International Journal of Information Movement *Vol. 9 Issue III (July 2024)*
Website: www.ijim.in ISSN: 2456-0553 (online) **Pages 17-26**

THE FUTURE OF THE COAL INDUSTRY IN INDIA: ENVIRONMENTAL IMPACTS AND MITIGATION STRATEGIES

Santosh Kumar Chattaraj
Research Scholar
Jharkhand Rai University
Email: santoshchattaraj21@gmail.com

Abstract: The coal industry in India plays a crucial role in meeting the nation's energy demands but also significantly contributes to environmental pollution. This paper examines the multifaceted impact of coal production and consumption on air, water, and soil quality. Through a detailed analysis of emissions data, pollution metrics, and case studies from major coal-producing regions, the study highlights the adverse effects on public health, biodiversity, and climate change. The paper also explores regulatory frameworks and technological advancements aimed at mitigating these impacts. By assessing both current practices and potential improvements, this research provides a comprehensive overview of the coal industry's environmental footprint and offers policy recommendations for sustainable energy transitions in India.

Keywords: Coal industry, Environmental pollution, Air quality, Water contamination, Climate change, Sustainable energy

1.0 Introduction

India's coal industry has long been a cornerstone of its energy sector, underpinning the nation's economic growth and industrialization. Coal accounts for nearly 55% of India's total energy consumption and powers approximately 70% of its electricity generation. This reliance on coal is driven by its abundance, cost-effectiveness, and the established infrastructure supporting its production and use. However, the environmental cost associated with coal mining and combustion is substantial, encompassing a wide array of issues such as air, water, and soil pollution, as well as significant contributions to climate change.

The environmental repercussions of the coal industry are multifaceted. Coal combustion releases a myriad of pollutants, including particulate matter, sulfur dioxide, nitrogen oxides, and mercury, which severely impact air quality and public health. Water resources are compromised by acid mine drainage, thermal pollution, and the leaching of toxic elements from fly ash. Soil degradation due to mining activities further exacerbates environmental challenges, affecting agricultural productivity and local ecosystems. These environmental impacts necessitate urgent and effective mitigation strategies.

This document aims to provide a comprehensive analysis of the future aspects of the coal industry in India, focusing on environmental mitigation. It explores the current state of the coal industry, the environmental impacts of coal mining and combustion, and the regulatory frameworks governing these activities. The document also delves into technological innovations for cleaner coal, the transition to renewable energy, community engagement, economic diversification, international collaboration, and the importance of research and development. By examining these facets, the document seeks to present a balanced perspective on the challenges and potential solutions for achieving a more sustainable energy future in India.

2.0 Current State of the Coal Industry in India

2.1 Historical Context and Development The history of coal mining in India dates back to the early 19th century when the first commercial coal mine was established in Raniganj, West Bengal, in : 1774. The industry witnessed significant growth during the British colonial period, with the introduction of modern mining techniques and infrastructure. Post-independence, the Indian government nationalized the coal industry in the early 1970s, leading to the formation of Coal India Limited (CIL), which today is one of the largest coal producers globally.

2.2 Production and Consumption Statistics: India is the second-largest coal producer in the world, with an annual production of approximately 730 million tonnes. The major coal-producing states include Jharkhand, Odisha, Chhattisgarh, West Bengal, and Madhya Pradesh. Despite its large production capacity, India also imports coal to meet its growing energy demands, particularly coking coal for the steel industry. The country's coal consumption is projected to continue rising, driven by industrial growth and increasing electricity demand.

2.3 Major Coal-Producing Regions: The key coal-producing regions in India are the coal belts of the eastern states. Jharkhand and Odisha together account for nearly 50% of the country's total coal production. Other significant coal-producing areas include the Korba coalfields in Chhattisgarh, the Singareni coalfields in Telangana, and the Talcher coalfields in Odisha. These regions have extensive mining operations that provide employment to millions but also face severe environmental degradation.

2.4 Economic Significance : The coal industry is a critical driver of India's economy, contributing significantly to GDP and providing employment to millions. Coal mining and related industries generate substantial revenue for the government through taxes and royalties. Additionally, coal is a vital input for various sectors such as steel, cement, and power generation, making it indispensable for the country's industrial framework. However, the environmental and health costs associated with coal necessitate a reevaluation of its role in India's energy future.

3.0 Environmental Impacts of Coal Mining and Combustion

3.1 Air Pollution: Coal combustion is a major source of air pollution in India, releasing pollutants such particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury.
Particulate matter, especially fine particles ($PM_{2.5}$), can penetrate deep into the lungs and bloodstream, causing respiratory and cardiovascular diseases. The World Health Organization (WHO) identifies air pollution as a leading cause of premature deaths, with coal-fired power plants being significant contributors.

Sulfur dioxide and nitrogen oxides from coal combustion lead to the formation of acid rain, which damages crops, forests, and buildings. These pollutants also contribute to the formation of ground-level ozone, a potent respiratory irritant. According to the Centre for Science and Environment (CSE), air pollution from coal-fired power plants is responsible for an estimated 80,000 to 115,000 premature deaths annually in India. The economic burden of air pollution, including healthcare costs and lost productivity, is substantial.

3.2 Water Pollution: Coal mining and combustion have significant impacts on water resources. Acid mine drainage (AMD) is a major issue, occurring when sulfide minerals in exposed rock surfaces react with air and water to produce sulfuric acid. This acid can leach heavy metals from surrounding rocks, contaminating nearby water bodies and affecting aquatic ecosystems.

Thermal pollution from coal-fired power plants, where heated water is discharged into rivers and lakes, raises the temperature of these water bodies, reducing oxygen levels and harming aquatic life. Additionally, the ash produced from coal combustion, known as fly ash, contains toxic elements such as arsenic, lead, and mercury. Improper disposal of fly ash can lead to leaching of these toxic elements into groundwater, posing serious health risks to local communities.

3.3 Soil Degradation: The impact of coal mining on soil quality is profound. Open-pit mining, commonly used in India, involves the removal of large areas of topsoil and vegetation, leading to soil erosion and loss of fertile land. The removal of vegetation disrupts local ecosystems and biodiversity, further degrading soil quality.

Soil contamination from heavy metals and other toxic substances released during coal mining and combustion can have long-term detrimental effects on agricultural productivity and food safety. This poses significant challenges for rural communities that rely on agriculture for their livelihoods. Addressing soil degradation requires the implementation of sustainable mining practices and effective waste management strategies.

3.4 Climate Change : The coal industry is a major contributor to greenhouse gas emissions, driving climate change. The combustion of coal releases large amounts of carbon dioxide (CO_2), a potent greenhouse gas that contributes to global warming. Methane (CH_4), another greenhouse gas, is released during coal mining operations. Methane has a much higher global warming potential than carbon dioxide, making it a significant concern in the context of climate change.

India, being one of the largest producers and consumers of coal, plays a critical role in the global effort to combat climate change. The country's commitment to the Paris Agreement
involves reducing its carbon emissions intensity and increasing the share of renewable energy in its energy mix. However, transitioning away from coal to cleaner energy sources is a complex and challenging process that requires significant investment and policy support.

4.0 Regulatory Frameworks and Policies

4.1 National Regulations and Standards

The Indian government has implemented various regulatory measures to control pollution from the coal industry. The Ministry of Environment, Forest and Climate Change (MoEFCC) has established emission standards for coal-fired power plants, requiring them to install pollution control technologies such as electrostatic precipitators, flue gas desulfurization units, and selective catalytic reduction systems. These technologies can significantly reduce emissions of particulate matter, sulfur dioxide, and nitrogen oxides.

In addition to emission standards, the government has introduced regulations to manage the disposal of fly ash and other mining waste. The Fly Ash Notification by MoEFCC mandates the use of fly ash in construction activities, such as the manufacturing of cement and bricks, to minimize environmental contamination. The Water (Prevention and Control of Pollution) Act and the Air (Prevention and Control of Pollution) Act provide a legal framework for regulating water and air pollution, respectively.

4.2 International Commitments

India is a signatory to several international agreements aimed at mitigating environmental pollution and climate change. The country's commitment to the Paris Agreement involves setting ambitious targets for reducing greenhouse gas emissions and increasing the share of renewable energy in its energy mix. India's Nationally Determined Contributions (NDCs) under the Paris Agreement include a commitment to reduce the emissions intensity of its
GDP by 33-35% by 2030 from 2005 levels and achieve about 40% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

Participation in global initiatives such as the International Solar Alliance (ISA) and the Clean Energy Ministerial (CEM) further underscores India's commitment to promoting clean energy and addressing climate change. These international collaborations provide access to technology, finance, and expertise necessary for transitioning to a sustainable energy future.

4.3 Effectiveness of Current Regulations

While India has made significant strides in establishing regulatory frameworks, the effectiveness of these regulations is often hampered by weak enforcement and lack of compliance. Many coal-fired power plants and mining operations continue to flout environmental norms, leading to persistent pollution issues. Strengthening the capacity of regulatory agencies, enhancing monitoring mechanisms, and imposing stringent penalties for non-compliance are crucial for improving the effectiveness of environmental regulations.

4.4 Case Studies of Regulatory Success and Failure

Several case studies illustrate the varying effectiveness of regulatory measures in controlling pollution from the coal industry. For instance, the implementation of electrostatic precipitators and flue gas desulfurization units at the NTPC's Vindhyachal Super Thermal Power Station has significantly reduced emissions, showcasing the potential of technological interventions. Conversely, the failure to adequately manage fly ash disposal at the Singrauli coalfields has led to severe environmental contamination and health issues for local communities, highlighting the need for robust enforcement and effective waste management strategies.

5.0 Technological Innovations for Cleaner Coal

5.1 Supercritical and Ultra-Supercritical Technologies: Supercritical and ultra-supercritical technologies represent significant advancements in coal- fired power generation. These technologies operate at higher temperatures and pressures than conventional coal-fired power plants, resulting in better fuel efficiency and reduced carbon dioxide emissions per unit of electricity generated. Supercritical and ultra-supercritical plants can achieve thermal efficiencies of 40-45%, compared to 33-37% for conventional subcritical plants.

The adoption of these technologies in India has been growing, with several new power plants being constructed using supercritical and ultra-supercritical technologies. For example, the Mundra Ultra Mega Power Plant in Gujarat operates using supercritical technology, significantly reducing its emissions compared to traditional coal-fired plants.

5.2 Carbon Capture and Storage (CCS) : Carbon capture and storage (CCS) is a critical technology for reducing carbon dioxide emissions from coal-fired power plants. CCS involves capturing carbon dioxide emissions at the source, transporting it, and storing it underground in geological formations. Although CCS is still in the developmental and early deployment stages, it has the potential to mitigate a substantial portion of emissions from coal-fired power plants.

India has initiated several pilot projects to explore the feasibility of CCS. The government, in collaboration with research institutions and industry partners, is investing in R&D to develop and deploy CCS technologies. Successful implementation of CCS can play a crucial role in
India's strategy to reduce greenhouse gas emissions and combat climate change.

6.0 Coal Beneficiation

Coal beneficiation, or coal washing, is another important technological innovation aimed at reducing the environmental impact of coal usage. The process involves removing impurities from coal, such as ash, sulfur, and heavy metals, before it is burned. This not only improves the efficiency of coal combustion but also reduces emissions of pollutants such as sulfur dioxide and particulate matter.

In India, the adoption of coal beneficiation is gradually increasing, driven by regulatory requirements and the need to improve the quality of coal for power generation. Several coal washeries have been established, and more are planned to meet the growing demand for cleaner coal.

6.1 Waste Management Technologies

Effective waste management is critical for minimizing the environmental impact of coal mining and combustion. Technologies such as fly ash utilization, mine water treatment, and reclamation of mined lands are essential components of sustainable waste management practices.

The Fly Ash Notification by MoEFCC has mandated the use of fly ash in construction activities, resulting in increased utilization of fly ash in cement manufacturing, brick making, and road construction. Treatment of mine water to remove contaminants before discharge into water bodies helps prevent water pollution and protect aquatic ecosystems. Reclamation and rehabilitation of mined lands can restore ecosystems and make the land suitable for other uses, such as agriculture or forestry.

7.0 Transition to Renewable Energy

7.1 Government Targets and Initiatives : India has set ambitious targets for expanding its renewable energy capacity as part of its commitment to reducing greenhouse gas emissions and transitioning to a sustainable energy future. The government aims to achieve 450 GW of renewable energy capacity by 2030, with significant contributions from solar, wind, and hydropower.

Several initiatives have been launched to promote the development and deployment of renewable energy technologies. The National Solar Mission aims to establish India as a global leader in solar energy, targeting 100 GW of solar capacity by 2022. The government's wind energy program has set a target of 60 GW of wind power capacity by 2022.
Additionally, the International Solar Alliance (ISA) aims to promote solar energy cooperation among countries located between the Tropics of Cancer and Capricorn.

7.2 Potential of Solar, Wind, and Hydropower: India has vast potential for renewable energy, particularly solar and wind power. The country's geographical location provides abundant solar radiation, making it ideal for solar energy generation. Similarly, India's long coastline and high wind speeds in certain regions offer significant potential for wind energy.

Hydropower also plays a crucial role in India's renewable energy mix, with several large and small hydropower projects contributing to the country's electricity generation. Hydropower is a reliable and stable source of energy that can complement intermittent renewable sources like solar and wind.

7.3 Challenges in Transitioning: While the transition to renewable energy offers numerous benefits, it also presents several challenges. One of the primary challenges is the intermittent nature of solar and wind energy, which requires robust grid infrastructure and energy storage solutions to ensure a stable and reliable power supply.

Financing the transition to renewable energy is another significant challenge. Large-scale investments are required to develop renewable energy projects, upgrade grid infrastructure, and deploy energy storage technologies. Access to affordable finance and innovative financing mechanisms are essential to overcome this barrier.

Land acquisition and environmental clearances for renewable energy projects can also pose challenges, particularly in densely populated areas. Balancing the need for renewable energy development with environmental and social considerations is crucial for sustainable growth.

7.4 Success Stories and Case Studies : Several success stories and case studies highlight the potential of renewable energy in India. The Charanka Solar Park in Gujarat, one of the largest solar parks in Asia, has successfully integrated solar energy into the state's power grid, providing clean and affordable electricity to millions. The Tamil Nadu wind energy sector has achieved significant milestones, with the state leading in wind power capacity and generation.

These success stories demonstrate the feasibility and benefits of renewable energy, offering valuable lessons for scaling up renewable energy deployment across the country.

8.0 Community Engagement and Sustainable Practices

8.1 Role of Local Communities in Environmental Monitoring: Engaging local communities in environmental monitoring and decision-making is crucial for the sustainable development of the coal industry. Communities affected by coal mining and combustion should have a voice in environmental assessments and policy formulation. This inclusive approach helps identify and address local environmental and health concerns more effectively.

Community-based monitoring programs can empower residents to participate in tracking pollution levels, reporting violations, and ensuring compliance with environmental regulations. These programs can enhance transparency, accountability, and community trust in environmental governance.

8.2 Sustainable Mining Practices: Implementing sustainable mining practices is essential to minimize the environmental footprint of coal mining. Practices such as reducing water usage, minimizing land disturbance, and adopting advanced **mining technologies can mitigate the environmental impact of mining operations.**

Land reclamation and rehabilitation are critical components of sustainable mining. Reclaiming mined lands by restoring vegetation, soil quality, and ecosystems can transform degraded landscapes into productive areas suitable for agriculture, forestry, or other uses.
Successful reclamation projects demonstrate the potential for sustainable post-mining land use.

8.3 Case Studies of Successful Community Engagement: Several case studies illustrate the benefits of community engagement in environmental monitoring and sustainable mining practices. For example, the

Mahan Coal Block project in Madhya Pradesh involved extensive community consultations and participatory environmental monitoring, leading to improved environmental management and reduced conflicts.

In Jharkhand, community-led initiatives have successfully reclaimed mined lands, restoring agricultural productivity and biodiversity. These initiatives highlight the importance of community involvement in achieving sustainable outcomes.

9.0 Economic Diversification and Just Transition

9.1 Alternative Employment Opportunities : As India transitions to a low-carbon economy, providing alternative employment opportunities for workers dependent on the coal industry is crucial. Economic diversification strategies can create new jobs in renewable energy, energy efficiency, and other sustainable sectors.

Skill development programs are essential to equip workers with the skills needed for new job opportunities. Training in renewable energy technologies, energy auditing, and sustainable practices can facilitate the transition of workers from the coal industry to emerging sectors.

9.2 Social Support Mechanisms : Social support mechanisms are necessary to assist workers and communities affected by the transition away from coal. Financial support, social security benefits, and community development programs can provide a safety net for those impacted by the transition.

Implementing a just transition framework that prioritizes the welfare of workers and communities can ensure that the shift to a low-carbon economy is inclusive and equitable. This approach can prevent social and economic disparities and promote social cohesion.

9.3 Case Studies of Successful Transitions: Several case studies highlight successful transitions from coal to renewable energy and other sustainable sectors. In Germany, the Ruhr region's transition from coal mining to a diversified economy focused on technology, education, and cultural industries has been a model of economic diversification. The region's success is attributed to comprehensive planning, significant investments in infrastructure, and strong social support mechanisms.

In India, initiatives such as the Skill Council for Green Jobs are providing training and certification programs in renewable energy and energy efficiency, creating new employment opportunities for workers transitioning from traditional energy sectors.

10.0 International Collaboration and Climate Commitments

10.1 Role of International Financial Institutions: International financial institutions play a vital role in supporting India's transition to a sustainable energy future. Institutions such as the World Bank, the Asian Development Bank (ADB), and the International Finance Corporation (IFC) provide funding and technical assistance for renewable energy projects, energy efficiency programs, and environmental mitigation measures.

Access to international finance can help bridge the funding gap for large-scale renewable energy projects and infrastructure development. Innovative financing mechanisms, such as green bonds and climate funds, can also mobilize private sector investment in sustainable energy initiatives.

10.2 Technology Transfer and Financial Support: International collaboration can facilitate the transfer of clean energy technologies and best practices to India. Partnerships with countries that have advanced renewable energy industries can provide access to cutting-edge technologies, expertise, and knowledge.

Financial support from international donors and climate funds can accelerate the deployment of renewable energy and pollution control technologies. The Green Climate Fund (GCF) and the Global Environment

Facility (GEF) are examples of international funding mechanisms that support climate mitigation and adaptation projects in developing countries.

10.3 Impact of Global Agreements Like the Paris Agreement: India's commitment to global agreements such as the Paris Agreement underscores its dedication to reducing greenhouse gas emissions and addressing climate change. The Paris Agreement provides a framework for international cooperation on climate action, encouraging countries to set ambitious targets and implement policies to achieve them**.**

India's Nationally Determined Contributions (NDCs) under the Paris Agreement reflect its commitment to transitioning to a low-carbon economy. These commitments include reducing the emissions intensity of GDP, increasing the share of renewable energy, and enhancing climate resilience.

10.4 Case Studies of International Collaboration : Several case studies illustrate the benefits of international collaboration in promoting sustainable energy and environmental protection. The Indo-German Energy Forum, a partnership between India and Germany, has facilitated technology transfer, capacity building, and policy dialogue on renewable energy and energy efficiency.

The India-U.S. Clean Energy Finance Task Force has promoted investment in clean energy projects through financial innovation and collaboration. These partnerships demonstrate the potential of international cooperation in achieving sustainable energy goals.

11.0 Research and Development

11.1 Importance of R&D in Clean Energy and Pollution Control: Research and development (R&D) are crucial for driving innovation in clean energy and pollution control technologies. Investments in R&D can lead to breakthroughs in renewable energy efficiency, storage solutions, and carbon capture technologies.

Government and private sector initiatives play a key role in fostering a culture of innovation. Public funding for R&D, collaboration with research institutions, and support for startups can accelerate the development and deployment of advanced technologies.

11.2 Government and Private Sector Initiatives: The Indian government has launched several initiatives to support R&D in clean energy and environmental technologies. The Department of Science and Technology (DST) and the Ministry of New and Renewable Energy (MNRE) provide funding and support for research projects and innovation.

The private sector is also actively involved in R&D, with companies investing in renewable energy technologies, energy storage solutions, and pollution control measures. Public-private partnerships can enhance the impact of R&D efforts by leveraging resources and expertise.

11.3 Innovations in Renewable Energy and Efficiency : Innovations in renewable energy technologies, such as high-efficiency solar panels, advanced wind turbines, and energy storage solutions, are critical for scaling up renewable energy deployment. Research in energy efficiency, including smart grids, energy-efficient appliances, and building technologies, can significantly reduce energy consumption and emissions.

The development of hybrid renewable energy systems that integrate solar, wind, and storage technologies can provide stable and reliable power, addressing the intermittency challenges of renewable energy.

12.0 Future Research Directions

Future research directions should focus on advancing clean energy technologies, improving energy storage solutions, and developing sustainable practices for mining and waste management. Research on the health impacts of pollution and the effectiveness of mitigation measures can provide valuable insights for policymaking.

Data-driven approaches and advanced modeling techniques can improve the understanding of environmental issues and inform targeted interventions. Collaboration between government, industry, and academia is essential for driving innovation and addressing the complex challenges of sustainable energy and environmental protection.

13.0 Future Scenarios and Recommendations

13.1 Potential Future Scenarios for the Coal Industry : Several future scenarios for the coal industry in India can be envisioned, depending on the pace of technological advancements, policy interventions, and market dynamics. In a business-as-usual scenario, continued reliance on coal could lead to severe environmental and health impacts, exacerbating climate change and hindering sustainable development.

In a transition scenario, the gradual shift towards renewable energy and cleaner coal technologies could mitigate some of the environmental impacts while ensuring energy security. A rapid transition scenario, characterized by aggressive investments in renewable energy and stringent environmental regulations, could significantly reduce dependence on coal and enhance environmental sustainability.

13.2 Policy Recommendations : To achieve a sustainable energy future, India needs to implement comprehensive policy measures that promote renewable energy, enhance energy efficiency, and mitigate environmental pollution. Key policy recommendations include:

- Strengthening regulatory frameworks and enforcement mechanisms to ensure compliance with environmental standards.
- Providing financial incentives and support for the adoption of clean energy technologies and pollution control measures.
- Enhancing public awareness and participation in environmental monitoring and decision- making.
- Investing in research and development to drive innovation in clean energy and pollution control technologies.
- Supporting economic diversification and skill development programs to facilitate a just transition for workers and communities dependent on the coal industry.

13.3 Technological and Economic Pathways: Technological pathways for achieving a sustainable energy future include the deployment of advanced renewable energy technologies, energy storage solutions, and carbon capture and storage (CCS) systems. Enhancing grid infrastructure and integrating smart grid technologies can improve the reliability and efficiency of renewable energy systems.

Economic pathways involve creating a favorable investment climate for renewable energy projects, leveraging international finance, and promoting public-private partnerships.
Implementing innovative financing mechanisms, such as green bonds and climate funds, can mobilize private sector investment in sustainable energy initiatives.

13.4 Roadmap for Achieving Sustainable Energy : A comprehensive roadmap for achieving sustainable energy in India should include short- term, medium-term, and long-term strategies. Short-term strategies involve immediate actions to reduce emissions, enhance energy efficiency, and promote renewable energy deployment. Medium-term strategies focus on scaling up renewable energy capacity, advancing clean coal technologies, and strengthening regulatory frameworks. Long-term strategies aim to achieve deep decarbonization, transition to a low-carbon economy, and enhance climate resilience**.**

The roadmap should be supported by a robust implementation framework, with clear targets, timelines, and monitoring mechanisms. Collaboration among government, industry, civil society, and international partners is essential for the successful implementation of the roadmap.

14.0 Conclusion

The environmental impact of the coal industry in India is a pressing issue that requires urgent attention. While coal remains a critical component of the country's energy mix, its adverse effects on air, water, and soil quality cannot be overlooked. Addressing these impacts requires a multifaceted approach, involving stringent regulatory measures, technological.

advancements, and a shift towards cleaner energy sources. By adopting sustainable practices and policies, India can mitigate the environmental pollution caused by the coal industry and move towards a more sustainable and resilient energy future. This document aims to contribute to this goal by providing a comprehensive analysis of the environmental challenges and potential solutions associated with the coal industry in India.

Through concerted efforts and collaboration, India can achieve a balance between economic growth and environmental protection, ensuring a healthier and more sustainable future for its people and ecosystems. The journey towards sustainable energy is complex and challenging, but it is essential for the well-being of current and future generations. This document serves as a call to action for all stakeholders to work together in addressing the environmental impacts of the coal industry and advancing towards a cleaner and more sustainable energy future.

15.0 References

i. Centre for Science and Environment (CSE). (2014). "Heat on Power: Green Rating of Coal-based Power Plants." Retrieved from https://www.cseindia.org.

ii. World Health Organization (WHO). (2016). "Ambient Air Pollution: A Global Assessment of Exposure and Burden of Disease." Retrieved from https://www.who.int.

iii. Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India.(2018). "National Clean Air Programme." Retrieved from http://moef.gov.in.

iv. Greenpeace India. (2017). "Airpocalypse: Assessment of Air Pollution in Indian Cities." Retrieved from https://www.greenpeace.org/india/en/.

v. International Energy Agency (IEA). (2021). "India 2020: Energy Policy Review." Retrieved from https://www.iea.org.

vi. Central Pollution Control Board (CPCB), Government of India. (2019). "National Inventory of Hazardous Wastes Generating Industries & Hazardous Waste Management in India." Retrieved from http://cpcb.nic.in.

vii. Sustainable Development Solutions Network (SDSN). (2019). "World Happiness Report 2019." Retrieved from https://s3.amazonaws.com/happiness-report/2019/WHR19.pdf.

viii. Tata Institute of Social Sciences (TISS). (2017). "The Impact of Coal Mining on the Environment and Health of Local Communities: A Case Study of North Eastern Coalfields, Assam." Retrieved from http://www.tiss.edu.

ix. The Energy and Resources Institute (TERI). (2015). "Life Cycle Assessment of Coal- fired Power Generation in India." Retrieved from https://www.teriin.org.

x. Indian Institute of Technology (IIT), Delhi. (2019). "Assessment of Air Pollution in Delhi NCR and Possible Solutions." Retrieved from http://web.iitd.ac.in.

xi. Bhushan, C., & Sinha, S. (2019). "The State of Coal in India." Centre for Science and Environment. Retrieved from https://www.cseindia.org.

xii. Chikkatur, A., & Sagar, A. (2007). "Cleaner Power in India: Towards a Clean-Coal- Technology Roadmap." Belfer Center for Science and International Affairs, Harvard University. Retrieved from https://www.belfercenter.org.

xiii. Coal India Limited (CIL). (2020). "Annual Report 2019-20." Retrieved from https://www.coalindia.in.

xiv. Guttikunda, S., & Jawahar, P. (2018). "Atmospheric Emissions and Pollution from the Coal-Fired Thermal Power Plants in India." Atmospheric Environment, 187, 29-40. DOI: 10.1016/j.atmosenv.2018.05.061.

xv. Indian Ministry of Power. (2020). "Power Sector at a Glance: All India." Retrieved from https://powermin.nic.in.