CO2_t + \alpha + \beta TIME + \vartheta CO2_{t-1} + \sigma_1 CO2_{t-1} + \ldots + \sigma_{\delta-1}\Delta CO2_{t-\delta-1} + e_t \tag{4}$$

$$\Delta CHM_t + \alpha + \beta TIME + \vartheta CHM_{t-1} + \sigma_1 CHM_{t-1} + \ldots + \sigma_{\delta-1}\Delta CHM_{t-\delta-1} + e_t$$

$$\Delta\ REC_t + \alpha + \beta TIME + \vartheta REC_{t-1} + \sigma_1 REC_{t-1} + \ldots + \sigma_{\delta-1}\Delta REC_{t-\delta-1} + e_t$$

$$\Delta FFC_t + \alpha + \beta TIME + \vartheta FFC_{t-1} + \sigma_1 FFC_{t-1} + \ldots + \sigma_{\delta-1}\Delta FFC_{t-\delta-1} + e_t$$

$$\Delta SQFFC_t + \alpha + \beta TIME + \vartheta SQFFC_{t-1} + \sigma_1 SQFFC_{t-1} + \ldots + \sigma_{\delta-1}\Delta SQFFC_{t-\delta-1} + e_t$$

$$\Delta CRW_t + \alpha + \beta TIME + \vartheta CRW_{t-1} + \sigma_1 CRW_{t-1} + \ldots + \sigma_{\delta-1}\Delta CRW_{t-\delta-1} + e_t$$

$$\Delta RET_t + \alpha + \beta TIME + \vartheta RET_{t-1} + \sigma_1 RET_{t-1} + \ldots + \sigma_{\delta-1}\Delta RET_{t-\delta-1} + e_t$$

$$\Delta GDPPC_t + \alpha + \beta TIME + \vartheta GDPPC_{t-1} + \sigma_1 GDPPC_{t-1} + \ldots + \sigma_{\delta-1}\Delta RGDP_{t-\delta-1} + e_t$$

where α is an intercept, β is the time-varying coefficient, and σ represents the lagged AR process. AIC lagged criterion is employed for selectingthe suitable lag length for variables estimation.

Pesaran and Shin [65], Pesaran et al. [66], and Pesaran et al. [67] proposed a technique known as Autoregressive Distributed Lag (ARDL), which is adopted in the current research. If the underlying independent variables are [I(0); I(1)] or mutually co-integrated in direction, then the ARDL approach may be used to identify both the short- and long-term connection between the variables in a more unified fashion than other methods. The ARDL description in the short term, shown by Equation (5), is as follows:

$$\begin{aligned} In(CO2) = \alpha_0 + & \sum_{i=0}^{p} \gamma\Delta In(CO2)_{t-1} + \sum_{i=0}^{p} \gamma\Delta In(CHM)_{t-1} + \sum_{i=0}^{q} \gamma In(REC)_{t-1} + \sum_{i=0}^{r} \gamma In(FFC)_{t-1} \\ & + \sum_{i=o}^{S} \gamma In(SQFFC)_{t-1} + \sum_{i=0}^{u} \gamma In(CRW)_{t-1} + \sum_{i=0}^{v} \gamma In(RET)_{t-1} + \sum_{i=0}^{n} \gamma In(RGDP)_{t-1} \\ & + \varnothing_1 In(CHM)_t + \varnothing_2 In(REC)_t + \varnothing_3 In(FFC)_t. + \varnothing_4 In(SQFFC)_t + \varnothing_5 In(CRW)_t \\ & + \varnothing_6 In(RET)_t + \varnothing_7 In(RGDP)_t + \varepsilon_t \end{aligned} \tag{5}$$

where p shows optimal lag length. The Wald F-statistics are employed to explore the null and alternative hypotheses, i.e.,

$$H_0;\ \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7$$

$$H_0;\ \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7$$

An error correction factor has been introduced to Equation (6) to ensure that the model converges to equilibrium under all possible long-term parameter combinations, i.e.,

$$\begin{aligned} In(CO2) = \alpha_0 + & \sum_{i=0}^{p} \gamma\Delta In(CO2)_{t-1} + \sum_{i=0}^{p} \gamma\Delta In(CHM)_{t-1} + \sum_{i=0}^{q} \gamma In(REC)_{t-1} + \sum_{i=0}^{r} \gamma In(FFC)_{t-1} \\ & + \sum_{i=o}^{S} \gamma In(SQFFC)_{t-1} + \sum_{i=0}^{u} \gamma In(CRW)_{t-1} + \sum_{i=0}^{v} \gamma In(RET)_{t-1} + \sum_{i=0}^{n} \gamma In(RGDP)_{t-1} \\ & + \varnothing_1 In(CHM)_t + \varnothing_2 In(REC) + \varnothing_3 In(FFC)_t. + \varnothing_4 In(SQFFC)_t + \varnothing_5 In(CRW)_t + \varnothing_6 In(RET)_t \\ & + \varnothing_7 In(RGDP)_t + \omega ECT_{t-1} + \varepsilon_t \end{aligned} \tag{6}$$

where ECT_{t-1} is the error correction term, and ω isthe model's adjustment parameter.

Following the estimation of findings, the VAR Granger causality test was conducted, yielding four distinct outcomes, one of which would be true in the variables connected, i.e.,

(i) Unidirectional Causality: CO_2 Granger causes CHM, REC, FFC, CRW, RET, and RGDP, but this causality does not become true in the opposite direction.
(ii) Reverse Causality: CHM, REC, FFC, CRW, RET, and RGDP connect to CO_2 but not vice versa.
(iii) Bidirectional Causality: The studied variables have two-way associations.
(iv) Neutrality: No cause-effect association has been recognized in the given analysis.

$$\begin{bmatrix} \ln(CO2)_t \\ \ln(CHM)_t \\ \ln(REC)_t \\ \ln(FFC)_t \\ \ln(SQFFC)_t \\ \ln(CRW)_t \\ \ln(RET)_t \\ \ln(RGDP)_t \end{bmatrix} = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \end{bmatrix} \sum\nolimits_{i=1}^{p} \begin{bmatrix} \sigma_{11t}\sigma_{12t}\sigma_{13t}\sigma_{14t}\sigma_{15t} \\ \sigma_{21t}\sigma_{22t}\sigma_{23t}\sigma_{24t}\sigma_{25t} \\ \sigma_{31t}\sigma_{32t}\sigma_{33t}\sigma_{34t}\sigma_{35t} \\ \sigma_{41t}\sigma_{42t}\sigma_{43t}\sigma_{44t}\sigma_{45t} \\ \sigma_{51t}\sigma_{52t}\sigma_{53t}\sigma_{54t}\sigma_{55t} \\ \sigma_{61t}\sigma_{62t}\sigma_{63t}\sigma_{64t}\sigma_{65t} \\ \sigma_{71t}\sigma_{72t}\sigma_{73t}\sigma_{74t}\sigma_{75t} \\ \sigma_{81t}\sigma_{82t}\sigma_{83t}\sigma_{84t}\sigma_{85t} \end{bmatrix} + \times \begin{bmatrix} \ln(CO2)_{t-1} \\ \ln(CHM)_{t-1} \\ \ln(REC)_{t-1} \\ \ln(FFC)_{t-1} \\ \ln(SQFFC)_{t-1} \\ \ln(CRW)_{t-1} \\ \ln(RET)_{t-1} \\ \ln(RGDP)_{t-1} \end{bmatrix} + \sum\nolimits_{j=p+1}^{dmax} \begin{bmatrix} \theta_{11j}\theta_{12j}\theta_{13j}\theta_{14j}\theta_{15j} \\ \theta_{21j}\theta_{22j}\theta_{23j}\theta_{24j}\theta_{25j} \\ \theta_{31j}\theta_{32j}\theta_{33j}\theta_{34j}\theta_{35j} \\ \theta_{41j}\theta_{42j}\theta_{43j}\theta_{44j}\theta_{45j} \\ \theta_{51j}\theta_{52j}\theta_{53j}\theta_{54j}\theta_{55j} \\ \theta_{61j}\theta_{62j}\theta_{63j}\theta_{64j}\theta_{65j} \\ \theta_{71j}\theta_{72j}\theta_{73j}\theta_{74j}\theta_{75j} \\ \theta_{81j}\theta_{82j}\theta_{83j}\theta_{84j}\theta_{85j} \end{bmatrix} \times \begin{bmatrix} \ln(CO2)_{j-1} \\ \ln(CHM)_{j-1} \\ \ln(REC)_{j-1} \\ \ln(FFC)_{j-1} \\ \ln(SQFFC)_{j-1} \\ \ln(CRW)_{j-1} \\ \ln(RET)_{j-1} \\ \ln(RGDP)_{j-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \end{bmatrix} \tag{7}$$

For Granger causality, the VAR framework is used, i.e., Equation (8) shows Granger causality for a multivariate system, i.e.,

$$\begin{aligned} &CO2_t \\ &= c_t + \sum_{i=t}^{2} \beta_1 CO2_{i=1} + \sum_{i=1}^{2} \beta_2 CHM_{i=1} + \sum_{i=1}^{2} \beta_3 REC_{i=1} + \sum_{i=1}^{2} \beta_4 FFC_{i=1} + QSqFFC_{i=1} + \sum_{i=1}^{2} \beta_6 CRW_{i=1} \\ &+ \sum_{i=t}^{2} \beta_7 RET_{i=1} \\ &+ \sum_{i=t}^{2} \beta_{87FCFPCEPT,\ eI\ (0),\ purelya\ (2021)2021)\ ;\ WangandZhu\ (2020).\ 2020)\ ;\ AnwarandElfaki\ (2021)\ ment} RGDP_{i=1} + \varepsilon \end{aligned} \tag{8}$$

$$\begin{aligned} CHM_t = c_1 &+ \sum_{i=1}^{2} \beta_1 CHM_{i=1} + \sum_{i=t}^{2} \beta_2 CO2_{i=1} + \sum_{i=1}^{2} \beta_3 REC_{i=1} + \sum_{i=1}^{2} \beta_4 FFC_{i=1} + \sum_{i=1}^{2} \beta_5 SQFFC_{i=1} \\ &+ \sum_{i=1}^{2} \beta_6 CRW_{i=1} + \sum_{i=t}^{2} \beta_7 RET_{i=1} + \sum_{i=t}^{2} \beta_{87FCFP} RGDP_{i=1} + \varepsilon \end{aligned}$$

$$\begin{aligned} REC_t = c_1 &+ \sum_{i=1}^{2} \beta_1 REC_{i=1} + \sum_{i=1}^{2} \beta_2 CO2_{i=1} + \sum_{i=1}^{2} \beta_3 CHM_{i=1} + \sum_{i=1}^{2} \beta_4 FFC_{i=1} + \sum_{i=1}^{2} \beta_5 SQFFC_{i=1} \\ &+ \sum_{i=1}^{2} \beta_6 CRW_{i=1} + \sum_{i=t}^{2} \beta_7 RET_{i=1} + \sum_{i=t}^{2} \beta_{87FCFP} GDPPC_{i=1} + \varepsilon \end{aligned}$$

$$\begin{aligned} FFC_t = c_1 &+ \sum_{i=1}^{2} \beta_1 FFC_{i=1} + \sum_{i=t}^{2} \beta_2 CO2_{i=1} + \sum_{i=1}^{2} \beta_3 CHM_{i=1} + \sum_{i=1}^{2} \beta_4 REC_{i=1} + \sum_{i=1}^{2} \beta_5 SQFFC_{i=1} \\ &+ \sum_{i=1}^{2} \beta_6 CRW_{i=1} + \sum_{i=t}^{2} \beta_7 RET_{i=1} + \sum_{i=t}^{2} \beta_{87FCFP} RGDP_{i=1} + \varepsilon \end{aligned}$$

$$\begin{aligned} SQFFC_t = c_1 &+ \sum_{i=1}^{2} \beta_1 SQFFC_{i=1} + \sum_{i=t}^{2} \beta_2 CO2_{i=1} + \sum_{i=1}^{2} \beta_3 CHM_{i=1} + \sum_{i=1}^{2} \beta_4 REC_{i=1} + \sum_{i=1}^{2} \beta_5 FFC_{i=1} \\ &+ \sum_{i=1}^{2} \beta_6 CRW_{i=1} + \sum_{i=t}^{2} \beta_7 RET_{i=1} + \sum_{i=t}^{2} \beta_{87FCFP} RGDP_{i=1} + \varepsilon \end{aligned}$$

$$\begin{aligned} CRW_t = c_1 &+ \sum_{i=1}^{2} \beta_1 CRW_{i=1} + \sum_{i=t}^{2} \beta_2 CO2_{i=1} + \sum_{i=1}^{2} \beta_3 CHM_{i=1} + \sum_{i=1}^{2} \beta_4 REC_{i=1} + \sum_{i=1}^{2} \beta_5 FFC_{i=1} \\ &+ \sum_{i=1}^{2} \beta_6 SQFFC_{i=1} + \sum_{i=t}^{2} \beta_7 RET_{i=1} + \sum_{i=t}^{2} \beta_{87FCFP} RGDP_{i=1} + \varepsilon \end{aligned}$$

$$\begin{aligned} RET_t = c_1 &+ \sum_{i=1}^{2} \beta_1 RET_{i=1} + \sum_{i=t}^{2} \beta_2 CO2_{i=1} + \sum_{i=1}^{2} \beta_3 CHM_{i=1} + \sum_{i=1}^{2} \beta_4 REC_{i=1} + \sum_{i=1}^{2} \beta_5 FFC_{i=1} \\ &+ \sum_{i=1}^{2} \beta_6 SQFFC_{i=1} + \sum_{i=t}^{2} \beta_7 CRW_{i=1} + \sum_{i=t}^{2} \beta_{87FCFP} RGDP_{i=1} + \varepsilon \end{aligned}$$

$$\begin{aligned} RGDP_t = c_1 &+ \sum_{i=1}^{2} \beta_1 RGDP_{i=1} + \sum_{i=t}^{2} \beta_2 CO2_{i=1} + \sum_{i=1}^{2} \beta_3 CHM_{i=1} + \sum_{i=1}^{2} \beta_4 REC_{i=1} + \sum_{i=1}^{2} \beta_5 FFC_{i=1} \\ &+ \sum_{i=1}^{2} \beta_6 SQFFC_{i=1} + \sum_{i=t}^{2} \beta_7 CRW_{i=1} + \sum_{i=t}^{2} \beta_{87FCFP} RET_{i=1} + \varepsilon \end{aligned}$$

Finally, the data set was subjected to a variance decomposition analysis in order to project future estimations. This lead to the VDA version of Equation (9), which is:

$$Var(\sigma(CO2,\ CVM = Var\ (E[\sigma \perp CHM)] + E[VAR(\sigma \perp CHM)] \rightarrow Var(E[\sigma \perp CHM)] \leq Var(\sigma E[CO2, CHM)] \tag{9}$$

$$Var(\sigma(CO2, REC = Var\ (E[\sigma \perp REC)] + E[VAR(\sigma \perp REC)] \rightarrow Var(E[\sigma \perp REC)] \leq Var(\sigma E[CO2, REC)],$$

$$\begin{aligned} Var(\sigma(CO2, FFC = Var\ (E[\sigma \perp FFC)] + E[VAR(\sigma \perp FFC)] \rightarrow Var(E[\sigma \perp FFC)] \\ \leq Var(\sigma E[CO2, FFC)], \end{aligned}$$

$$Var(\sigma(CO2, SQFFC = Var\ (E[\sigma \perp SQFFC)] + E[VAR(\sigma \perp SQFFC)] \rightarrow Var(E[\sigma \perp SQFFC)] \leq Var(\sigma E[CO2, SQFFC)]$$

$$Var(\sigma(CO2, CRW = Var\ (E[\sigma \perp CRW)] + E[VAR(\sigma \perp CRW)] \rightarrow Var(E[\sigma \perp CRW)] \leq Var(\sigma E[CO2, CRW)],$$

$$Var(\sigma(CO2, RET = Var\ (E[\sigma \perp RET)] + E[VAR(\sigma \perp RET)] \rightarrow Var(E[\sigma \perp RET)] \leq Var(\sigma E[CO2, RET)]$$

$$\begin{aligned} Var(\sigma(CO2, RGDP = Var\ (E[\sigma \perp RGDP)] + E[VAR(\sigma \perp RGDP)] \rightarrow Var(E[\sigma \perp RGDP)] \\ \leq Var(\sigma E[CO2, RGDP)] \end{aligned}$$

4. Results

Table 2 provides descriptive statistics of the variables. In terms of carbon emissions, the range is from 0.765 metric tonnes per capita up to 1.812 metric tonnes, with a mean and standard deviation of 1.236 metric tonnes and 0.374 metric tonnes, respectively, and a positive skewness and a low-tailed kurtosis distribution. In addition, the lowest value of the chemical utilized is 13.617%, while the maximum value is 23.700%. The mean value is 17.947%, and the standard deviation is 2.4593%. In addition, the minimum value of REC is 32.410%, associated with a mean value of 41.277%, a standard deviation value of 7.663%, a low positive skewness, and a medium kurtosis.

Table 2. Descriptive Statistics.

Variables	**CO_2**	**CHM**	**REC**	**FFC**	**SQFFC**	**CRW**	**RET**	**RGDP**
Mean	1.236	17.947	41.277	68.727	4743.743	53.266	256,151.9	1.36×10^{12}
Median	1.158	18.042	40.450	70.074	4911.552	52.248	238,249.4	1.23×10^{12}
Maximum	1.812	23.700	54.484	73.576	5413.572	57.663	640,620.2	2.69×10^{12}
Minimum	0.765	13.617	32.410	60.825	3699.700	49.735	83,070.65	5.54×10^{11}
Std. Dev.	0.374	2.459	7.663	4.596	625.987	2.497	157,096.6	6.58×10^{11}
Skewness	0.273	0.488	0.362	−0.290	−0.249	0.509	0.738571	0.602
Kurtosis	1.507	2.931	1.703	1.499	1.456596	1.792685	2.644313	2.158

Note: CO_2: carbon emissions, CHM: chemical use, REC: renewable energy, FFC: fossil fuel consumption, SQFFC: square of FFC, CRW: combustible renewable waste, RET: renewable energy technology, and RGDP: real GDP.

Trend analysis of the variables in natural log form is shown in Figure 1 for ready reference.

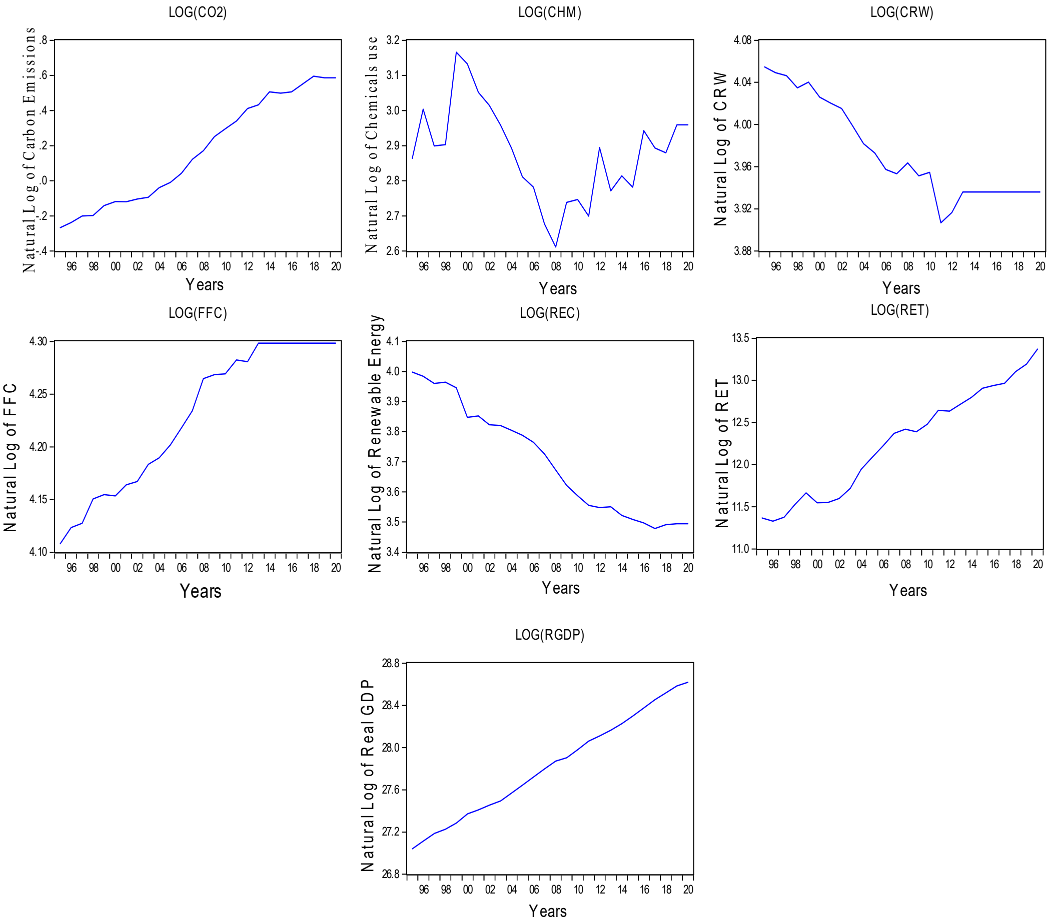

Figure 1. Trend analysis of the variables. Source: authors' calculation. The blue line shows the variable's observations.

In addition, the negative skewness and low platy kurtosis distribution values of mean FFC and Square FFC are 68.727% and 4743.743%, respectively. The range of values for CRW, RET, and RGDP is from 49.735% to 57.663%, with a standard deviation of 2.497%, a mean value of 256151.9%, and a standard deviation of 6.58 × 10^{11}%, respectively. The correlation matrix of the research is shown in Table 3. Chemical consumption is negatively correlated with carbon emissions, suggesting that a country's per-capita chemical use might be used as a proxy for its overall commitment to reducing carbon emissions.

Table 3. Correlation Matrix.

Variables	**CO_2**	**CHM**	**REC**	**FFC**	**SQFFC**	**CRW**	**RET**	**RGDP**
CO_2	1							
CHM	−0.333	1						
REC	−0.984	0.388	1					
FFC	0.971	−0.476	−0.985	1				
SQFFC	0.970	−0.477	−0.985	0.999	1			
CRW	−0.906	0.546	0.944	−0.958	−0.959	1		
RET	0.970	−0.363	−0.945	0.947	0.947	−0.890	1	
RGDP	0.988	−0.314	−0.978	0.964	0.964	−0.908	0.977	1

Note: CO_2: carbon emissions, CHM: chemical use, REC: renewable energy, FFC: fossil fuel consumption, SQFFC: square of FFC, CRW: combustible renewable waste, RET: renewable energy technology, and RGDP: real GDP.

Additionally, a negative correlation between REC and carbon emissions suggests that the latter decreases as the former increases. Consistent with the findings of prior research by Nakhil et al. [68], Sheraz et al. [69], and Adebayo et al. [70]. The research concluded that to slow the rate of environmental deterioration; more attention should be paid to public education on environmental concerns and the promotion of renewable energy sources. Further, energy security, clean and greener energy, clean production, and environmental sustainability should be prioritized in the development of environmental regulations, and this would help achieve the desired carbon neutrality. Furthermore, a favorable association between FFC and its square term and carbon emissions indicated that both sources contribute to a country's total carbon output. The study results are related to those of earlier research by Uzair et al. [25] and Tan et al. [71]. Recent research has linked rising GDP to higher carbon emissions, suggesting that technological advancement is necessary to counteract the size and composite impact. In addition, promoting energy efficiency and the effective use of natural resources may help mitigate climate change's adverse environmental effects.

Additionally, it has been shown via analysis of the relationship between CRW and carbon emissions that the value of CRW decreases carbon emissions in an economy, in common with previous research by Ali et al. [72] and Ben Jebil and Ben Youssef [73]. Based on these findings, it is advised that new RE sources be investigated and that existing technological innovations in the green and clean energy industry be implemented. In addition, governments and businesses should be held to the same standards for developing and disseminating green technology, particularly in energy production. Additionally, a positive association between GDP per capita and carbon emissions demonstrated that as a country's standard of living rises, so does its carbon footprint. The findings of this research are consistent with those of previous investigations by Leitao and Lorente [74] and Aydogan and Vardar [75]. According to the findings, if we want to solve environmental and economic growth problems, we need to advance the ICTs in industrial production and employ a massive investment in economic growth and carbon-led reduction efforts. Moreover, the effort of high-tech FDI should be increased to affirm stronger environmental sustainability and to use it as an essential tool to reach the goal of sustainable economic development.

Table 4 reports the testing results for the ADF's unit root. According to the ADF unit root test findings, CO_2 and RET are I(0) variables (stationary at the level). However, I(1) variables (CHM, REC, FFC, SQFFC, CRW, and RGDP) are stationary. The ARDL-Bounds testing model, which did well under a mixed order of integration, was validated by the discovery of a mixed order of integration I(0) and I(1)] between the research variables.

Table 4. ADF Unit Root Estimates.

Variables	**Level**		**First Difference**		**Decision**
	Constant	**Constant and Trend**	**Constant**	**Constant and Trend**	
CO_2	−0.397(0.895)	−4.556(0.008)	−3.978(0.005)	−3.875(0.029)	I(0)
CHM	−1.860(0.344)	−1.244(0.877)	−6.129(0.000)	−6.117(0.000)	I(1)
REC	−1.390(0.570)	−0.584(0.971)	−2.578(0.111)	−4.547(0.007)	I(1)
FFC	−2.134(0.233)	−0.157(0.990)	−4.377(0.002)	−4.988(0.002)	I(1)
SQFFC	−2.189(0.214)	−0.157(0.990)	−4.378(0.002)	−5.023(0.002)	I(1)
CRW	−1.670(0.433)	−1.132(0.902)	−5.281(0.000)	−5.642(0.000)	I(1)
RET	0.640(0.988)	−3.413(0.073)	−3.654(0.012)	−3.659(0.045)	I(0)
RGDP	0.071(0.956)	−2.821(0.203)	−4.255(0.003)	−4.168(0.016)	I(1)

Note: CO_2: carbon emissions, CHM: chemical use, REC: renewable energy, FFC: fossil fuel consumption, SQFFC: square of FFC, CRW: combustible renewable waste, RET: renewable energy technology, and RGDP: real GDP. Small brackets: probability values.

Table 5 shows the results of the ARDL–Bound test model using five alternative lag length selection criteria: AIC, SIC, HQ, FPE, and LR. The shortest lag time among the available lag times is the one we should choose for our model, as determined by the Average Root-Mean-Square Error (ARDL) lag length selection criteria. Our study's optimal lag duration was determined using the AIC value, which reported the smallest number compared to the other lag selection criteria.

Table 5. Lag Length Selection Criteria.

Lag	LogL	LR	FPE	AIC	SC	HQ
1	471.199	NA	3.74×10^{-26}	−38.683	−38.339	−38.592
2	657.306	248.142	4.91×10^{-31}	−50.108	−47.360	−49.379
3	763.092	79.339 *	1.63×10^{-32} *	−54.841 *	−49.687 *	−53.473 *

Source: Authors' calculation. * indicates appropriate lag length.

Table 6 displays the ARDL-Bound testing short-term and long-term estimates. The findings indicate a positive and statistically significant link between CHM and carbon output over the medium to long term. Increasing CHM use is associated with a rise in a country's carbon emissions, as shown by the positive sign of the coefficient and the statistical significance of the resulting link. The findings are consistent with those of previous research by Zhao et al. [76], Wei et al. [77], Costa and Ribeiro [78], and Zheng et al. [79]. Based on the findings, it is recommended that regulations be put in place to ensure the long-term health of our planet's natural resources while encouraging innovative economic practices that entirely use these assets while reducing their consumption. Further, by decreasing the distance between factories, and altering the spatial pattern of factories, carbon emissions reduction can be made more sensitive to the likely pattern of future industrialization. Increasing incentives to develop a green and clean environment through higher and optimal use of resources is needed for sustained growth.

Similarly, there is a positive link between REC and carbon emissions in the short and long term, which aligns with the findings of Khochiani and Nademi [80], Usman et al. [81], Nguyen and Kakinaka [82], Jebli & Belloumi et al. [37], and Nawaz et al. [83]. Studies found that reducing reliance on fossil fuels and non-renewable sources may be achieved without jeopardizing economic growth if appropriate policies are designed and structured. The Paris Agreement aims to reduce greenhouse gas emissions and bolster the Sustainable Development Goals (SDGs). Thus, it is essential to spotlight technological advancements and innovative ideas in the renewable energy sector.

Additionally, RET has a substantial and negative correlation with CO_2 emissions in the short and long term, suggesting that increasing a country's investment in green technology enhances environmental quality. Previous research by Shao et al. [84], Chien et al. [85], Shan et al. [86], and Khan et al. [87] are in line with the stated results. The earlier research discovered a correlation between REC and GHG emissions. They proposed that more strategic energy usage might mitigate these emissions' consequences and spur the development of cutting-edge tools to boost renewable power's productivity. Moreover, the efficiency of clean energy in a nation is enabled by the implementation of inexpensive renewable energy pricing and the ease of access to new renewable technology in the public and private sectors.

The linear association between FFC and carbon emissions and the negative relationship between the square of FFC and carbon emissions are statistically significant in the short and long term. This supports the inverted U-shaped EKC theory for a given nation. The findings are consistent with prior research by Rani et al. [88], Ali et al. [89], Isik et al. [90], and Raza et al. [91]. In order to effectively reduce the impact of high fossil fuel reliance and carbon emissions, these studies advocated for the innovation and provision of technology to high carbon-producing sectors and the building sector. In addition, a green energy economic framework should be created and carbon reduction objectives established for individual industries. Moreover, carbon-leading technology used in fossil fuels should be modernized, and the industrial structure should be organized to accommodate carbon-neutral production methods. Further, a government may boost its environmental policies for the long-term by reducing carbon emissions and developing a comprehensive program for bolstering environmental sustainability via green technology innovation and renewable energy.

Table 6. ARDL Short- and Long-Term Estimates.

Dependent Variable: CO_2				
Selected Model: ARDL				
Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
$CO_2(-1)$ *	−0.632	0.106	−5.931	0.004
CHM(−1)	0.103	0.062	1.665	0.171
REC(−1)	3.449	0.677	5.094	0.007
FFC(−1)	34.601	6.961	4.970	0.007
SQFFC(−1)	−119.468	24.491	−4.877	0.008
CRW(−1)	−2.759	0.4595	−6.004	0.003
RET(−1)	−0.165	0.042	−3.904	0.017
RGDP(−1)	1.044	0.224	4.644	0.009
D(CHM)	0.184	0.035	5.156	0.006
D(CHM(−1))	0.082	0.035	2.326	0.080
D(REC)	2.305	0.404	5.700	0.004
D(FFC)	119.158	45.414	2.623	0.058
D(FFC(−1))	95.343	38.885	2.451	0.070
D(SQFFC)	−501.466	192.860	−2.600	0.060
D(SQFFC(−1))	−408.469	165.050	−2.474	0.068
D(CRW)	−0.627	0.215	−2.914	0.043
D(RET)	−0.212	0.043	−4.917	0.007
D(RET(−1))	−0.049	0.012	−3.840	0.018
D(RGDP)	0.923	0.196	4.706	0.009
D(RGDP(−1))	1.284	0.275	4.660	0.009
Long run Coefficient estimates				
CHM	0.164	0.104	1.575	0.190
REC	5.451	0.822	6.626	0.002
FFC	54.685	6.723	8.133	0.001
SQFFC	−188.814	24.042	−7.853	0.001
CRW	−4.361	0.824	−5.289	0.006
RET	−0.261	0.056	−4.652	0.009
RGDP	1.651	0.271	6.086	0.003

Note: * shows variable converge to equilibrium. CO_2: carbon emissions, CHM: chemical use, REC: renewable energy, FFC: fossil fuel consumption, SQFFC: square of FFC, CRW: combustible renewable waste, RET: renewable energy technology, and RGDP: real GDP.

CRW and carbon emissions have a negative and substantial link, both in the short and long term, suggesting that industrial waste management aids in lowering carbon emissions. Previous research by Anser et al. [92] and Sasmoko et al. [93] are referenced in this article. According to these findings, environmental policy should prioritize a green and inclusive ecological economy, swiftly implementing guiding principles and actions that lead to low-carbon energy. This method, which employs sustainable knowledge and chemical reactions to create ecological resources and a sustainable economy, also eliminates the sources of carbon emissions from the waste formation while recycling combustible refuse into clean and green energy.

Furthermore, long-term and short-term carbon emissions are positively and significantly related to GDP per capita. Adams [94], Raihan [95], Do [96], and Ali [97] confirmed the findings with the studied results). Based on the results of these analyses, it is feasible to decrease public and private sector demand for fossil fuels if technical progress is implemented to meet the expanding demand for renewable energy and bring down the cost of renewable energy. Table 7 shows the ARDL-Bounds estimate for ready reference.

Table 7. ARDL-Bounds Estimates.

Test Statistic	**Value**	**k**
F-statistic	10.084	7
Critical Value Bounds		
Significance	**I(0) Bound**	**I(1) Bound**
10%	1.70	2.83
5%	1.97	3.18
2.5%	2.22	3.49
1%	2.54	3.91

Source: Authors' Calculation.

The F-statistic value of 10.040 in the ARDL bound testing estimate, which is more than the upper limit critical value, indicates that a long-term connection does exist between the research variables. There is no evidence of heteroskedasticity in the model, according to the findings of the Breusch–Pagan–Godfrey Heteroskedasticity test and the other diagnostic tests included in Table 8. According to the Ramsey RESET test findings, the model is likely to remain stable for a considerable amount of time. The results of the Jarque–Bera normality test confirmed that the model is normally distributed when the significance threshold is set at 5% or above.

Table 8. Diagnostic Tests Estimates.

Heteroskedasticity Test: Breusch-Pagan-Godfrey				0.550
F-statistic	0.730	Prob. F(20, 3)	0.717	Accept Ho
Obs × R-squared	16.178	Prob. Chi-Square(20)	0.511	
Scaled explained SS	0.550	Prob. Chi-Square(20)	1.000	
Ramsey RESET Test				
	Value	d.f	Prob.	Accept Ho
F-statistic	2.248	3	0.110	
Likelihood ratio	5.053	(1, 3)	0.110	
Jarque-Bera normality test				Accept Ho
Jarque-Bera value		0.862		
Prob.		0.649		

Source: Authors' Calculation.

Figure 2 shows the results of the CUSUM and CUSUM square tests that found that the model is stable at a 5% significance level.

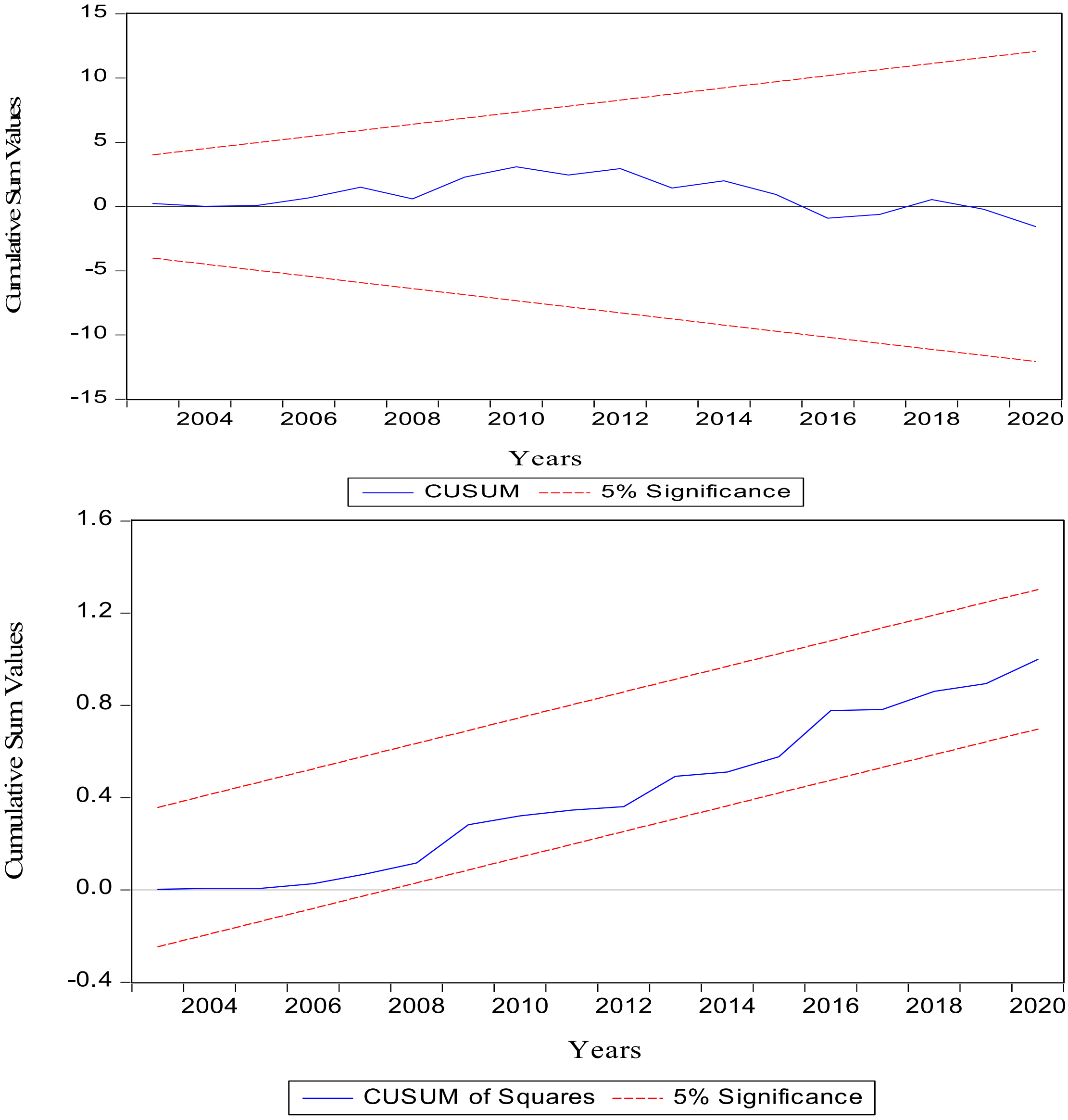

Figure 2. CUSUM and CUSUM Square Test Estimates. Source: Authors' calculation. Red line shows critical level, blue line shows target value, and black horizontal line shows the sigma value.

Figure 3 shows the stability of the recursive coefficients estimates for ready reference. The Granger causality test demonstrates the causation between the variables in Table 9 after the examination of diagnostic tests. There is a bidirectional causality between CHM and CO_2 emissions. Furthermore, a unidirectional causality exists between FFC, SQFFC, REC, CHM, and RGDP, and CO_2 emissions in a country. The results are consistent with the previous studies of Saidi and Omri [98], Yousaf et al. [99], Otim et al. [100], and Baz et al. [101]. Research deepens and broadens our knowledge of FFC and its relevance to long-term growth and recommends using clean technology, equipment, and energy sources to reduce carbon emissions. Countries should boost renewable energy generation while simultaneously eliminating subsidies to ensure environmental sustainability in the long run. As an additional step, we should speed up clean energy technology development, push for greater energy efficiency, and create robust institutions and human capacity to deal with environmental concerns. Moreover, there is unidirectional causation connecting CHM to REC, CHM to FFC, FFC to REC, SQFFC to RET, CRW to SQFFC, and RGDP to CRW. Finally, VDA estimates are presented in Table 10.

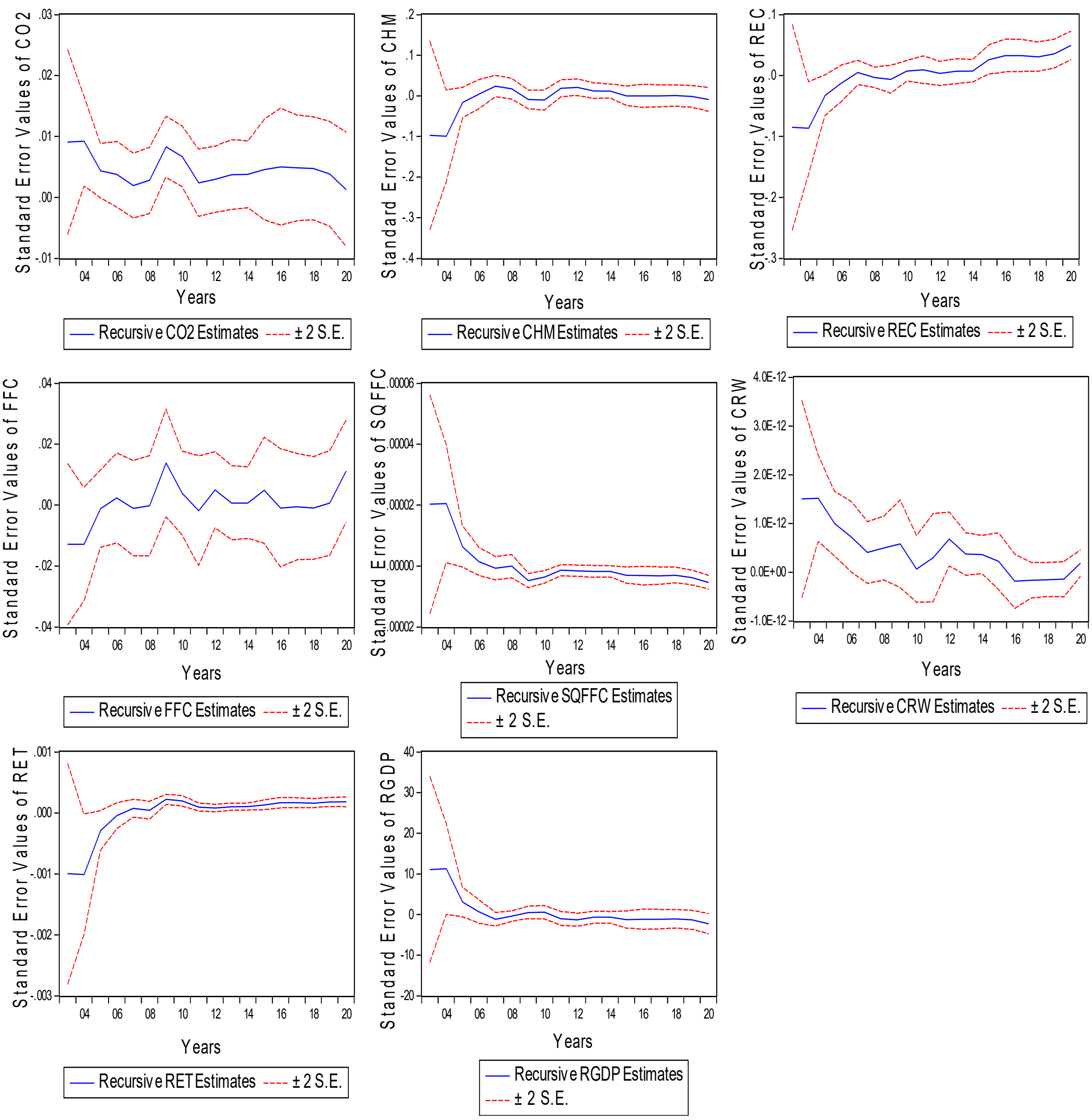

Figure 3. Recursive Coefficient Test Estimates. Source Authors' calculation. Note: Red lines show ±2 standard error shocks (2S.E.), while blue lines show recursive estimates.

Table 9. Granger Causality Estimates.

Null Hypothesis	F-Statistics	*p*-Value	Decision
CHM↔CO_2	7.716	0.003	Bidirectional causality
	3.142	0.006	
REC→CO_2	2.147	0.144	Neutral
FFC→CO_2	25.570	4×10^{-6}	Unidirectional causality
SQFFC→CO_2	25.575	4×10^{-6}	Unidirectional causality
CRW→CO_2	6.891	0.005	Unidirectional causality
RGDP→CO_2	0.557	0.581	Neutral
CHM→REC	3.791	0.041	Unidirectional causality

Table 9. *Cont.*

Null Hypothesis	F-Statistics	*p*-Value	Decision
CHM→FFC	6.551	0.006	Unidirectional causality
SQFFC→CHM	0.976	0.394	Neutral
CRW→CHM	0.336	0.718	Neutral
FFC→REC	15.163	0.000	Unidirectional causality
SQFFC→RET	15.805	9×10^{-5}	Unidirectional causality
SQFFC↔FFC	2.978	0.075	Bidirectional causality
	2.942	0.077	
CRW→FFC	11.572	0.000	Unidirectional causality
CRW→SQFFC	11.169	0.000	Unidirectional causality
RGDP→SQFFC	1.113	0.349	Neutral
RGDP→CRW	0.418	0.663	Neutral

Note: CO_2: carbon emissions, CHM: chemical use, REC: renewable energy, FFC: fossil fuel consumption, SQFFC: square of FFC, CRW: combustible renewable waste, RET: renewable energy technology, and RGDP: real GDP. ↔ isbidirectional, → isunidirectional.

Table 10. VDA Estimates.

Years	S.E.	CO_2	CHM	REC	FFC	SQFFC	CRW	RET	RGDP
2022	0.016	100	0	0	0	0	0	0	0
2023	0.025	78.198	7.208	4.291	8.438	0.379	1.281	0.201	1.58×10^{-10}
2024	0.029	60.875	24.057	3.542	6.652	2.743	1.919	0.209	2.24×10^{-10}
2025	0.037	38.191	46.689	4.871	7.093	1.702	1.177	0.272	1.69×10^{-10}
2026	0.044	29.588	52.556	5.538	5.128	1.974	4.643	0.570	2.96×10^{-10}
2027	0.051	28.005	55.509	4.091	4.585	1.848	5.281	0.677	2.95×10^{-10}
2028	0.059	32.738	52.797	3.509	3.536	1.448	5.271	0.697	2.68×10^{-10}
2029	0.065	36.920	49.335	3.342	2.896	1.279	5.548	0.677	2.55×10^{-10}
2030	0.071	38.982	48.417	2.848	2.595	1.234	5.272	0.649	2.34×10^{-10}
2031	0.077	41.874	46.360	2.556	2.316	1.107	5.157	0.628	2.21×10^{-10}

Note: CO_2 shows carbon emissions, CHM shows chemical use, REC shows renewable energy, FFC shows fossil fuel consumption, SQFFC shows the square of FFC, CRW shows combustible renewable waste, RET shows renewable energy technology, and RGDP shows real GDP.

With a variance of 46.360%, the findings indicated that CHM would likely have the greatest effect on carbon emissions, followed by CRW, REC, and FFC. Many factors will affect carbon emissions during the next decade, although RGDP will be the least affected.

5. Conclusions

The impact of chemicals, green energy consumption, consumption of fossil fuels consumption, industrial waste, energy technologies, and GDP per capita on India's carbon emissions are analyzed in this research spanning 1995Q1 to 2020Q4. A positive and statistically significant correlation between chemical use and CO_2 output was found in the investigation. Carbon emissions are positively correlated with the use of renewable energy sources. As with fossil fuels, using renewable energy sources increases pollution levels. Furthermore, the inverted U-shaped EKC theory is supported by the positive and substantial association between fossil fuel energy consumption and carbon emissions and the negative and significant relationship between square fossil fuel and carbon emissions in a nation. Furthermore, there is a positive and substantial association between GDP per capita and carbon emissions. In contrast, there is a negative and significant link between combustible renewable and waste and carbon emissions. Additionally, the relationship between chemical use and carbon emissions is not one-way but rather two-way. There is a clear correlation between fossil fuels, renewable energy, chemicals, GDP per capita, and the release of greenhouse gases. The research bolsters and broadens our knowledge of fossil fuel energy consumption and its relevance to sustainable development. It recommends using clean technology, equipment, and energy sources to decrease carbon emissions.

The following initiatives are proposed to clean up the Indian economy and protect the environment from carbon pollution:

- Establishment of a carbon emissions reduction framework to maintain environmental sustainability agenda:
    - In order to achieve the long-term objectives outlined in the Paris Agreement and the Sustainable Production Goals (SDGs), progress must be made in the area of renewable energy development, and this topic has been given special attention.
    - Raise public consciousness about the need to reduce reliance on fossil fuels and increase the use of renewable energy sources for the sake of protecting the environment and ensuring the planet's long-term existence, and
    - Create a flexible and adaptable program to help reduce carbon emissions and improve environmental conditions.
- Establishment of a renewable energy system and improve energy transition:
    - Make it possible for the public and commercial sectors to have ready access to cutting-edge renewable energy technologies at competitive rates, maximizing clean energy's efficacy.
    - Long-term environmental sustainability necessitates both an increase in the generation of renewable energy and a gradual reduction in government subsidies, and
    - Increasing environmental resilience via renewable power and cutting-edge eco-tech.
- Establishment of a technology innovation structure to curb the effect of fossil fuels carbon emissions as possible:
    - Expanding and comprehending the complexity of the technologies with the clean energy mix to achieve climatic and environmental objectives.
    - Reducing reliance on fossil fuels and other non-renewable sources may be achieved by well-planned and implemented policies.
    - Two ways that may aid people are benefiting the environment and lowering a country's reliance on fossil fuels, i.e., solar panel installation and green electricity, and
    - Carbon emissions from fossil fuels may be mitigated by increasing the use and production of renewable energy sources, including solar, hydroelectric, and wind power.

Incentives should be provided so businesses can quickly embrace alternative energy sources. This may be done by providing communities with funds to install renewable power-producing appliances, tariff credits for communities that increase their proportion of electricity consumption, or both. Additionally, increased public funding for energy R&D is needed to support eco-friendly innovations. A significant reduction in the price of clean energy sources is possible with creative thinking in this area. CO_2 emissions are decreased by the positive stimulation of scientific advances but are increased by the negative shock. Thus, spending more on science and technology via tech advancements will aid in introducing more ecologically and power-efficient tools and methodologies, thus reducing CO_2 emissions. More funding for digitalization necessitates the implementation of appropriate governmental measures.

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References

1. Rehman, A.; Ozcan, R.; Badshah, W.; Radulescu, M.; Ozturk, I. Symmetric and asymmetric impacts of commercial energy distri-bution from key sources on economic progress in Pakistan. *Sustainability* **2021**, *13*, 12670. [CrossRef]
2. Hanif, I. Impact of fossil fuels energy consumption, energy policies, and urban sprawl on carbon emissions in East Asia and the Pacific: A panel investigation. *Energy Strat. Rev.* **2018**, *21*, 16–24. [CrossRef]
3. Ocko, I.B.; Sun, T.; Shindell, D.; Oppenheimer, M.; Hristov, A.N.; Pacala, S.W.; Mauzerall, D.L.; Xu, Y.; Hamburg, S.P. Acting rapidly to deploy readily available methane mitigation measures by sector can immediately slow global warming. *Environ. Res. Lett.* **2021**, *16*, 054042. [CrossRef]
4. Chien, F.; Hsu, C.-C.; Ozturk, I.; Sharif, A.; Sadiq, M. The role of renewable energy and urbanization towards greenhouse gas emission in top Asian countries: Evidence from advance panel estimations. *Renew. Energy* **2022**, *186*, 207–216. [CrossRef]
5. Awan, U.; Sroufe, R. Interorganisational Collaboration for Innovation Improvement in Manufacturing Firms's: The Mediating Role of Social Performance. *Int. J. Innov. Manag.* **2019**, *24*, 20500498. [CrossRef]
6. Koval, V.; Olczak, P.; Vdovenko, N.; Boiko, O.; Matuszewska, D.; Mikhno, I. Ecosystem of Environmentally Sustainable Municipal Infrastructure in Ukraine. *Sustainability* **2021**, *13*, 10223. [CrossRef]
7. Depledge, J.; Saldivia, M.; Peñasco, C. Glass half full or glass half empty? The 2021 Glasgow Climate Conference. *Clim. Policy* **2022**, *22*, 147–157. [CrossRef]
8. PIB. *India's Stand at COP-26*; Press Information Bureau, Minister of State, Ministry of Environment, Forest & Climate Change: Delhi, India, 2022. Available online: https://pib.gov.in/PressReleasePage.aspx?PRID=1795071 (accessed on 1 October 2022).
9. IEA. Global Energy Review: CO2 Emissions in 2021. *Part of Global Energy Review, Flagship Report. March 2022.* Available online: https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2 (accessed on 30 September 2022).
10. Jeon, H. CO_2 emissions, renewable energy and economic growth in the US. *Electr. J.* **2022**, *35*, 107170. [CrossRef]
11. Zaman, K.; Aziz, A.R.A.; Sriyanto, S.; Sasmoko; Indrianti, Y.; Jambari, H. The role of solar energy demand in the relationship between carbon pricing and environmental degradation: A blessing in disguise. *J. Public Aff.* **2021**, e2702. [CrossRef]
12. Hanif, I.; Aziz, B.; Chaudhry, I.S. Carbon emissions across the spectrum of renewable and nonrenewable energy use in developing economies of Asia. *Renew. Energy* **2019**, *143*, 586–595. [CrossRef]
13. Rashid Khan, H.U.; Awan, U.; Zaman, K.; Nassani, A.A.; Haffar, M.; Abro, M.M. Assessing hybrid solar-wind potential for industrial decarbonization strategies: Global shift to green development. *Energies* **2021**, *14*, 7620. [CrossRef]
14. Koçak, E.; Ulucak, Z. The effect of energy R&D expenditures on CO_2 emission reduction: Estimation of the STIRPAT model for OECD countries. *Environ. Sci. Pollut. Res.* **2019**, *26*, 14328–14338. [CrossRef]
15. Musah, M.; Owusu-Akomeah, M.; Boateng, F.; Iddris, F.; Mensah, I.A.; Antwi, S.K.; Agyemang, J.K. Long-run equilibrium relationship between energy consumption and CO_2 emissions: A dynamic heterogeneous analysis on North Africa. *Environ. Sci. Pollut. Res.* **2021**, *29*, 10416–10433. [CrossRef] [PubMed]
16. Mentel, U.; Wolanin, E.; Eshov, M.; Salahodjaev, R. Industrialization and CO_2 Emissions in Sub-Saharan Africa: The Mitigating Role of Renewable Electricity. *Energies* **2022**, *15*, 946. [CrossRef]
17. Jiang, Q.; Rahman, Z.U.; Zhang, X.; Guo, Z.; Xie, Q. An assessment of the impact of natural resources, energy, institutional quality, and financial development on CO_2 emissions: Evidence from the B&R nations. *Resour. Policy* **2022**, *76*, 102716. [CrossRef]
18. Umar, M.; Ji, X.; Kirikkaleli, D.; Alola, A.A. The imperativeness of environmental quality in the United States transportation sector amidst biomass-fossil energy consumption and growth. *J. Clean. Prod.* **2020**, *285*, 124863. [CrossRef]
19. Apergis, N.; Jebli, M.B.; Youssef, S.B. Does renewable energy consumption and health expenditures decrease carbon dioxide emissions? Evidence for sub-Saharan Africa countries. *Renew. Energy* **2018**, *127*, 1011–1016. [CrossRef]
20. Rasoulinezhad, E.; Saboori, B. Panel estimation for renewable and non-renewable energy consumption, economic growth, CO2 emissions, the composite trade intensity, and financial openness of the commonwealth of independent states. *Environ. Sci. Pollut. Res.* **2018**, *25*, 17354–17370. [CrossRef]
21. Hu, H.; Xie, N.; Fang, D.; Zhang, X. The role of renewable energy consumption and commercial services trade in carbon dioxide reduction: Evidence from 25 developing countries. *Appl. Energy* **2018**, *211*, 1229–1244. [CrossRef]

22. Pata, U.K.; Samour, A. Do renewable and nuclear energy enhance environmental quality in France? A new EKC approach with the load capacity factor. *Prog. Nucl. Energy* **2022**, *149*, 104249. [CrossRef]
23. Murshed, M.; Saboori, B.; Madaleno, M.; Wang, H.; Doğan, B. Exploring the nexuses between nuclear energy, renewable energy, and carbon dioxide emissions: The role of economic complexity in the G7 countries. *Renew. Energy* **2022**, *190*, 664–674. [CrossRef]
24. Piłatowska, M.; Geise, A.; Włodarczyk, A. The Effect of Renewable and Nuclear Energy Consumption on Decoupling Economic Growth from CO_2 Emissions in Spain. *Energies* **2020**, *13*, 2124. [CrossRef]
25. Uzair Ali, M.; Gong, Z.; Ali, M.U.; Asmi, F.; Muhammad, R. CO_2 emission, economic development, fossil fuel consumption and population density in India, Pakistan and Bangladesh: A panel investigation. *Int. J. Financ. Econ.* **2022**, *27*, 18–31. [CrossRef]
26. Rehman, A.; Ma, H.; Ozturk, I.; Radulescu, M. Revealing the dynamic effects of fossil fuel energy, nuclear energy, renewable energy, and carbon emissions on Pakistan's economic growth. *Environ. Sci. Pollut. Res.* **2022**, *29*, 48784–48794. [CrossRef] [PubMed]
27. Adebayo, T.S. Environmental consequences of fossil fuel in Spain amidst renewable energy consumption: A new insights from the wavelet-based Granger causality approach. *Int. J. Sustain. Dev. World Ecol.* **2022**, *29*, 579–592. [CrossRef]
28. Jin, L.; Chang, Y.-H.; Wang, M.; Zheng, X.-Z.; Yang, J.-X.; Gu, J. The dynamics of CO_2 emissions, energy consumption, and economic development: Evidence from the top 28 greenhouse gas emitters. *Environ. Sci. Pollut. Res.* **2022**, *29*, 36565–36574. [CrossRef]
29. Dumor, K.; Li, Y.; Amouzou, E.K.; Ampaw, E.M.; Kursah, M.B.; Akakpo, K. Modeling the dynamic nexus among CO_2 emissions, fossil energy usage, and human development in East Africa: New insight from the novel DARDL simulation embeddedness. *Environ. Sci. Pollut. Res.* **2022**, *29*, 56265–56280. [CrossRef]
30. Li, B.; Haneklaus, N. The role of renewable energy, fossil fuel consumption, urbanization and economic growth on CO_2 emissions in China. *Energy Rep.* **2021**, *7*, 783–791. [CrossRef]
31. Hanif, I.; Raza, S.M.F.; Gago-De-Santos, P.; Abbas, Q. Fossil fuels, foreign direct investment, and economic growth have triggered CO_2 emissions in emerging Asian economies: Some empirical evidence. *Energy* **2019**, *171*, 493–501. [CrossRef]
32. Mensah, I.A.; Sun, M.; Gao, C.; Omari-Sasu, A.Y.; Zhu, D.; Ampimah, B.C.; Quarcoo, A. Analysis on the nexus of economic growth, fossil fuel energy consumption, CO_2 emissions and oil price in Africa based on a PMG panel ARDL approach. *J. Clean. Prod.* **2019**, *228*, 161–174. [CrossRef]
33. Gokmenoglu, K.K.; Sadeghieh, M. Financial development, CO_2 emissions, fossil fuel consumption and economic growth: The case of Turkey. *Strategy Plan Energy Environ.* **2019**, *38*, 7–28. [CrossRef]
34. Bandyopadhyay, A.; Rej, S. Can nuclear energy fuel an environmentally sustainable economic growth? Revisiting the EKC hypothesis for India. *Environ. Sci. Pollut. Res.* **2021**, *28*, 63065–63086. [CrossRef] [PubMed]
35. Kartal, M.T. The role of consumption of energy, fossil sources, nuclear energy, and renewable energy on environmental degradation in top-five carbon producing countries. *Renew. Energy* **2021**, *184*, 871–880. [CrossRef]
36. Ali, U.; Guo, Q.; Kartal, M.T.; Nurgazina, Z.; Khan, Z.A.; Sharif, A. The impact of renewable and non-renewable energy consumption on carbon emission intensity in China: Fresh evidence from novel dynamic ARDL simulations. *J. Environ. Manag.* **2022**, *320*, 115782. [CrossRef]
37. Jebli, M.B.; Belloumi, M. Investigation of the causal relationships between combustible renewables and waste consumption and CO_2 emissions in the case of Tunisian maritime and rail transport. *Renew. Sustain. Energy Rev.* **2017**, *71*, 820–829. [CrossRef]
38. Solarin, S.A.; Al-Mulali, U.; Gan, G.G.G.; Shahbaz, M. The impact of biomass energy consumption on pollution: Evidence from 80 developed and developing countries. *Environ. Sci. Pollut. Res.* **2018**, *25*, 22641–22657. [CrossRef]
39. Sun, C.; Ma, T.; Ouyang, X.; Wang, R. Does Service Trade Globalization Promote Trade and Low-Carbon Globalization? Evidence from 30 Countries. *Emerg. Mark. Financ. Trade* **2019**, *57*, 1455–1473. [CrossRef]
40. Larsen, A.W.; Fuglsang, K.; Pedersen, N.H.; Fellner, J.; Rechberger, H.; Astrup, T. Biogenic carbon in combustible waste: Waste composition, variability and measurement uncertainty. *Waste Manag. Res. J. Sustain. Circ. Econ.* **2013**, *31*, 56–66. [CrossRef]
41. Feng, R.; Shen, C.; Huang, L.; Tang, X. Does trade in services improve carbon efficiency?—Analysis based on international panel data. *Technol. Forecast. Soc. Chang.* **2021**, *174*, 121298. [CrossRef]
42. Sun, L.; Fujii, M.; Tasaki, T.; Dong, H.; Ohnishi, S. Improving waste to energy rate by promoting an integrated municipal solid-waste management system. *Resour. Conserv. Recycl.* **2018**, *136*, 289–296. [CrossRef]
43. Ibrahim, K.H.; Sari, D.W.; Handoyo, R.D. Environmental Impact of Services Trade: New Evidence from African Countries. *Pol. J. Environ. Stud.* **2021**, *30*, 134294. [CrossRef]
44. Longe, A.E.; Omitogun, O.; Adelokun, O.O.; Adebayo, E.O.; Muhammad, S. The Impact of Trade and Transport Services on the En-vironment in Africa. *Econ. Them.* **2020**, *58*, 415–439. [CrossRef]
45. Batool, Z.; Raza, S.M.F.; Ali, S.; Abidin, S.Z.U. ICT, renewable energy, financial development, and CO_2 emissions in developing countries of East and South Asia. *Environ. Sci. Pollut. Res.* **2022**, *29*, 35025–35035. [CrossRef] [PubMed]
46. Sahoo, M.; Sahoo, J. Effects of renewable and non-renewable energy consumption on CO_2 emissions in India: Empirical evidence from disaggregated data analysis. *J. Public Aff.* **2020**, *22*, 2307. [CrossRef]
47. Karakurt, I.; Aydin, G. Development of regression models to forecast the CO_2 emissions from fossil fuels in the BRICS and MINT countries. *Energy* **2022**, *263*, 125650. [CrossRef]
48. Filipović, S.; Lior, N.; Radovanović, M. The green deal—Just transition and sustainable development goals Nexus. *Renew. Sustain. Energy Rev.* **2022**, *168*, 112759. [CrossRef]

49. Vieira, L.C.; Longo, M.; Mura, M. From carbon dependence to renewables: The European oil majors' strategies to face climate change. *Bus. Strat. Environ.* **2022**. [CrossRef]
50. Demekas, D.; Grippa, P. Walking a tightrope: Financial regulation, climate change, and the transition to a low-carbon economy. *J. Financ. Regul.* **2022**, *8*, 203–229. [CrossRef]
51. Lal, S.R.S.; Herbert, G.M.J.; Arjunan, P.; Suryan, A. Advancements in renewable energy transition in India: A review. *Energy Sources Part A Recover. Util. Environ. Eff.* **2022**, 1–31. [CrossRef]
52. Singh, U.; Rizwan, M.; Malik, H.; García Márquez, F.P. Wind energy scenario, success and initiatives towards renewable energy in India—A review. *Energies* **2022**, *15*, 2291. [CrossRef]
53. Shuai, J.; Zhao, Y.; Wang, Y.; Cheng, J. Renewable energy product competitiveness: Evidence from the United States, China and India. *Energy* **2022**, *249*, 123614. [CrossRef]
54. Ma, Q.; Tariq, M.; Mahmood, H.; Khan, Z. The nexus between digital economy and carbon dioxide emissions in China: The moderating role of investments in research and development. *Technol. Soc.* **2022**, *68*, 101910. [CrossRef]
55. Sun, Y.; Guan, W.; Razzaq, A.; Shahzad, M.; An, N.B. Transition towards ecological sustainability through fiscal decentralization, renewable energy and green investment in OECD countries. *Renew. Energy* **2022**, *190*, 385–395. [CrossRef]
56. Kurramovich, K.K.; Abro, A.A.; Vaseer, A.I.; Khan, S.U.; Ali, S.R.; Murshed, M. Roadmap for carbon neutrality: The mediating role of clean energy development-related investments. *Environ. Sci. Pollut. Res.* **2022**, *29*, 34055–34074. [CrossRef] [PubMed]
57. Mohan, S.; Joseph, C.P. Potential Hazards due to Municipal Solid Waste Open Dumping in India. *J. Indian Inst. Sci.* **2021**, *101*, 523–536. [CrossRef]
58. Sharma, P.; Dutta, D.; Udayan, A.; Kumar, S. Industrial wastewater purification through metal pollution reduction employing microbes and magnetic nanocomposites. *J. Environ. Chem. Eng.* **2021**, *9*, 106673. [CrossRef]
59. Frondel, M.; Schmidt, C.M. Measuring Energy Security—A Conceptual Note. Ruhr Economic Paper No. 52. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1161141 (accessed on 6 October 2022).
60. Lefèvre, N. Measuring the energy security implications of fossil fuel resource concentration. *Energy Policy* **2010**, *38*, 1635–1644. [CrossRef]
61. Jansen, J.C.; Arkel, W.V.; Boots, M.G. Designing Indicators of Long-Term Energy Supply Security. 2004. Available online: https://repository.tudelft.nl/islandora/object/uuid:6a0ed336-11f0-407e-9395-dd06be6b7c46/datastream/URL/download (accessed on 6 October 2022).
62. Stern, P.C. Information, Incentives, and Proenvironmental Consumer Behavior. *J. Consum. Policy* **1999**, *22*, 461–478. [CrossRef]
63. Davis, F.D. A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results. Ph.D. Thesis, Massachusetts Institute of Technology, Cambridge, MA, USA, 1985.
64. *World Development Indicators*; World Bank: Washington, DC, USA, 2022.
65. Pesaran, M.H.; Shin, Y. An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. 1995. Available online: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.153.3246&rep=rep1&type=pdf (accessed on 6 October 2022).
66. Pesaran, M.H.; Shin, Y.; Smith, R.J. *Testing for the Existence of a Long-Run Relationship*; Faculty of Economics, University of Cambridge: Cambridge, UK, 1996.
67. Pesaran, M.H.; Shin, Y.; Smith, R.J. Bounds testing approaches to the analysis of level relationships. *J. Appl. Econom.* **2001**, *16*, 289–326. [CrossRef]
68. Nakhli, M.S.; Shahbaz, M.; Ben Jebli, M.; Wang, S. Nexus between economic policy uncertainty, renewable & non-renewable energy and carbon emissions: Contextual evidence in carbon neutrality dream of USA. *Renew. Energy* **2021**, *185*, 75–85. [CrossRef]
69. Sheraz, M.; Deyi, X.; Mumtaz, M.Z.; Ullah, A. Exploring the dynamic relationship between financial development, renewable energy, and carbon emissions: A new evidence from belt and road countries. *Environ. Sci. Pollut. Res.* **2021**, *29*, 14930–14947. [CrossRef] [PubMed]
70. Adebayo, T.S.; Rjoub, H.; Akinsola, G.D.; Oladipupo, S.D. The asymmetric effects of renewable energy consumption and trade openness on carbon emissions in Sweden: New evidence from quantile-on-quantile regression approach. *Environ. Sci. Pollut. Res.* **2021**, *29*, 1875–1886. [CrossRef] [PubMed]
71. Tan, H.; Iqbal, N.; Wu, Z. Evaluating the impact of stakeholder engagement for renewable energy sources and economic growth for CO_2 emission. *Renew. Energy* **2022**, *198*, 999–1007. [CrossRef]
72. Ali, S.; Akter, S.; Ymeri, P.; Fogarassy, C. How the Use of Biomass for Green Energy and Waste Incineration Practice Will Affect GDP Growth in the Less Developed Countries of the EU (A Case Study with Visegrad and Balkan Countries). *Energies* **2022**, *15*, 2308. [CrossRef]
73. Ben Jebli, M.; Ben Youssef, S. Combustible renewables and waste consumption, agriculture, CO_2 emissions and economic growth in Brazil. *Carbon Manag.* **2019**, *10*, 309–321. [CrossRef]
74. Leitão, N.C.; Lorente, D.B. The Linkage between Economic Growth, Renewable Energy, Tourism, CO_2 Emissions, and International Trade: The Evidence for the European Union. *Energies* **2020**, *13*, 4838. [CrossRef]
75. Aydoğan, B.; Vardar, G. Evaluating the role of renewable energy, economic growth and agriculture on CO_2 emission in E7 countries. *Int. J. Sustain. Energy* **2020**, *39*, 335–348. [CrossRef]
76. Zhao, Y.; Qiu, J.; Xing, J.; Sun, X. Chemical activation of binary slag cement with low carbon footprint. *J. Clean. Prod.* **2020**, *267*, 121455. [CrossRef]

77. Wei, G.; Deng, L.; Yuan, H.; Yang, X.; Huang, Z.; Zheng, A.; Xu, L. Enhanced chemical looping gasification of biomass coupled with CO_2 splitting based on carbon negative emission. *Energy Convers. Manag.* **2022**, *260*, 115597. [CrossRef]
78. Costa, F.; Ribeiro, D. Reduction in CO_2 emissions during production of cement, with partial replacement of traditional raw materials by civil construction waste (CCW). *J. Clean. Prod.* **2020**, *276*, 123302. [CrossRef]
79. Zheng, Y.; Yang, H.; Huang, J.; Cui, Q.; Zhan, J. Industrial agglomeration measured by plants' distance and CO_2 emissions: Evidence from 268 Chinese prefecture-level cities. *Technol. Forecast. Soc. Chang.* **2022**, *176*, 121469. [CrossRef]
80. Khochiani, R.; Nademi, Y. Energy consumption, CO2 emissions, and economic growth in the United States, China, and India: A wavelet coherence approach. *Energy Environ.* **2020**, *31*, 886–902. [CrossRef]
81. Usman, O.; Akadiri, S.S.; Adeshola, I. Role of renewable energy and globalization on ecological footprint in the USA: Implications for environmental sustainability. *Environ. Sci. Pollut. Res.* **2020**, *27*, 30681–30693. [CrossRef] [PubMed]
82. Nguyen, K.H.; Kakinaka, M. Renewable energy consumption, carbon emissions, and development stages: Some evidence from panel cointegration analysis. *Renew. Energy* **2018**, *132*, 1049–1057. [CrossRef]
83. Nawaz, M.A.; Hussain, M.S.; Kamran, H.W.; Ehsanullah, S.; Maheen, R.; Shair, F. Trilemma association of energy consumption, carbon emission, and economic growth of BRICS and OECD regions: Quantile regression estimation. *Environ. Sci. Pollut. Res.* **2020**, *28*, 16014–16028. [CrossRef]
84. Shao, X.; Zhong, Y.; Liu, W.; Li, R.Y.M. Modeling the effect of green technology innovation and renewable energy on carbon neutrality in N-11 countries? Evidence from advance panel estimations. *J. Environ. Manag.* **2021**, *296*, 113189. [CrossRef]
85. Chien, F.; Ajaz, T.; Andlib, Z.; Chau, K.Y.; Ahmad, P.; Sharif, A. The role of technology innovation, renewable energy and globali-zation in reducing environmental degradation in Pakistan: A step towards sustainable environment. *Renew. Energy* **2021**, *177*, 308–317. [CrossRef]
86. Shan, S.; Genç, S.Y.; Kamran, H.W.; Dinca, G. Role of green technology innovation and renewable energy in carbon neutrality: A sustainable investigation from Turkey. *J. Environ. Manag.* **2021**, *294*, 113004. [CrossRef]
87. Khan, Z.; Ali, S.; Umar, M.; Kirikkaleli, D.; Jiao, Z. Consumption-based carbon emissions and International trade in G7 countries: The role of Environmental innovation and Renewable energy. *Sci. Total Environ.* **2020**, *730*, 138945. [CrossRef]
88. Rani, T.; Wang, F.; Rauf, F.; Ain, Q.U.; Ali, H. Linking personal remittance and fossil fuels energy consumption to environmental degradation: Evidence from all SAARC countries. *Environ. Dev. Sustain.* **2022**, 1–22. [CrossRef]
89. Ali, M.U.; Zhimin, G.; Asmi, F.; Xue, Z.; Muhammad, R. The nexus between environmental degradation and industrial development in Pakistan and roles of financial development and fossil fuel. *Environ. Prog. Sustain. Energy* **2021**, *40*, e13621. [CrossRef]
90. Işık, C.; Ongan, S.; Özdemir, D. Testing the EKC hypothesis for ten US states: An application of heterogeneous panel estimation method. *Environ. Sci. Pollut. Res.* **2019**, *26*, 10846–10853. [CrossRef] [PubMed]
91. Raza, S.M.; Ali, I.; Malik, M.Y.; Ahmad, M.; Abidin, S.Z.; Masood, S. Renewable Energy Consumption Towards Environmental Sustainability: Evidence OfEkc Hypothesis in The Framework of Economic Growth and CO_2 Emissions. *PalArch's J. Archaeol. Egypt Egyptol.* **2022**, *19*, 1238–1253.
92. Anser, M.K.; Khan, M.A.; Nassani, A.A.; Aldakhil, A.M.; Voo, X.H.; Zaman, K. Relationship of environment with technological innovation, carbon pricing, renewable energy, and global food production. *Econ. Innov. New Technol.* **2020**, *30*, 807–842. [CrossRef]
93. Sasmoko; Zaman, K.; Malik, M.; Awan, U.; Handayani, W.; Jabor, M.K.; Asif, M. Environmental Effects of Bio-Waste Recycling on Industrial Circular Economy and Eco-Sustainability. *Recycling* **2022**, *7*, 60. [CrossRef]
94. Adams, S.; Nsiah, C. Reducing carbon dioxide emissions; Does renewable energy matter? *Sci. Total Environ.* **2019**, *693*, 133288. [CrossRef] [PubMed]
95. Raihan, A.; Tuspekova, A. Toward a sustainable environment: Nexus between economic growth, renewable energy use, forested area, and carbon emissions in Malaysia. *Resour. Conserv. Recycl. Adv.* **2022**, *15*, 200096. [CrossRef]
96. Do, T.V.T.; Dinh, H.L. Short-and long-term effects of GDP, energy consumption, FDI, and trade openness on CO_2 emissions. *Accounting* **2020**, *6*, 365–372. [CrossRef]
97. Ali, S.S.S.; Razman, M.R.; Awang, A. The Nexus of Population, Gdp Growth, Electricity Generation, Electricity Consumption and Carbon Emissions Output in Malaysia. *Int. J. Energy Econ. Policy* **2020**, *10*, 84–89. [CrossRef]
98. Saidi, K.; Omri, A. The impact of renewable energy on carbon emissions and economic growth in 15 major renewable ener-gy-consuming countries. *Environ. Res.* **2020**, *186*, 109567. [CrossRef]
99. Yousaf, U.S.; Ali, F.; Aziz, B.; Sarwar, S. What causes environmental degradation in Pakistan? Embossing the role of fossil fuel energy consumption in the view of ecological footprint. *Environ. Sci. Pollut. Res.* **2022**, *29*, 33106–33116. [CrossRef] [PubMed]
100. Otim, J.; Watundu, S.; Mutenyo, J.; Bagire, V. Fossil Fuel Energy Consumption, Economic Growth, Urbanization, and Carbon Dioxide Emissions in Kenya. Available online: https://assets.researchsquare.com/files/rs-1461171/v1_covered.pdf?c=1648824634 (accessed on 6 October 2022).
101. Baz, K.; Deyi, X.; Ali, H.; Khan, U.; Cheng, J.; Abbas, K.; Ali, I. Nexus of minerals-technology complexity and fossil fuels with carbon dioxide emission: Emerging Asian economies based on product complexity index. *J. Clean. Prod.* **2022**, *373*, 133703. [CrossRef]