Balancing Economic Growth and Environmental sustainability in India

Aamir Ahmad Teeli*

Doctoral Fellow, Department of Economics, Central University of Tamil Nadu, Tiruvarur India, 610001

E-mail: imamireconomics@gmail.com

Syed Rizwana Qadri

Email: syedrizwana84@gmail.com

Doctoral Fellow, Department of Economics, Lovely Professional University, Phagwara Punjab India

Abstract

This study delves into the intricate relationship between environmental sustainability and economic prosperity in India, analyzing multi-dimensional data from 2012 to 2023. Despite efforts to diversify energy sources, fossil fuels remain integral to India's energy mix, driving industrial development and economic growth while contributing to environmental degradation. The analysis reveals significant success in terms of achieving lower carbon emission levels. However there are some moments of disconnect between economic growth and environmental impact, underscoring the potential for sustainable development strategies. Regulatory frameworks supporting renewable energy and energy efficiency emerge as critical avenues for balancing economic growth with environmental stewardship. However, the study acknowledges limitations, including reliance on publicly available data, omission of socioeconomic and policy factors, and the limited study period. Despite these constraints, the study emphasizes the urgency of addressing India's dual goals of environmental sustainability and economic growth through integrated strategies and innovative partnerships, ensuring India's leadership in climate action and sustainable development.

Keywords: India, Sustainable Growth, Carbon Emissions, Environment.

Introduction

The dynamic nature of the global business environment has led enterprises to recognize the significance of preserving a balance between expansion and sustainability (Ahmad et, al, 2016). It is crucial for countries like India to set the course for a sustainable business environment as climate change takes center stage in the sustainability debate. India is leading the way in the net zero revolution right now, using sustainable growth as its compass (Alam et.al, 2011). India has set high standards for sustainable development as a result of its amazing economic growth, which has seen it move from the 13th to the fifth largest economy in the world. India's economy, one of the fastest-growing in the world, is at a crossroads where the need for environmental sustainability must coexist with the goal of economic growth (Ali & Khung, 2015). The nation faces tremendous challenges in striking a balance between its economic aspirations and the preservation of its natural resources and ecosystems due to its rapidly growing population, fast urbanization, and industrialization (Zubair et, al, 2020). India's economy has grown remarkably in the last few decades, bringing millions out of poverty and making it a major player on the world stage. But the environment has paid a heavy price for this growth, with pollution, deforestation, biodiversity loss, and the effects of climate change to name a few (Balaguer & Cantvella, 2016).

The need to address environmental degradation is becoming more and more urgent, as demonstrated by extreme weather events, water scarcity, and declining air quality. Furthermore, millions of Indians are in danger due to rising sea levels, altered weather patterns, and disruptions to agriculture as a result of climate change (cole, 2004). India is extremely vulnerable to these effects. Given these difficulties, policymakers, corporations, and civil society are coming to the realisation that sustainable development is not only desirable but also essential to India's long-term prosperity and well-being (Aergis, 2016). In India, the idea of sustainable development which aims to meet present needs without compromising the ability of future generations to meet their own needs is central to the conversation about striking a balance between economic growth and environmental sustainability (Ghosh & Kanjilal, 2014). This means promoting inclusive growth, guaranteeing fair access to opportunities and resources, and incorporating economic, social, and environmental factors into decision-making processes (Kaya & Yokobari, 1993; Hanif et, al, 2019). A paradigm change in our conception and pursuit of growth is necessary to achieve sustainable development; we must abandon the conventional model of resource exploitation in favour of a more comprehensive and regenerative strategy (Yeh, 2017; Zhang et, al, 2009).

India has been advancing environmental sustainability through technological innovation, public-private partnerships, and policy interventions. Government efforts to address environmental issues and promote sustainable practices are exemplified by programmes like the Clean India Campaign, Swachh Bharat Mission, and National Action Plan on Climate Change (Dinda, 2004). In addition, the nation's carbon footprint is being reduced as it moves towards a low-carbon economy through the use of green technologies, energy efficiency initiatives, and the adoption of renewable energy sources (Elen et.al, 2019; Heidari et.al, 2014). But in order to actually implement these promises, a number of obstacles must be removed, such as low institutional capacity, lax regulatory enforcement, and socioeconomic inequality (Zaman et.al, 2012). Moreover, addressing more general development objectives like poverty reduction, access to healthcare, and education cannot be separated from the pursuit of environmental sustainability (Zhang, 2018). Therefore, navigating the complex interplay between environmental conservation and economic growth requires a comprehensive and integrated approach (De bryun & Heintz, 2002). In India, achieving both environmental sustainability and economic growth is a complex task that calls for cooperation from all parties involved. India can pave the way for a future that is more resilient, inclusive, and environmentally sustainable by embracing the principles of sustainable development, utilizing technological advancements, and cultivating partnerships (Dasgupta & Laplante, 2002). In the Indian context, important tactics, policy interventions, and best practices for achieving the twin goals of environmental stewardship and economic prosperity are of utmost importance (Dean, J.M, 2004; Dinda, 2004; Granger, 1988).

In the back drop of this we try to examine the various environmental and economic dynamics of India to have insights about India’s current positions and future challenges in balancing between sustainable environment and sustainable economic growth. We particularly evaluate coal, oil, and natural gas…….. consumptions in India's patterns of energy consumption during the study period.

Rest of the study is …….

1. Review of literature

The relationship between environmental degradation and economic growth has drawn more attention in the past few decades. Despite the fact that this relationship has been documented in literature, it is still unclear what causes what and in which direction.

Energy, expansion and development of the economy have always been closely related. Nevertheless, the process has not sufficiently addressed the negative externalities linked to energy consumption. One of the main obstacles to sustainable development is adverse externalities. Without a doubt, the biggest obstacle to sustainable development is climate change brought on by human-caused global warming. If climate change is not controlled, it has the potential to halt the advancement of development and jeopardise the safety and security of both current and future generations. The warmest 30-year span in the Northern Hemisphere occurred between 1983 and 2012, according to the IPPC's Fifth Assessment Report (AR5). Since industrialization, the concentration of CO2, CH4, and nitrous oxide has increased, which is the main cause of it. Actually, compared to the mid-1800s, the concentration of CO2 in 2012 was 40% higher.

In 2016, Balaguer and Cantavella conducted a structural analysis of Spain's EKC for the years 1874–2011. Real oil prices are used in the research paper as a gauge for changes in fuel energy consumption. Both in the short and long terms, the EKC hypothesis is supported by the evidence. The hypothesis that variations in real oil prices are significant in explaining CO2 emissions is further supported by empirical findings. They note that Spain's CO2 emissions decrease by 0.4% for every 1% increase in oil prices. In an EKC framework for Turkey, Boluk and Mert (2015) offer empirical support for the potential of renewable energy. The relationship between income, carbon emissions, and the amount of electricity produced from renewable energy sources has been examined for the years 1961–2010 using the ARDL approach. The authors' analysis leads them to the conclusion that per capita emissions and per capita real income have an inverted U-shaped relationship, which supports the EKC hypothesis over the long and short terms. In their 2015 study, Jelbi and Youssef examine the dynamic causal relationships that exist between trade, economic growth, CO2 emissions, and the consumption of renewable and non-renewable energy in Tunisia between 1980 and 2009. The authors note that while the inverted U-shaped EKC hypothesis is supported in the short term, the EKC hypothesis is not supported in the long run. When it comes to trade, per capita CO2 emissions are positively impacted by both imports and exports. In order to examine the relationship between CO2, energy consumption, economic growth, trade liberalisation, and population density in Pakistan, Ahmed and Long (2012) hypothesised EKC.

An ARDL model approach is used in the study for the 1971–2009 sample period. The study's two main conclusions are as follows: first, there is no evidence to support the existence of EKC in the short run, despite an inverted U-shaped relationship between

variables over the long term. Second, trade liberalisation only temporarily enhances the environment. Furthermore, it has been estimated that Pakistan's high population density contributes to environmental degradation.

Tiwari et al. (2013) use trade openness and coal consumption to test the EKC hypothesis for the Indian economy. The research uses an ARDL model for the years 1966–2009, and Johansen cointegration is used to support the findings. The authors conclude that EKC is present in both the short- and long-terms based on their analysis. Moreover, over time, trade openness and coal consumption both increase carbon emissions. Holtz-Eakin and Selden (1995) used a panel data model for 130 countries over the years 1951– 1986. According to their findings, there may be evidence of a declining marginal propensity to emit CO2 as economies grow. Furthermore, the forecast results show that CO2 emissions worldwide will keep rising at a 1.8% annual rate. Using fully modified ordinary least squares, quantile estimation techniques, and common correlated effects, Apergis (2016) evaluates the "emission-income" relationship in the EKC hypothesis. The data from 1960 to 2013 is used in the analysis for 15 countries. The study's findings show that, in most of the 15 countries, there is a nonlinear relationship between emissions per person and per capita personal income. Li and colleagues (2016) use panel data covering the years 1996–2012 to calculate the effects of economic urbanisation, trade openness, energy consumption, and development on carbon dioxide, Emissions of solid waste and liquid waste for 28 Chinese provinces. The broad approach to moments estimate (GMM) estimator and both long- and short-term ARDL estimates support the EKC hypothesis for the following three major pollutants: carbon dioxide, Emissions from industrial waste solid and water in China. The outcomes additionally show that urbanisation and trade openness eventually result in environmental degradation (estimates are negligible in the near term) in China, albeit the severity varies across various emissions of pollutants.

2. Data and Methodology

The methodology adopted in this chapter is descriptive examination of real-time data, aiming to offer insights into the dynamics of sustainability and economic growth dynamics. The chapter provides overview about the existing statistics as well as trends of economic growth and environmental indicators thereby providing insights for better understanding the current scenario. Real-time data, on……. Has been collected from…….. Graphical representations and tables are utilized to present the data visually, facilitating intuitive

interpretation of trends and patterns. Emphasizing its purely descriptive nature, this methodology enables a nuanced exploration of environment and economic growth trade-off, enriching the discourse with empirical evidence grounded in theoretical underpinnings.

Discussion on Indian Dynamics

India's energy consumption is a key determinant of the country's industrial growth, economic activity, and overall development trajectory. Gaining an understanding of the country's energy landscape and its consequences for environmental sustainability can be achieved by analysing the trends and patterns of energy consumption, including the sources that are used. We analyse India's energy consumption from 2012 to 2023 in this section, highlighting important energy sources like coal, oil, gas, nuclear, and hydroelectric power.

The trends and patterns in the use of various energy sources over the given time period are described in the sections that follow.

Coal: In India, coal continues to be the primary energy source, contributing significantly to the nation's overall energy consumption. The demand for coal has been steadily increasing over the last ten years, mostly due to the power generation and industrial sectors. Because of its abundance and relative affordability, coal continues to be a major source of energy for India, even in the face of efforts to diversify the energy mix and promote cleaner alternatives. But using coal so much creates issues with greenhouse gas emissions, air pollution, and environmental damage, which emphasises how critical it is to switch to greener energy sources.

Oil: Over the period under review, India's oil consumption has also increased, driven by the country's rapidly growing transportation sector, industrial activities, and urbanisation. Being one of the world's biggest consumers of crude oil, India is extremely vulnerable to changes in the price of oil globally as well as geopolitical events. The substantial reliance on oil presents problems for energy security and sustainability even with efforts to improve energy efficiency and support alternative fuels like renewable energy and natural gas. Reducing reliance on fossil fuels and promoting cleaner technologies are key to mitigating the negative environmental effects of oil consumption, such as carbon emissions and air pollution.

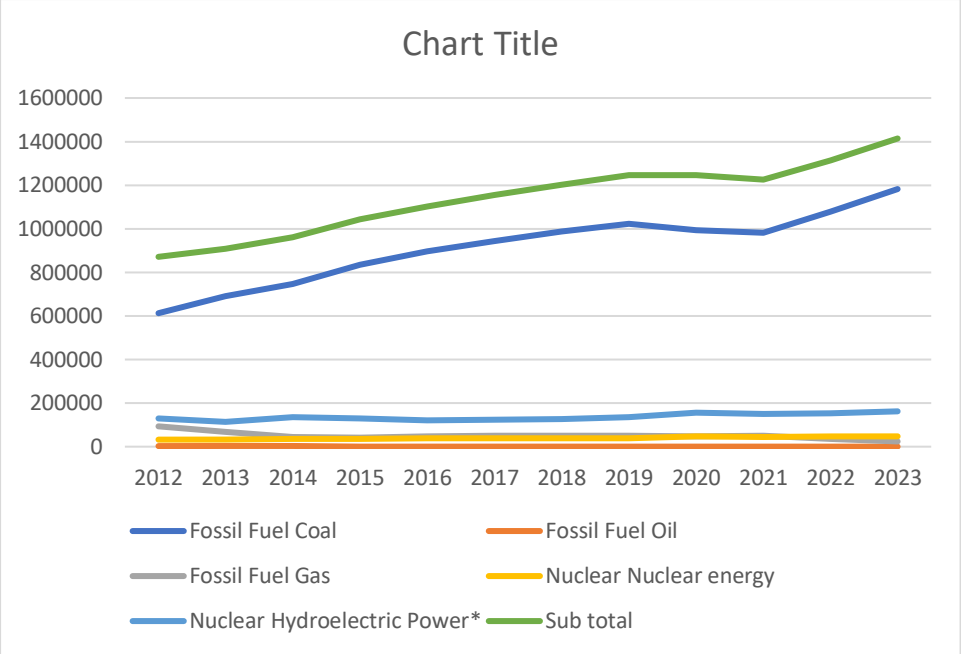
Natural Gas: India's natural gas consumption has increased significantly in recent years due to government initiatives to improve energy security, encourage cleaner energy alternatives, and expand gas infrastructure. Technological advancements, investment incentives, and

policy reforms have made it easier for natural gas to be adopted in a variety of sectors, such as transportation, fertilisers, and power generation. The widespread use of natural gas as a primary energy source is still hampered by issues like supply chain disruptions, pricing reforms, and infrastructure limitations. In order to achieve energy diversification and sustainability goals, it is critical to address these issues and fully utilise natural gas's potential to supplement renewable energy sources and lower carbon emissions.

Nuclear Energy: India's energy mix includes a small but noteworthy amount of nuclear energy, which helps the nation meet its goals for energy security and electricity generation. Through domestic technological development and international partnerships, India has advanced its nuclear power capacity despite regulatory obstacles, safety worries, and public apprehensions. The government's drive for sustainable and dependable energy sources has improved the outlook for nuclear energy, even though there are still discussions about its long-term viability, waste management, and cost-effectiveness. In India's energy policy discourse, striking a balance between the possible advantages of nuclear power and the risks and difficulties it entails continues to be a topic of examination and discussion.

Hydroelectric power: In India, hydroelectric power uses the nation's plentiful water resources to generate electricity, making it a sustainable and green energy source. Hydroelectric power has its own benefits, but interstate water disputes, environmental concerns, and land acquisition problems have hindered its growth. Even so, India's energy portfolio still heavily relies on hydroelectric projects, especially in areas with potential for rivers and high rainfall. Incorporating innovative technologies and prioritising sustainable development principles can augment the impact of hydroelectric power on India's energy security and mitigation of climate change.

Figure 1:



Throughout the period, there is a general upward trend in the consumption of coal, with a notable increase from 2012 to 2023. The fact that consumption almost doubled between 2012 and 2023 suggests that coal will remain India's main energy source. Over the years, oil consumption has shown comparatively steady levels with only slight variations. From 2012 to 2015, there is a small decline in consumption, which is then gradually increased in the years that follow. The amount of natural gas consumed varies noticeably over time. After reaching its peak in 2012, consumption fluctuated for the rest of the period before slightly declining at the end. The consumption of nuclear energy has been steadily rising over time, suggesting that it is becoming a larger part of the energy mix. Between 2012 and 2023, consumption almost doubled due to increases in nuclear power capacity. The amount of hydroelectric power used varies over time due to various factors like water availability and rainfall patterns. The amount consumed peaked in some years (like 2015 and 2020) and fluctuated slightly in other years.

The visualization of data shows how India's energy sector is changing, with a combination of conventional and renewable energy sources over the period of 2012-2023. Even though coal still dominates the energy mix, efforts to diversify it are visible in the steady contribution of hydroelectric power and the steady rise in nuclear energy consumption. Furthermore, variations in natural gas consumption point to difficulties in its broad adoption, possibly as a result of dynamics in pricing or supply. Policymakers and other stakeholders must

comprehend these consumption patterns in order to create policies that support resilience, sustainability, and energy security in India's energy infrastructure.

Sector-Wise examination of Fossil Fuels, Nuclear, and Hydroelectric Energy Consumption in India (2012-2023)

Evaluating the energy use's effects on the environment and socioeconomic ramifications requires an understanding of the sectoral distribution of energy consumption. In India, the use of nuclear and hydroelectric power in addition to fossil fuels (coal, oil, and natural gas) varies depending on the sectordomestic, industrial, commercial, and agricultural. A thorough understanding of the nation's energy demand dynamics, energy security issues, and prospects for advancing sustainable development can be gained by examining the trends and patterns of energy consumption within each sector. This section will examine India's sector-by-sector consumption of nuclear, hydroelectric, and fossil fuel energy from 2012 to 2023, illuminating the various factors that influence and are impacted by energy use in important economic sectors.

Domestic consumption:

There has been a slight increase in domestic energy consumption over time, which suggests that household activities are requiring more energy. Although there have been some fluctuations, the general trend points to a gradual increase in domestic energy consumption, which is probably due to rising living standards, urbanisation, and population growth.

Commercial consumption:

Between 2012 and 2023, there will be fluctuations in the amount of energy used in businesses, but overall, this will be a decrease. Changes in business practices aimed at lowering energy usage in commercial establishments, efficiency improvements, and technological advancements could all be contributing factors to the decline in commercial energy consumption.

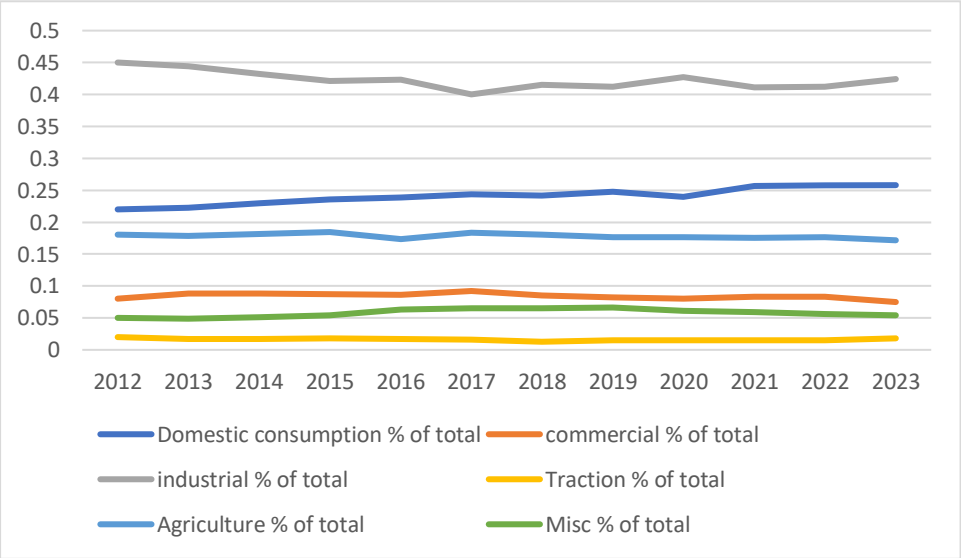
Industrial consumption: Over the period, there is no discernible trend in the industrial energy consumption; instead, there are fluctuations. A number of variables, including economic activity, industrial output, and the energy-efficiency initiatives implemented by various industries, may have an impact on variations in industrial energy consumption.

Traction: With only small variations over time, traction energy consumption is largely constant. The transportation and railway industries are the main users of traction energy, and the industry's stable demand may be indicated by the levels of consumption that have been steady.

Agriculture Consumption: Energy use in agriculture fluctuates between 2012 and 2023, with a general downward trend. Mechanisation, changes in cropping patterns, and efficiency gains in agricultural practices can all be blamed for the decrease in agricultural energy consumption.

Miscellaneous: Over the period, there is no discernible trend in the fluctuations of miscellaneous energy consumption. Since miscellaneous energy includes a wide range of other industries and activities that are not clearly classified, it can be difficult to pinpoint the precise causes of shifts in consumption.

Figure 2: Sector wise consumption of fossil fuels



Overall, the analysis of energy consumption by sector reveals the various dynamics and drivers influencing energy demand in India's various sectors. Policymakers, energy planners, and stakeholders must comprehend these consumption patterns in order to develop targeted interventions and strategies meant to improve energy efficiency, encourage the use of renewable energy sources, and accomplish sustainable development objectives.

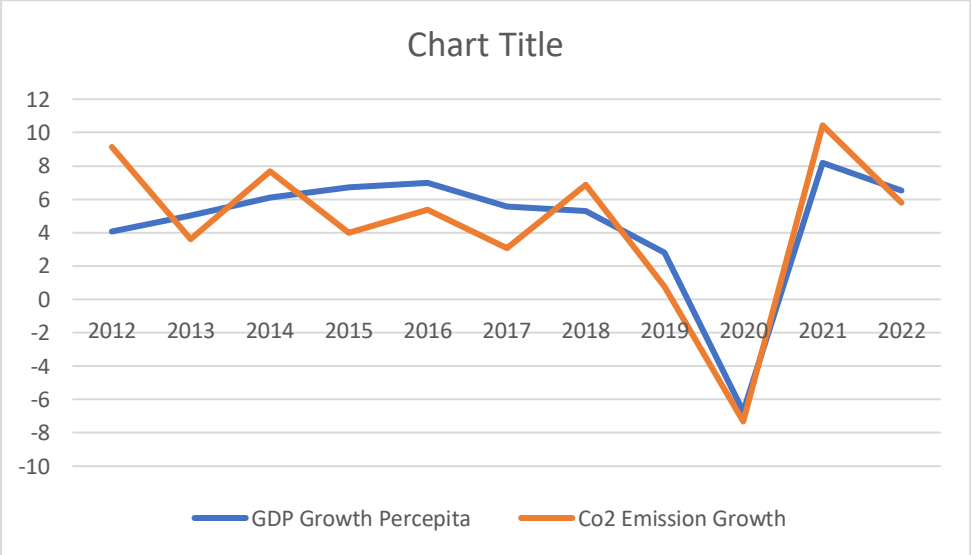
GDP Growth Per Capita and CO2 Emission (2012-2023)

Examining the relationship between GDP growth per capita and CO2 emission growth provides valuable insights into the economic development trajectory and environmental sustainability of a country. In the context of India, understanding how economic growth correlates with carbon emissions is crucial for assessing the country's progress towards achieving sustainable development goals. This section will analyse the trends in GDP growth per capita alongside CO2 emission growth in India from 2012 to 2023, shedding light on the complex interplay between economic prosperity and environmental impact.

Economic Growth

GDP growth per capita is a crucial measure of both economic development and living standards in India since it represents the average economic output per person. The data demonstrates that GDP growth per capita has varied over time, with some significant variations seen.

Figure 3: GDP Growth and CO2 Emission Growth



Source:

India's GDP grew per person at a comparatively strong rate between 2012 and 2015, signifying a period of economic expansion and rising prosperity. But in 2020, there was a sharp decline, with GDP growth per person falling to -6.73%. This was probably caused by the COVID-19 pandemic and the ensuing lockdown measures. The following years, especially 2021 and 2022, saw rapid growth and a robust recovery, demonstrating the resilience of India's economy.

CO2 Emission: The annual increase in carbon dioxide emissions, a major greenhouse gas that contributes to climate change and environmental degradation, is measured by the CO2 emission growth index. The data shows that CO2 emissions have grown at different rates over time, which suggests variations in India's carbon footprint. Remarkably, in certain years, like 2013 and 2019, the growth in CO2 emissions showed a downward trend, indicating either mitigation efforts or external factors impacting patterns of energy consumption. Nonetheless, there were times when CO2 emission growth sharply increased, especially in 2020 and 2021. The COVID-19 pandemic's effects on transport and industry may have contributed to the spike in CO2 emission growth in 2020. This was followed by a brief drop in emissions in 2021 as economic activity picked back up.

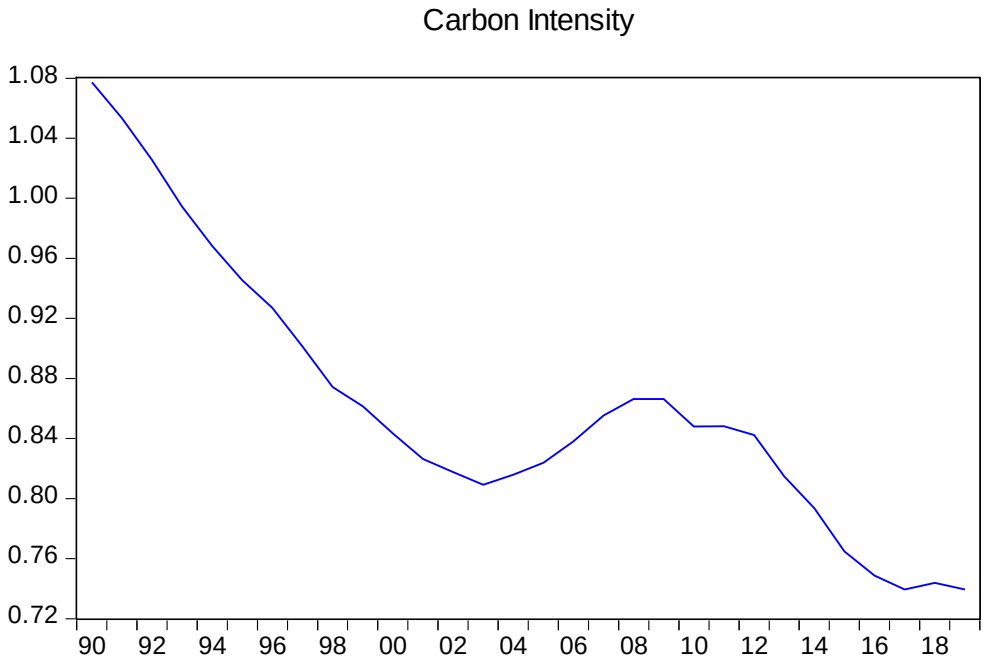
An examination of the growth in GDP per capita and CO2 emissions reveals the intricate connection between India's environmental degradation and economic development. Although strong economic expansion is frequently accompanied by higher CO2 emissions, the data also shows times when economic expansion and emissions did not go hand in hand, indicating possible routes to sustainable development. Changes in behaviour, technology, and policy all have a significant impact on how the environmental impact of economic growth develops over time. Going forward, it will take coordinated efforts to decouple economic growth from carbon emissions through the adoption of renewable energy sources, energy-saving techniques, and sustainable development strategies in order to achieve a balance between environmental sustainability and economic prosperity.

Carbon Intensity of Economic growth

The carbon intensity of economic growth refers to the amount of CO2 emissions produced per unit of economic output, usually measured in terms of GDP. Figure-4 represents carbon elasticity of India’s economic growth for the period of 1990-2019. These estimates have been estimated using rolling regression approach. Thank to the efforts taken on various levels, Carbon intensity for India’s economic growth has been continuously decreasing except for the period of 2004-09, where it actually increased. The figure shows that India is well on the way to meet its commitment of (UNFCCC), to reduce emissions intensity by 45% from the 2005 level by 2030. During 1990 1 percent increase was associated with almost similar increase in carbon emissions; however this intensity decreased significantly to 0.75 percent in 2019, decreasing by around 25

percentage points during this period of 30 years. Although India is going well towards sustainable growth goals, still more efforts are needed on the part of government and policy makers in future too.

Figure-4



3. **Conclusion**:

The thorough analysis of energy consumption, GDP growth per person, CO2 emission growth, and the contribution of fossil fuels to India's development trajectory offers important new perspectives on the intricate interactions that exist between environmental sustainability and economic prosperity. We now have a better understanding of India's energy transition journey and its implications for sustainable development thanks to a number of important findings and implications that have emerged from the analysis of multi-dimensional data spanning from 2012 to 2023. First of all, the study showed that a large portion of India's energy mix comes from fossil fuels, mainly coal, oil, and natural gas. In spite of initiatives to diversify the energy mix and support renewable energy sources, fossil fuels remain essential for supplying the nation's energy needs, fostering industrial development, and accelerating economic growth. Nonetheless, the negative environmental effects of using fossil fuels, such as air pollution and CO2 emissions, highlight how urgently we must switch to more sustainable and cleaner energy sources.

Second, the analysis brought to light the complex interplay among energy consumption, environmental degradation, and economic growth. Although times of strong GDP growth per person were frequently associated with higher energy use and carbon emissions, the data also showed times when economic growth disconnected itself from environmental effects, pointing to possible ways to meet sustainable development objectives. This emphasises the significance of implementing integrated strategies that place an equal emphasis on economic growth and environmental sustainability, highlighting the necessity of legislative actions, technological advancements, and behavioural adjustments to support the shift to a low-carbon economy.

Furthermore, the research pinpointed significant prospects and obstacles for advancing sustainable development in India. The implementation of regulatory frameworks that support sustainable development, encourage the use of renewable energy sources, and improve energy efficiency have all been identified as critical strategies for striking a balance between the goals of environmental stewardship and economic growth. Encouraging inclusive growth, establishing partnerships, and welcoming innovation will be crucial in propelling India's shift to a future that is more environmentally sustainable, equitable, and resilient. The study's conclusion emphasises how critical it is to address India's dual goals of environmental sustainability and economic growth. Policymakers, stakeholders, and companies can map out a route to a more sustainable and prosperous future by utilising insights from energy consumption patterns, GDP growth dynamics, and environmental impact assessments. This will guarantee that India becomes a global leader in climate action and sustainable development.

4. Limitations of the study:

The study's reliance on publicly accessible data sources may have limited its coverage, accuracy, and dependability. The analysis may contain biases or inaccuracies due to differences in data gaps, reporting standards, and data collection methodologies.

The study ignored other significant factors like socioeconomic indicators, technological advancements, and policy dynamics that could affect the relationship between economic growth and environmental sustainability in favour of concentrating primarily on energy consumption, GDP growth per capita, CO2 emission growth, and fossil fuel usage.

The study period, which ran from 2012 to 2023, might not have included longer-term patterns or structural modifications to India's energy environment and path of economic development.

Extended time series data may offer a more comprehensive comprehension of past patterns and anticipated future developments.

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