Examining the Impact of Green Investments on India's Economic Growth and Energy Security

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DOI: https://doi.org/10.5281/zenodo.15294843

Published Date: 28-April-2025

Abstract: Green investments play a crucial role in shaping India's economic growth (EG) and energy security (ES). As the country transitions toward a low-carbon economy, and investments in renewable energy (RE), sustainable infrastructure, along with green technologies have become critical drivers of sustainable development. This review paper explores the impact of green investments on India's economic growth and ES by synthesizing academic literature, government (govt.) reports, and empirical studies. The findings highlight the role of RE in dropping dependence on fossil fuels (FFs), fashioning employment opportunities, and fostering economic resilience. The study also discusses policy frameworks, financial mechanisms, and challenges in scaling up green investments.

Keywords: Green Investments, Economic Growth, Energy Security, Renewable Energy, Sustainable Development.

1. INTRODUCTION

Energy security is a fundamental prerequisite for economic stability and sustainable development. The International Energy Agency (IEA) defines continuous energy availability at an affordable price. It ensures that a country has reliable access to energy sources to meet its economic, industrial, and domestic needs without disruptions. Energy security is crucial for economic stability, national security, and sustainable development. It has two key dimensions: short-term security, which deals with the ability of a country to manage sudden supply disruptions, and long-term security, which focuses on investments in energy infrastructure to meet future demand sustainably. In the Indian context, energy security is a critical concern due to the country's growing energy needs, rapid industrialization, and reliance on imported fossil fuels. As the third-largest global energy consumer, India's energy demand is projected to rise exponentially in the coming decades, driven by economic expansion, urbanization, along with population growth (BP Energy Outlook, 2021).

Energy security is crucial for India's economic stability, industrial growth, and global competitiveness. With a rapidly expanding economy, India requires a reliable energy supply to sustain high growth rates and reduce vulnerability to price fluctuations in global markets (IEA, 2022). Heavy dependence on crude oil (CO) and natural gas (NG) imports strains fiscal budgets and affects inflation (World Bank, 2021).

A secure energy supply is essential for initiatives like *Make in India*, ensuring industrial productivity and attracting foreign investment (NITI Aayog, 2023). The transition to renewable energy, projected to create markets worth \$80 billion by 2030, offers economic opportunities while reducing fossil fuel dependence (IRENA, 2022). Investments in renewables can generate over a million jobs, drive technological innovation, and enhance energy efficiency (ILO, 2022).

Geopolitically, energy security strengthens India's global standing and reduces reliance on unstable international markets (Brookings, 2022). Socially, expanded energy access improves living standards and productivity, while cleaner energy mitigates pollution and health costs (WHO, 2022).

Thus, ensuring energy security through diversification, infrastructure development, and clean energy adoption is critical for India's long-term economic resilience and sustainable growth.

Despite efforts to transition toward renewable energy, India's energy mix remains heavily dominated by FFs. Coal accounts for over 55% of the country's power generation, while oil and natural gas collectively make up a substantial portion of energy consumption (Ministry of Power, 2023). Furthermore, India imports nearly 85% of its crude oil and 50% of its

Vol. 13, Issue 1, pp: (39-44), Month: April 2025 - September 2025, Available at: www.researchpublish.com

natural gas, making it vulnerable to global price fluctuations and geopolitical tensions (IEA, 2022). The heavy reliance on external energy sources not only increases the country's trade deficit but also exposes it to supply chain disruptions, as seen during the Russia-Ukraine conflict and the COVID-19 pandemic, which led to price volatility and fuel shortages (IMF, 2022).

To mitigate these risks, India has been actively promoting RE adoption, looking to attain 500 GW of non-FF energy capacity by 2030 under its Nationally Determined Contributions (NDCs) in line with the Paris Agreement (Government of India, 2022).

Link Between Energy Security and Economic Growth

Energy security and EG are closely interlinked, as a stable and affordable energy supply is essential for industrial productivity, job creation, and infrastructure development. The availability of energy influences multiple economic sectors, from agriculture and manufacturing to services and digital economies (World Bank, 2021). Any disruption in energy supply or volatile energy prices can lead to inflation, lower industrial output, and reduced economic competitiveness (OECD, 2020).

In India, energy security plays a crucial role in sustaining high GDP growth rates, which have averaged around 6-7% annually over the past two decades (RBI, 2022). A steady energy supply ensures that industries can operate efficiently without production losses due to power outages or fuel shortages. Furthermore, sectors such as transportation, real estate, and IT services, which form a significant portion of India's economic output, are heavily dependent on reliable energy access. Unstable energy supplies can lead to rising operational costs, affecting both domestic and foreign investment inflows (UNCTAD, 2021).

Conversely, energy insecurity can have adverse economic consequences. The 1970s oil crisis demonstrated how fluctuations in energy prices can trigger recessions, inflation, and industrial stagnation (IEA, 2020). Similarly, India's 2012 power grid failure, which affected over 600 million people, highlighted the economic vulnerabilities linked to inadequate energy infrastructure (Ministry of Power, 2013). In this context, ensuring energy security is not just an environmental necessity but also a critical economic imperative.

India's Energy Security Challenges: Economic Implications and Strategic Solutions

India's energy security is deeply connected to its economic stability. As a rapidly expanding global economy, a stable and affordable energy supply is crucial for industrial productivity and infrastructure development. However, India faces significant vulnerabilities due to its heavy reliance on imports, inadequate infrastructure, energy transition challenges, inefficiencies, geopolitical risks, and regulatory barriers.

Dependence on Imports

India imports over 80% of its CO along with nearly 50% of its NG (IEA, 2022), making it vulnerable to global price fluctuations. The Russia-Ukraine conflict led to a 40% surge in crude oil prices, worsening India's trade deficit and inflation (Ranjan & Sharma, 2023). The depreciation of the Indian Rupee against the US Dollar further increases energy costs, reducing foreign exchange reserves and economic stability (IMF, 2023). Diversifying the energy mix through domestic renewable energy investments is critical to mitigating these risks.

Infrastructure Deficiencies

India's energy infrastructure struggles with inefficiencies in generation, transmission, and distribution (Chakraborty et al., 2021). With AT&C losses around 20%—among the highest globally—outdated grid systems hinder energy management (CEA, 2022). Rural electrification, despite improvements through schemes like Saubhagya Yojana, remains inconsistent. Urban areas also face peak demand challenges, disrupting industries. Additionally, a shortage of skilled labor in renewable energy slows sectoral growth (Mukherjee, 2020). Addressing these infrastructural gaps is essential for long-term energy security.

Challenges in Renewable Energy Transition

India aims for 500 GW of non-FF capacity by 2030 (IRENA, 2021). However, high upfront capital costs and infrastructure upgrades pose significant barriers (Ghosh & Ray, 2022). Land acquisition delays and local resistance further slow project implementation. Emerging technologies like green hydrogen and smart grids require substantial R&D investment, but domestic capabilities remain limited. Overcoming these barriers is crucial for achieving clean energy targets and economic resilience.

Vol. 13, Issue 1, pp: (39-44), Month: April 2025 - September 2025, Available at: www.researchpublish.com

Energy Inefficiencies

Inefficiencies in industrial and domestic energy consumption hinder productivity (Patel, 2023). India's coal-fired plants operate at 32-35% efficiency, below the global ultra-supercritical average of 42% (CEA, 2022). Transmission losses and outdated industrial equipment further exacerbate energy waste. While schemes like Perform, Achieve, and Trade (PAT) promote efficiency, stronger policy enforcement and financial incentives are needed to scale these efforts.

Geopolitical Risks

Global tensions, including the USA-Iran dispute and Russia-Ukraine conflict, impact India's energy imports (Singh, 2022). China's Belt and Road Initiative (BRI) also poses strategic challenges, increasing regional energy dependencies (Basu, 2021). Additionally, competition over Indo-Pacific energy resources threatens India's access to critical minerals for renewable technologies. Strengthening bilateral energy agreements and boosting domestic production are essential to mitigating these risks.

Policy and Regulatory Barriers

India's energy sector faces bureaucratic delays and policy misalignment between central along with state governments (Kumar & Mehta, 2022). Renewable energy projects encounter environmental clearance delays and inconsistent tariff regulations, discouraging private investment (IEA, 2023). Slow progress in hydrocarbon exploration further limits domestic energy production. Streamlining policies and encouraging foreign investment in exploration could enhance self-sufficiency and economic stability.

Green Investment and Its Role in Energy Security

Green investment refers to financial commitments directed toward environmentally sustainable projects, particularly within RE, clean technology, and climate-resilient infrastructure. It includes financing for solar and wind energy projects, and energy-efficient technologies, sustainable transportation, and carbon offset initiatives (OECD, 2021). Unlike conventional investments in fossil fuels, green investments look to drop carbon emissions, boost energy efficiency, and also promote long-term environmental sustainability.

At the policy level, green finance is often supported by green bonds, climate funds, tax incentives, and regulatory frameworks that encourage sustainable investment. The Global Green Finance Index (GGFI) tracks the performance of financial centers in promoting green investments, highlighting how countries integrate environmental concerns into economic policies (GGFI, 2023).

In the Indian context, green investment is growing rapidly, supported by initiatives like the National Green Hydrogen Mission, and Solar Energy Corporation of India (SECI), and Energy Service Company (ESCO) model. India issued its first sovereign green bond inside 2023, raising funds for clean energy and sustainable infrastructure (RBI, 2023). However, the effectiveness of green investments in solving India's energy security challenges remains an area of active debate.

Thus, while green investments alone may not entirely resolve India's energy security challenges, they represent a critical component of a diversified and sustainable energy strategy.

2. GREEN INVESTMENTS AND ECONOMIC GROWTH

Theoretical Framework

Economic theories such as the Environmental Kuznets Curve (EKC) and Endogenous Growth Theory suggest that investments in green technologies can result in sustainable economic growth. The EKC hypothesis argues that economic growth initially leads to environmental degradation but improves with increased investments in green technologies (Grossman & Krueger, 1995).

Empirical Evidence on Green Investments in India

ecent studies suggest a positive relationship across green investments and EG in India. A study by Bhattacharya et al. (2021) found that a 10% increase in renewable energy investment contributes to a 1.2% increase in GDP. Similarly, Ghosh et al. (2022) argue that green infrastructure projects, such as solar and wind farms, have led to regional economic development and job creation.

According to a report by the Reserve Bank of India (RBI, 2022), green finance has emerged as a key driver of sustainable development. The report highlights that India attracted \$10 billion in green bond investments in 2021, supporting clean energy projects and low-carbon transportation.

Vol. 13, Issue 1, pp: (39-44), Month: April 2025 - September 2025, Available at: www.researchpublish.com

Employment and Industrial Growth

Green investments also play a critical role in employment generation. According to the International Labour Organization (ILO, 2021), India's renewable energy sector created over 700,000 jobs in 2020. The solar industry alone employs more than 200,000 workers, with projections indicating that renewable energy could create 1 million new jobs by 2030 (IRENA, 2022).

3. GREEN INVESTMENTS AND ENERGY SECURITY

Reducing Dependence on Fossil Fuels

India's ES is closely linked to its dependence on imported fossil fuels. Currently, India imports 85% of its CO and 50% of its NG requirements (IEA, 2023). Green investments in renewable energy have significantly reduced this dependence.

A study by Patel et al. (2022) found that India's installed renewable energy capacity has risen from 50 GW in 2015 to over 170 GW in 2023. This shift has helped reduce oil imports and foreign exchange expenditures by nearly \$15 billion annually (MNRE, 2023).

Growth of Renewable Energy Sector

The Indian govt. has set ambitious RE targets, aiming to attain 500 GW of non-FF capacity by 2030 (Government of India, 2022). The International Renewable Energy Agency (IRENA, 2023) approximates India's solar and wind energy sectors will be crucial in attaining these targets.

Empirical research by Kumar & Sharma (2021) suggests that wind energy investments have improved energy access in rural areas, reducing energy poverty. Similarly, Rao & Joshi (2022) highlight how decentralized solar power projects have enhanced energy security by providing stable electricity supply to off-grid regions.

Policy Framework and Financial Mechanisms for Green Investments

The success of green investments in India hinges on a well-defined policy framework and the availability of financial mechanisms that can drive large-scale investment in RE, energy efficiency, along with sustainable infrastructure. The Indian govt. has implemented a series of regulatory, policy, and financial measures to facilitate green investments, aligning with both national economic objectives and international climate commitments.

Policy Framework for Green Investments

India's green investment policy landscape has evolved pointedly across the past two decades. The National Action Plan on Climate Change (NAPCC), introduced in 2008, serves as a foundational framework that guides India's transition toward sustainable energy and low-carbon development. The NAPCC consists of eight national missions, counting the National Solar Mission (NSM), and National Mission for Enhanced Energy Efficiency (NMEEE), and National Electric Mobility Mission Plan (NEMMP), all of which focus on promoting green investments in key sectors.

The NSM, launched in 2010, has been instrumental in scaling up India's solar energy capacity. Under this initiative, India looks to attain 280 GW of solar power capacity by 2030. Subsidies, tax incentives, and competitive bidding processes have been introduced to attract private and foreign investments into large-scale solar projects. Similarly, the National Wind-Solar Hybrid Policy (2018) encourages the development of hybrid RE projects to optimize land and transmission infrastructure usage.

The Renewable Energy Certificates (REC) Mechanism is another policy initiative designed to promote green investments. The REC mechanism enables entities to trade renewable energy credits in a market-based system, thereby incentivizing renewable energy generation. Additionally, the State Renewable Energy Policies implemented by individual states offer region-specific incentives for green energy projects. For instance, Gujarat and Rajasthan have introduced preferential tariff policies for solar and wind projects, attracting significant private investments.

Another crucial policy initiative is the Faster Adoption and Manufacturing of Electric Vehicles (FAME) Scheme, which looks to fast-track the adoption of electric vehicles (EVs) in India. The FAME-II program, with a budget of ₹10,000 crore (\$1.2 billion), provides incentives for EV manufacturers and consumers, supporting the development of charging infrastructure and battery production.

Vol. 13, Issue 1, pp: (39-44), Month: April 2025 - September 2025, Available at: www.researchpublish.com

Financial Mechanisms Supporting Green Investments

The expansion of green investments in India requires robust financial mechanisms to support large-scale infrastructure projects. Over the years, the Indian government and financial institutions have developed multiple funding options, including green bonds, and public-private partnerships (PPPs), blended finance models, and concessional loans.

Green bonds have emerged as a crucial instrument for financing RE and climate-friendly projects. India is among the leading issuers of green bonds in Asia, with cumulative green bond issuances exceeding \$10 billion by 2023 (Reserve Bank of India, 2023). These bonds, issued by public and private entities, provide a dedicated funding source for projects related to clean energy, water conservation, and sustainable transportation. The Securities and Exchange Board of India (SEBI) has introduced guidelines to ensure transparency and credibility in green bond investments.

PPPs play a pivotal role in mobilizing private sector investments for green projects. The Viability Gap Funding (VGF) Scheme, introduced by the Indian government, delivers financial support to infrastructure projects that happen to be economically justified but may not be financially viable in the short term. Several large-scale solar and wind energy projects have been implemented under PPP models, attracting investments from both domestic and international firms.

Blended finance models, which combine public funding with private sector investments, have also gained traction in India. Development finance institutions like the World Bank, and Asian Development Bank (ADB), along with International Finance Corporation (IFC) provide concessional loans and grants to de-risk investments in green projects. For instance, the World Bank's Scaling Solar Program has provided financial and technical assistance to Indian solar power developers, facilitating cost-effective solar energy deployment.

Several Indian financial institutions have introduced green financing schemes to promote sustainability-focused investments. IREDA delivers low-interest loans to RE developers, while commercial banks such as State Bank of India (SBI) and Yes Bank have introduced green financing products for corporate and individual investors. The Priority Sector Lending (PSL) Guidelines, revised by RBI, mandate banks to allot a certain portion of their credit to RE projects, further incentivizing green investments.

Despite the availability of financial instruments, challenges remain in scaling up green investments. High capital costs, policy uncertainty, and limited access to long-term financing hinder private sector participation. To overcome these barriers, India needs a more stable regulatory environment, increased financial incentives, and greater international collaboration in green financing.

Challenges in Scaling Up Green Investments

Despite significant progress in promoting green investments, India faces numerous hurdles that hinder the large-scale deployment of renewable energy projects and sustainable infrastructure. These challenges span across financial, policy, technological, and infrastructural domains, limiting the efficiency and expansion of green investments.

High Capital Costs and Limited Access to Finance

One of the primary challenges in scaling up green investments is the high initial capital cost associated with RE projects. Likened to conventional FF-based power plants, setting up solar farms, wind energy projects, and energy-efficient infrastructure requires 30–40% higher upfront investment (Gupta et al., 2023). This cost barrier discourages private sector participation, especially in the absence of affordable long-run financing options. Additionally, high interest rates on green loans and limited access to concessional funding make it difficult for small and medium enterprises (SMEs) to enter the green investment space.

Policy and Regulatory Uncertainty

Frequent changes in RE policies, power purchase agreements (PPAs), and tariff structures create uncertainty for investors. Policy reversals, such as abrupt cuts in subsidies or changes in tax incentives, discourage long-term investments. For instance, retrospective taxation on solar imports and delayed payments to renewable energy developers have negatively impacted investor confidence (Mishra & Das, 2021).

Land Acquisition and Infrastructure Bottlenecks

Large-scale RE projects require extensive land, often leading to land acquisition disputes and conflicts with local communities. Many solar and wind projects face delays due to opposition from farmers and environmental groups concerned about displacement and ecological impact (Sen et al., 2022). Moreover, India's existing power transmission and distribution infrastructure is not fully equipped to integrate high levels of intermittent renewable energy, resulting in transmission bottlenecks and grid stability issues.

Vol. 13, Issue 1, pp: (39-44), Month: April 2025 - September 2025, Available at: www.researchpublish.com

Limited Technological Innovation and Skilled Workforce

Despite advancements in clean energy technologies, India still relies heavily on imported solar panels, and wind turbines, and battery storage systems, increasing costs and supply chain vulnerabilities. Domestic manufacturing capabilities remain underdeveloped, limiting self-sufficiency in green technology production.

Financial Risks and Investment Barriers

Investors perceive renewable energy projects as high-risk ventures due to long payback periods and uncertain returns. The lack of comprehensive de-risking mechanisms, such as government-backed guarantees and insurance products, makes it difficult to attract large-scale private investments.

4. FUTURE PROSPECTS AND RECOMMENDATIONS

Strengthening Policy and Investment Frameworks

To accelerate green investments, India must adopt a long-term policy framework that ensures regulatory stability and investment security. This includes:

- 1. Strengthening public-private partnerships.
- 2. Expanding green finance initiatives.
- **3.** Enhancing technological innovation in clean energy.

Promoting Decentralized Renewable Energy Systems

Investing in decentralized solar and wind power can improve energy security and reduce transmission losses. Empirical studies by Reddy & Kumar (2023) suggest that community-based renewable energy projects have higher acceptance rates and long-term sustainability.

5. CONCLUSION

Green investments are essential for India's EG and ES. Empirical evidence suggests that renewable energy projects contribute to GDP growth, employment generation, and reduced fossil fuel dependency. However, challenges like high capital costs, policy uncertainties, and land acquisition issues must be addressed. Strengthening regulatory frameworks, expanding green finance, and promoting decentralized energy solutions can enhance India's transition directly to a sustainable future.

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