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International Journal for Research
Trends in Social Science & Humanities
ISSN: 2584-2455, Volume 4, Issue 4
Aug 2026, PP- 1-14

Oil Crisis, Energy Security and Climate Change in India: An Empirical Analysis of Geopolitical Oil Shocks

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Abstract- India's rapid economic growth has been accompanied by a substantial increase in energy demand and dependence on imported crude oil. This dependence exposes the Indian economy to international oil-price volatility arising from geopolitical conflicts, supply disruptions and global economic crises. At the same time, continued dependence on fossil fuels creates challenges for India's climate commitments and long-term energy transition. This study empirically examines the relationship between geopolitical oil shocks, energy security and climate change in India. The analysis focuses on the transmission of international crude oil-price shocks to India's oil import dependence, energy consumption, economic growth and carbon dioxide emissions. Annual data covering the period 1990–2024 are proposed to be analysed using descriptive statistics, correlation analysis, unit-root tests, the Autoregressive Distributed Lag (ARDL) bounds-testing approach and an Error Correction Model (ECM). Structural-break analysis is incorporated to capture major episodes such as the 1991 Gulf War, the 2008 global financial crisis, the 2014–2016 oil-price collapse, the COVID-19 shock and the Russia–Ukraine conflict. The study conceptualises energy security through import dependence, oil-price volatility and energy diversification, while climate change is represented through CO_2 emissions and carbon intensity. The empirical framework is designed to identify both short-run and long-run relationships between geopolitical oil shocks, energy security and environmental outcomes. The study is expected to demonstrate that India's high dependence on imported oil increases vulnerability to external shocks, while diversification toward renewable energy, electric mobility, biofuels, energy efficiency and strategic petroleum reserves can simultaneously strengthen energy security and support climate objectives.

Keywords- Oil Crisis, Energy Security, Geopolitical Risk, Crude Oil Prices, Climate Change, CO_2 Emissions, India, ARDL, Energy Transition Certainly.

I. Introduction

Energy is the foundation of modern economic development, influencing industrial production, transportation, trade, employment, household welfare and overall economic growth. Among the various sources of energy, crude oil continues to occupy a strategically important position in the global economy because of its extensive use in transportation, manufacturing, petrochemicals and other productive activities. However, the international oil market is highly vulnerable to geopolitical conflicts, supply disruptions, economic crises and policy changes in major oil-producing countries. Consequently, sudden fluctuations in crude oil prices have increasingly become a major concern for oil-importing developing economies such as India.

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India's rapid economic growth and expanding population have generated a continuous increase in energy demand. Although India has made substantial progress in renewable energy and alternative fuels, crude oil remains a critical component of the country's energy mix, particularly in the transport sector. India's dependence on imported crude oil makes the economy vulnerable to developments occurring beyond its national boundaries. International conflicts, sanctions, disruptions in oil-producing regions and changes in global supply conditions can rapidly increase crude oil prices and consequently raise India's import expenditure. Such external shocks can influence domestic inflation, the current account balance, exchange rates, fiscal conditions and economic growth. The Reserve Bank of India has highlighted the importance of crude-oil price movements for India's macroeconomic stability, particularly through their effects on inflation and the external sector.

The vulnerability of India to oil shocks has become increasingly evident through successive global crises. The Gulf War of 1990–91, the global financial crisis and oil-price surge of 2008, the Arab Spring of 2011, the sharp decline in oil prices during 2014–16, the COVID-19 pandemic in 2020 and the Russia–Ukraine conflict in 2022 represent major episodes of disruption in the international energy market. These events demonstrate that oil crises are not merely temporary fluctuations in commodity prices; they can generate wider economic and strategic consequences for countries that depend heavily on imported energy. The Russia–Ukraine conflict, in particular, demonstrated how geopolitical tensions, sanctions and changes in global trade flows can substantially alter the structure of international energy markets.

For India, the issue is particularly significant because crude-oil import dependence has remained very high. The country's increasing dependence on external sources means that domestic energy security is closely connected with international oil-market stability. A rise in international crude-oil prices increases India's oil-import bill and can place pressure on the current account and domestic prices. At the same time, fluctuations in oil prices create uncertainty for households, firms and policymakers. Therefore, energy security in India cannot be understood simply in terms of the physical availability of energy. It must also incorporate the dimensions of affordability, reliability, accessibility, diversification and resilience against external geopolitical shocks.

The energy-security challenge is closely connected with the issue of climate change. India's economic development has historically been associated with increasing fossil-fuel consumption, which has contributed to rising greenhouse-gas emissions. Oil consumption, particularly in transportation and industrial activities, contributes to carbon emissions and therefore creates an important link between energy security and environmental sustainability. This produces a complex policy dilemma. On the one hand, India needs reliable and affordable energy to sustain economic growth and improve living standards. On the other hand, continued dependence on fossil fuels increases environmental pressures and may make it more difficult to achieve long-term climate objectives.

This relationship has become more important as India moves toward a low-carbon development pathway. The expansion of solar and wind power, electric mobility, biofuels, energy efficiency and other clean-energy technologies provides opportunities

to reduce dependence on imported fossil fuels. From an energy-security perspective, diversification away from oil can reduce India's exposure to international price and supply shocks. From a climate perspective, the same transition can contribute to lower carbon intensity and reduced greenhouse-gas emissions. Thus, the transition toward renewable and alternative sources of energy can potentially serve a dual purpose: strengthening India's energy security while supporting its climate-change mitigation objectives.

However, the relationship between geopolitical oil shocks, energy security and climate change is not necessarily straightforward. A sudden increase in oil prices may encourage investment in renewable energy and alternative technologies in the long run, but it may also generate short-run economic pressures that encourage governments and consumers to rely on conventional fuels. Similarly, lower international oil prices may reduce the immediate cost of energy imports but could weaken the economic incentives for energy conservation and renewable-energy substitution. Therefore, understanding the dynamic and empirical relationship among oil prices, geopolitical shocks, energy consumption, energy security and carbon emissions is essential for designing appropriate energy policies.

Existing studies have examined several individual dimensions of this issue, including the relationship between crude-oil prices and economic growth, oil imports and economic activity, energy consumption and CO_2 emissions, and geopolitical risk and energy markets. However, there remains scope for an integrated empirical analysis that connects geopolitical oil shocks with India's energy-security vulnerability and climate-related outcomes. In particular, examining whether oil-price shocks have persistent effects on India's energy dependence and whether energy diversification can moderate these effects provides an important area for further research.

Against this background, the present study investigates the relationship between oil crises, energy security and climate change in India, with particular emphasis on the role of geopolitical oil shocks. The study examines the evolution of India's crude-oil dependence, analyses major geopolitical episodes that have affected global oil markets, and empirically investigates the relationship between international oil prices, oil consumption, economic growth, renewable energy and CO_2 emissions. The study further attempts to distinguish between short-run and long-run effects of oil shocks using appropriate time-series econometric techniques.

The significance of the study lies in its attempt to bring together three closely interconnected dimensions of India's development challenge—energy security, economic stability and climate sustainability. The findings are expected to contribute to the growing literature on energy economics and provide policy insights into how India can reduce its vulnerability to geopolitical oil shocks while accelerating its transition toward a more diversified, resilient and low-carbon energy system.

II. Review of Literature

The relationship between oil prices, energy security, economic growth and environmental sustainability has received considerable attention in the energy economics literature. Previous studies have examined these issues from different

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perspectives, including crude-oil import dependence, oil-price shocks, energy consumption, economic growth and carbon emissions. The major findings of the relevant literature are discussed below.

Ghosh (2009) examined the relationship between crude-oil imports, income and imported crude-oil prices in India using the ARDL bounds-testing approach for the period 1970–71 to 2005–06. The study found a long-run relationship among the variables and reported that economic growth significantly increased crude-oil imports. The findings highlighted the need for energy-efficiency measures, demand management and substitution of imported fuels to reduce India's dependence on imported crude oil.

Chattopadhyay and Majumdar (1996) investigated the impact of oil-price shocks on carbon emissions in India. Using data for 1970–1988 and a Bayesian VAR framework, the study found that the 1973 oil shock was associated with a structural change in the growth of carbon emissions. The authors also observed that an oil-price shock could have an immediate negative effect on GDP while producing persistent effects on carbon emissions. This study established an early connection between oil-price instability, economic activity and environmental outcomes in India.

Murthy, Panda and Parikh examined the relationship between economic growth, energy demand and CO_2 emissions in India. Their work emphasised the close connection between India's economic development and increasing energy requirements, highlighting the environmental implications of India's energy-use pattern.

A study by the Economic Modelling literature (2014) examined the relationship between energy consumption, carbon emissions and economic growth in India using data for 1970–2008. The findings indicated that energy consumption unidirectionally caused both carbon emissions and economic growth, while carbon emissions and economic growth also exhibited bidirectional causality. The study further identified trade openness as an important factor influencing energy consumption and emissions.

Objectives of the Study

The present study aims to analyse the relationship between oil crises, energy security and climate change in India, with particular emphasis on the impact of geopolitical oil shocks.

The specific objectives are:

1. To examine the trends and patterns of crude-oil consumption and import dependence in India.
2. To analyse the major geopolitical events and their influence on international crude-oil prices.
3. To examine the impact of oil-price fluctuations on India's energy security.
4. To analyse the relationship between oil consumption and carbon dioxide (CO_2) emissions in India.
5. To examine the role of renewable energy in reducing India's dependence on imported crude oil.

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III. Research Methodology

Research Design
The study adopts a descriptive and analytical research design to examine the relationship between oil crises, energy security and climate change in India. The study focuses particularly on India's dependence on imported crude oil, fluctuations in international crude-oil prices, oil consumption, renewable-energy development and carbon dioxide emissions.

Data Sources
The study is based entirely on secondary data collected from reliable national and international sources. The major sources include:

- **Energy Institute (EI) –** historical energy consumption, oil production and oil-price data
- **World Bank –** World Development Indicators (WDI) – GDP, CO_2 emissions and other macroeconomic indicators
- **International Energy Agency (IEA) –** energy supply, oil demand and energy-security information
- **Petroleum Planning and Analysis Cell (PPAC), Government of India** – crude-oil production, consumption and import data
- **Ministry of Petroleum and Natural Gas, Government of India –** petroleum-sector statistics
- **Reserve Bank of India (RBI) –** macroeconomic and exchange-rate data

Study Period
The study covers the period 1990 to 2025. The period is selected to capture the major changes in India's energy sector, increasing dependence on imported crude oil and significant geopolitical and economic shocks affecting the international oil market.
The study period includes several major oil and economic shocks, such as the 1990–91 Gulf War, the 2008 global financial crisis and oil-price surge, the 2014–16 oil-price decline, the COVID-19 pandemic in 2020, and the Russia–Ukraine conflict beginning in 2022. The inclusion of 2025 provides a more recent assessment of India's oil consumption, energy security and climate-related developments.

The latest international energy data provide annual oil information through 2025, while India's PPAC provides historical and current petroleum-sector data on consumption, imports and exports.

Data Sources
The study uses secondary data collected from reliable national and international sources, including:

- Petroleum Planning and Analysis Cell (PPAC), Government of India
- Ministry of Petroleum and Natural Gas, Government of India
- International Energy Agency (IEA)
- Energy Institute
- World Bank – World Development Indicators
- Reserve Bank of India (RBI)

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PPAC provides historical information on India's petroleum consumption, crude-oil imports and exports, while the IEA provides international oil supply, consumption and trade data.

Variables of the Study

The study considers the following major variables:

Variable	Measurement
Crude-oil consumption	Million tonnes / barrels per day
Crude-oil imports	Million tonnes
Oil import dependence	Percentage
International crude-oil price	US dollars per barrel
CO_2 emissions	Million tonnes
Renewable energy	Percentage/share
Economic growth	GDP growth rate
Energy consumption	Total energy consumption

Statistical Tools

The study uses simple statistical techniques to analyse the data:

1. Trend Analysis – to examine changes in oil consumption, imports, renewable energy and CO_2 emissions.
2. Percentage Change – to measure year-to-year changes.
3. Compound Annual Growth Rate (CAGR) – to measure long-term growth.
4. Descriptive Statistics – mean, minimum, maximum and standard deviation.
5. Correlation Analysis – to examine the relationship between oil consumption, oil prices, renewable energy and CO_2 emissions.
6. Graphical Analysis – line graphs and bar charts are used to present major trends clearly.

India's Crude-Oil Consumption: 1990–2025

For a consistent international series, oil consumption can be expressed in thousand barrels per day (kbd). The historical EIA series reports India at 1,168 kbd in 1990, 2,147 kbd in 2000 and 3,305 kbd in 2010. The Energy Institute series reports 4,190 kbd in 2015, 4,772 kbd in 2020 and 5,757 kbd in 2024.

Table 1: India’s Oil Consumption

Year	Oil consumption (kbd)	Approx. trend
1990	1,168	Base year
1995	1,655	Strong increase
2000	2,147	Rapid expansion
2005	2,550	Continued growth
2010	3,305	High growth
2015	4,190	Strong demand
2020	4,772	COVID-19 disruption

Year	Oil consumption (kbd)	Approx. trend
2024	5,757	Record-level demand
2025	~6,000+	Continued expansion*

Statistical analysis

Statistic	Result
Mean of benchmark observations	3,193 kbd
Standard deviation	1,605.7 kbd
Coefficient of variation	50.29%
CAGR, 1990–2024	4.80%
Increase, 1990–2024	≈393%

Interpretation

India's crude-oil demand shows a strong long-run upward trend. Consumption increased from about 1.17 million barrels per day in 1990 to 5.76 million barrels per day in 2024. The expansion reflects industrialisation, urbanisation, motorisation, rising freight movement, aviation and increasing household energy demand. The temporary fall in 2020 demonstrates the sensitivity of oil demand to economic shocks.

India's Crude-Oil Import Dependence: 1990–2025

Import dependence should be calculated as:

Import Dependence (%) =Crude Oil Consumption/ Crude Oil Imports×100

PPAC data show that dependence has increased substantially in recent decades. For example, dependence was around 70.1% in 2010–11, while recent PPAC figures show 88.3% in FY2024–25.

Table 2: India’s Crude-Oil Import Dependence

Financial year	Import dependence (%)
1997–98	52.0
1999–00	67.0
2000–01	72.0
2004–05	77.0
2010–11	70.1
2014–15	84.0
2015–16	85.3
2016–17	85.9
2017–18	86.6
2018–19	87.6
2019–20	88.0
2020–21	87.1
2021–22	88.3

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Financial year	Import dependence (%)
2022–23	89.3
2023–24	89.6
2024–25	88.3

The historical 1997–2005 figures come from PPAC/TERI material, while later figures are based on PPAC data reported by government/parliamentary and contemporary sources.

Interpretation

The evidence indicates a structural increase in India's dependence on imported crude oil. Domestic crude production has not increased sufficiently to match the rapid expansion in demand. This creates vulnerability to:

- international crude-price fluctuations
- exchange-rate depreciation
- inflationary pressure
- widening trade/current-account deficits
- geopolitical supply disruptions.

The pandemic caused a temporary reduction in demand, but import dependence subsequently returned to very high levels.

International Crude-Oil Price: 1990–2025

The Energy Institute/Our World in Data series provides annual crude-oil prices based on S&P Global Platts.

Table 3: International Crude-Oil Price

Year	Approx. Brent price (US$/barrel)	Major event/trend
1990	23.7	Gulf War period
1995	17.0	Relatively low prices
2000	28.5	Beginning of upward cycle
2005	54.5	Strong global demand
2010	79.5	Post-global-crisis recovery
2015	52.4	Major price decline
2020	42.0	COVID-19 shock
2024	~80	Geopolitical and supply pressures
2025	~68–70	Moderation from 2024

Statistical analysis

Using the benchmark observations:

Statistic	Result
Mean	US$47.19/barrel
Standard deviation	US$24.01
Coefficient of variation	50.87%

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Statistic	Result
CAGR, 1990–2024	3.64%
Maximum period	2010–2014 period
Major negative shock	2020

Interpretation

Crude-oil prices exhibit much greater volatility than a simple long-term trend would suggest. The major price movements are associated with geopolitical conflicts, OPEC decisions, global recessions, rapid demand growth and the COVID-19 pandemic.

India's CO_2 Emissions: 1990–2025

The appropriate indicator is annual territorial CO_2 emissions from fossil fuels and industry, excluding land-use change. The current Global Carbon Budget dataset reports India at 3.19 billion tonnes in 2024.

Table 4: India's CO_2 Emissions

Year	CO_2 emissions (billion tonnes)
1990	0.697
1995	~0.834
2000	~0.970
2005	1.195
2010	1.679
2015	2.232
2020	2.423
2021	2.676
2022	2.831
2023	3.063
2024	3.193
2025	Not yet available in GCB 2025 dataset

The 2005–2024 values shown above are consistent with the Global Carbon Budget/OWID series; 2024 is reported at 3.193 billion tonnes.

Statistical analysis

Statistic	Result
Mean of benchmark observations	1.653 billion tonnes
Standard deviation	0.891 billion tonnes
Coefficient of variation	53.93%
CAGR, 1990–2024	4.58%
Increase, 1990–2024	≈358%

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Statistic	Result
Linear trend	Strong positive
R^2 of benchmark time trend	≈0.935

Interpretation

India's CO_2 emissions increased substantially alongside economic and energy expansion. Emissions increased more than fourfold between 1990 and 2024. The increase is associated particularly with fossil-fuel-based electricity generation, industrialisation, transport and rising overall energy consumption.

However, increasing renewable electricity generation creates a potential pathway for partial decoupling between economic/energy growth and emissions.

Renewable Energy Growth in India: 1990–2025

For consistency, measuring renewable growth as renewable electricity generation in TWh, rather than mixing installed capacity (MW), electricity generation (TWh) and renewable share (%).

The latest OWID/Energy Institute/Ember data report 500.98 TWh of renewable electricity generation for India in 2025.

Table 5: Renewable Electricity Generation in India

Year	Renewable generation (TWh)	Observation
1990	Historical hydro-dominated system	Low modern-renewable contribution
2000	Hydro-dominated	Solar/wind still limited
2010	Hydro + emerging wind	Transition beginning
2014–15	191.0	Renewable expansion
2017–18	228.0	Strong wind/solar growth
2019–20	294.3	Rapid expansion
2020–21	297.5	Resilient during pandemic
2021–22	322.6	Continued expansion
2022–23	365.6	Strong growth
2023–24	359.9	Temporary decline
2024–25	343.5	Mixed generation conditions
2025	500.98	Strong renewable generation

The 2014–25 figures come from Indian renewable-generation data, while the latest 2025 OWID/Ember series report 500.98 TWh.

In 2025, India's primary-energy mix included approximately 104 TWh wind, 178.2 TWh solar, 163.1 TWh hydro, 69.2 TWh biofuels and 78 TWh other renewables in the Energy Institute series.

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Interpretation

The renewable-energy transition has accelerated particularly after 2010. The most significant structural change has been the rapid expansion of solar and wind, alongside India's established hydropower base. In 2025, solar alone generated about 196 TWh of electricity, according to the latest OWID series.

Thus, renewable energy is becoming an increasingly important counterweight to India's oil- and coal-intensive energy system.

Relationship between Oil Consumption and CO_2 Emissions

This is the most important statistical section for your research paper.

Table 6: Oil Consumption and CO_2 Emissions

Year	Oil consumption (kbd)	CO_2 emissions (Gt)
1990	1,168	0.697
1995	1,655	~0.834
2000	2,147	~0.970
2005	2,550	1.195
2010	3,305	1.679
2015	4,190	2.232
2020	4,772	2.423
2024	5,757	3.193

Pearson correlation

Using these benchmark observations:

r=0.993

This indicates an extremely strong positive relationship between oil consumption and CO_2 emissions.

Test	Result
Pearson correlation, r	0.993
R^2	0.986
p-value	<0.001
Relationship	Very strong positive

Simple regression

The estimated benchmark relationship is:

CO2=−0.1073+0.0005513(Oil)

where:

- CO_2 = billion tonnes
- Oil = thousand barrels per day

The coefficient of determination is approximately:

R2=0.986

Interpretation

The statistical relationship indicates that periods of higher oil consumption are associated with substantially higher CO_2 emissions. The very high correlation suggests that petroleum consumption is an important contributor to India's carbon-emission trajectory.

However, do not interpret the correlation coefficient as proof that oil consumption alone causes 98.6% of India's CO_2 emissions. CO_2 emissions are also strongly affected by coal, natural gas, cement production, electricity generation and industrial activity. The OWID dataset itself separates emissions from coal, oil, gas, cement and flaring.

Overall Statistical Findings

Table 8: Summary of Major Findings

Indicator	Major finding, 1990–2025
Oil consumption	Strong upward trend
Oil import dependence	Increased substantially; around 88% in FY2024–25
International oil price	Highly volatile
CO_2 emissions	Strong upward trend
Renewable energy	Rapid acceleration, particularly after 2010
Oil–CO_2 correlation	$r \approx 0.993$ in benchmark observations
Oil–CO_2 regression	$R^2 \approx 0.986$
Policy implication	Reduce oil dependence and accelerate renewable transition

Overall analysis

The six indicators reveal a clear structural pattern in India's energy economy. Oil consumption has expanded rapidly, while domestic crude production has not kept pace, resulting in high import dependence. At the same time, higher fossil-fuel consumption has been accompanied by a substantial increase in CO_2 emissions. International crude prices introduce an additional source of economic vulnerability because India's high import dependence transmits global oil-price shocks into the domestic economy. PPAC and EIA evidence supports this vulnerability.

Major Findings

1. **Increasing crude-oil consumption:** India’s crude-oil consumption has shown a clear long-term upward trend from 1990 to 2025, reflecting rapid economic growth, industrialisation, urbanisation, rising transport demand, and increasing energy requirements.
2. **High import dependence:** Domestic crude-oil production has not increased at the same pace as consumption. Consequently, India has become increasingly dependent on imported crude oil to meet its energy requirements.
3. **Vulnerability to international oil prices:** Changes in international crude-oil prices have a significant impact on India’s energy security and economic stability. Sharp increases in global oil prices can raise import expenditure, transportation costs and inflationary pressures.

4. **Growing CO_2 emissions**: The increase in fossil-fuel consumption, particularly oil and other conventional energy sources, has contributed to the continuous growth of India's CO_2 emissions during the study period.
5. **Renewable energy is expanding**: Renewable energy capacity and utilisation have increased substantially, particularly in the recent period. This indicates India's gradual transition towards cleaner and more sustainable sources of energy.
6. **Oil consumption and environmental pressure:** The data indicate a positive relationship between increasing oil consumption and CO_2 emissions. Continued dependence on petroleum products therefore creates both economic and environmental challenges.
7. **Energy security remains a major concern:** India's high dependence on imported crude oil exposes the economy to geopolitical risks, supply disruptions and fluctuations in international petroleum prices.
8. **Recent transition towards diversification:** The growth of renewable energy suggests that India is moving towards diversification of its energy mix. However, the transition is gradual because petroleum continues to play an important role in transportation, industry and other economic activities.
9. **Need for sustainable energy policies:** The overall findings indicate that economic development and rising energy demand need to be balanced with energy security and environmental sustainability.
10. **Long-term structural challenge:** India faces a dual challenge of meeting its growing energy demand while reducing dependence on imported oil and controlling carbon emissions. Therefore, the energy transition needs to be accelerated without compromising economic growth.

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