Impact of Coal mining sites near Hazaribagh, Jharkhand- A Socio- Environmental analysis

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***Abstract*—A large portion of Jharkhand's GDP, especially in the areas surrounding Hazaribagh, comes from coal mining. Appropriate mining extraction and the development of rural and tribal communities around mining sites have been often stated by the government, but these claims have not been turned into practical solutions. The rich are meeting their growing needs by plundering rural and tribal areas' natural resources. This article aimed to examine the effects of coal mining on the local ecology, considering both control and experimental villages, in light of the context provided. Although it has dealt with environmental issues on a local level, the majority of its attention has been on the social effects of mining on water, noise, and air quality. The pollution index show that the industrial area (180) and rural area (120) are alarmingly high. The same result also is there depicted from spatial distribution of pollution in the study area. The findings highlight the transition of coal based energy dependency to renewable sources of energy and area is having enough potential in this. The findings highlight the need for renew regulatory measures, improved sustainable mining practices to mitigate the negative impacts. Addressing these issues is crucial for balancing economic benefits with environmental and social well-being**

***Index Terms*—Pollution, biodiversity, livelihoods.**

I. INTRODUCTION

Several coal-extracting companies have sprung up alongside the commercialization of coal mining as a means to satisfy the country's energy demands. Coal mining is a common activity that brings in a lot of money for the country, but also has a negative impact on people's wellness and the surroundings. Doing so endangers local livelihood systems, has a detrimental effect on the regional financial system, and degrades the local ecology. The socioeconomic and ecological costs of depleting a country's natural resource wealth are clear. Research by Ramsay (2011), Rossi (2011), and Williams (2011) demonstrates that resource extraction has multiple detrimental effects on a worldwide scale. While Hota and Behra (2016) found that people living in the vicinity of mining experienced advantages as well as disadvantages from extraction of coal, they also found that resource rents should be reinvested in the regrowth of the region's natural wealth. They demonstrate how the state encouraged mining on rural areas while ignoring the value of natural capital assets. According to their research, one area where resistance could arise is in the general degradation of the natural resource base. It is crucial to remember (Use 3.5-for impact) that the scale and dimension of mining are always up for debate, and the study's reliance on a raw materialistic approach implies that the effect of extraction of coal should be understood in terms of resource curses and blessings. They state that the forest, river, and lake all vanished because of extraction activities that went on for a hundred years.

In same way coal mining is a crucial economic activity in Jharkhand, particularly in the Hazaribagh region, which is rich in coal reserves. It plays a vital role in India's energy production, supporting industries and employment. However, mining activities have significant social and environmental repercussions, affecting local communities and ecosystems. Studies have shown that mining-induced displacement disrupts the socio-economic fabric of affected populations, leading to loss of livelihoods, inadequate rehabilitation, and cultural erosion (Singh & Lahiri-Dutt, 2019). Many displaced communities struggle with inadequate compensation and limited access to alternative employment opportunities, exacerbating poverty and social unrest. Environmentally, coal mining leads to deforestation, soil erosion, and contamination of air and water sources. Research indicates that coal dust and emissions from mining sites contribute to air pollution, leading to respiratory diseases among local populations (Tiwary, 2001). Additionally, the contamination of groundwater and surface water by heavy metals and toxic effluents threatens agricultural productivity and drinking water safety (Mishra & Patel, 2018). Unregulated and unsustainable mining practices further accelerate biodiversity loss and climate change concerns in the region. Given these challenges, this study aims to examine the social and environmental impact of coal mining in regions near Hazaribagh. By analysing existing literature and field data, it highlights the urgent need for sustainable mining practices, better regulatory frameworks, and effective rehabilitation programs to mitigate adverse effects. Addressing these issues is essential for ensuring a balance between economic growth and environmental sustainability.

II. STUDY AREA

It gives an overview of the geographical and socio-economic characteristics of Hazaribagh. It lays down the district's location, demographic profile, economic activities, and cultural context in relation to coal mining. The chapter shall go ahead to present the environment and social problems that face Hazaribagh, which relate to pollution, health, and infrastructure issues. The major intention of this chapter is to set the stage for the research being conducted, with an excellent understanding of the study area and pointing out the unique characteristics and challenges that a coal-based community in Hazaribagh faces.

The study area is located within the geographic coordinates of 23.25° N latitude and 85.34° E longitude, placing it in the eastern part of India, specifically in the state of Jharkhand. Covering an area of approximately 4,312 square kilometers, this region includes a combination of hilly terrains, flat plains, and forested areas, making it geographically diverse. Its strategic location in/ Jharkhand places it within a region that is rich in natural resources, particularly coal, which has played a critical role in the economic development of the area. To the north, the study area is bounded by the Koderma district, known for its mineral-rich deposits, including mica and other industrial minerals. This northern boundary forms a vital link between the region's mining activities and the transport routes that facilitate the export of minerals to nearby processing centers. The southern boundary is shared with Ramgarh district, an area that is heavily industrialized due to its rich coal deposits and the presence of thermal power plants that supply electricity to neighboring states. The close proximity of the study area to Ramgarh enhances its connectivity to key industrial zones, further emphasizing its role as an energy provider for the region (Singh & Patel, 2021).

The topography of the study area is characterized by a mixture of plains, plateaus, and hilly terrains, significantly influencing both the natural resources and economic activities of the region. The region's altitude ranges from 300 to 800 meters above sea level, creating a diverse landscape. The climate of the study area falls within the tropical monsoon zone, which is characterized by hot summers, significant monsoon rains, and mild winters. During the summer months, temperatures can soar to as high as 40°C, while winter temperatures typically range between 10°C and 15°C. The monsoon season, which lasts from June to September, brings the majority of the annual rainfall, ranging from 1,200 to 1,500 mm per year

III. METHODOLOGY

The methodology applied in the investigation of the socio-economic and environmental impacts arising from the dependency on coal in the study area, alongside the exploration of renewable energy solutions near Hazaribagh, Jharkhand. The methodology encompasses a multifaceted approach designed to capture both quantitative and qualitative data, ensuring a comprehensive understanding of the dynamics at play in coal-dependent communities. This research aims to explore the socio-economic challenges, environmental degradation, and the readiness for the transition to renewable energy systems, such as solar and wind power, that can potentially offset the negative impacts of coal mining and consumption

The research design is methodologically grounded in a mixed-method approach, blending quantitative data from household surveys and environmental statistics with qualitative data derived from interviews and focus groups with key stakeholders. This dual approach enables a holistic exploration of both numerical trends and human perspectives, making the findings more robust and actionable. The collection and analysis of data are tailored to address the core research questions, including the extent of socio-economic dependence on coal, the environmental impacts of mining activities, and the viability of renewable energy adoption in the region. Additionally, by utilizing modern statistical and analytical tools such as SPSS for quantitative analysis and NVivo for thematic analysis of qualitative data, this research ensures accuracy and reliability in its findings.

The data collection methods were carefully chosen to ensure the inclusivity of various demographic groups and sectors affected by coal dependency. The study involves stratified random sampling to ensure the representativeness of the surveyed population, while interviews target stakeholders from government, industry, and the local community. This diversity in data sources strengthens the validity of the findings by ensuring that all relevant perspectives are considered. Furthermore, secondary data sources, including official government reports and academic literature on environmental impacts and energy transitions, provide critical background information that informs the analysis.

The analytical techniques employed in this study are designed to provide clear insights into the research questions. Quantitative data are analysed using descriptive and inferential statistical methods to identify trends in employment, income, health impacts, and environmental degradation. Qualitative data, on the other hand, are processed through thematic coding, allowing for the identification of key themes and patterns in the narratives provided by community members and stakeholders. By using this combination of analytical techniques, the research ensures that the results are both reliable and valid, contributing to a deeper understanding of the region's socio-economic and environmental challenges as well as the opportunities for renewable energy transition.

IV. RESULT AND DISCUSSION

A. Socio-economic impact:

The study area relies heavily on coal-based businesses, affecting employment, income distribution, and economic stability. Since a large section of the population works in coal mining and related businesses, coal dependency has shaped local employment patterns. This dependence on a single business makes the local economy vulnerable to coal demand swings or policy-driven output cuts. Due to reliance, the job sector is dominated by mining and industrial labour with little diversity. Since coal markets fluctuate due to global energy transitions and environmental laws, the region confronts job security issues. Industry sensitivity to demand swings, technology advances, and regulatory pressures causes cyclic employment instability for many individuals.

Economic inequality exists between coal-dependent industrial workers and agricultural and small-business owners in the study area. Due to its high-risk and labour-intensive nature, coal mining wages are slightly higher than other local industries. However, this income advantage has high health and environmental costs. For instance, respiratory ailments and chronic health difficulties among coal workers and their families increase healthcare costs, offsetting mining income gains. The concentration of economic opportunities in coal mining creates income inequality, as non-mining households earn less and have fewer economic options.

These socio-economic dynamics highlight the need for specific actions to diversify employment, reduce income inequality, and boost economic resilience by investing in renewable energy and sustainable agriculture. By solving these socio-economic issues, the region might reduce its coal dependence, increase job security, and develop a more balanced, sustainable economy that meets global energy transition goals.

B. Environmental Impact:

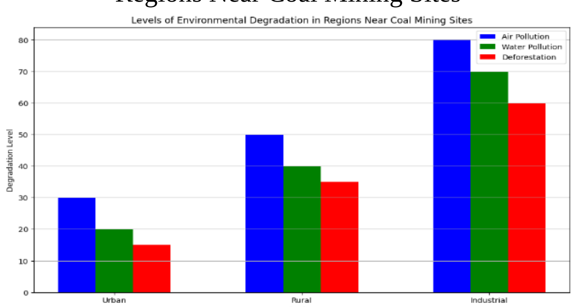
Widespread coal mining in the study area affected air and water quality, deforestation, and biodiversity. Heavy air pollution is caused by excavation and coal combustion, which release particulates, sulphur dioxide, and nitrogen oxides (Table 1 and Figure 1). This pollution affects air quality and causes respiratory illnesses, especially in mines. Mining dust pollutes air and waterways, endangering adjacent communities. Verma & Singh (2024) said so. From Table 1 it is clear that industrial locations have 180 AQI, while urban areas have 75. Industrial and rural areas have higher AQI levels due to coal mining pollution.

Table 1: Environmental Pollution Indicators by Region

Indicator	Urban	Rural	Industrial
Air Quality Index	75	120	180
Water Contamination	Low	Moderate	High
Deforestation Rate (%)	5	15	25

Monsoon season coal mining intensifies environmental difficulties. Monsoons damage streams and crops with mine tailings and rubbish. Heavy rainfall causes soil erosion and restricts infrastructure access on mining-destabilized ground, worsening landslides. Environmental deterioration and regional health, safety, and agricultural productivity concerns grow with seasonality. Figure 1 compares environmental degradation in urban, rural, and industrial regions near Hazaribagh area, showing coal mining's harmful effects. Air pollution, water pollution, and deforestation are shown in the figure to quantify how coal mining harms the environment. The graph shows how these environmental impacts vary by location near coal mining sites.

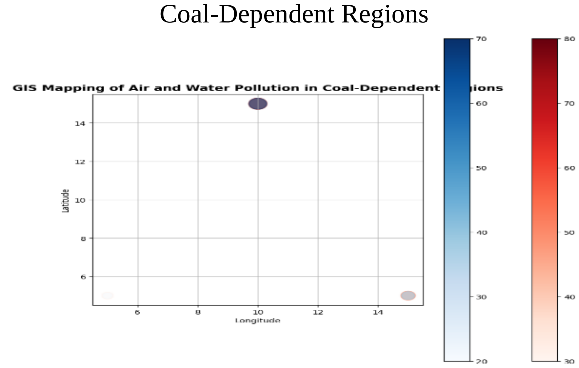
Figure 1: Levels of Environmental Degradation in Regions Near Coal Mining Sites



Heavy metals and acidic discharge from coal mining pollute rivers and groundwater. This pollution increases mercury, arsenic, and lead in water, threatening humans, and aquatic life. Community drinking and agricultural water users can develop gastrointestinal and chronic ailments from these contaminants. Farming communities suffer economically from polluted water's effects on growth and soil fertility. Also reported by Sharma et al., 2024. Coal mining destroys ecosystems and displaces many species. Forest loss reduces biodiversity and carbon sequestration, causing climate change. Habitat destruction threatens endemic flora and fauna, reducing biodiversity. Forestry and mining-induced soil erosion reduces soil stability and increases landslide risk. Kumar & Rao (2024) reported this. Addressing these environmental impacts requires stringent regulatory measures and a shift towards more sustainable practices, such as land reclamation, water treatment facilities, and stricter emissions controls. By implementing these measures, the region could mitigate some of the environmental degradation caused by coal mining and create a more sustainable, resilient ecosystem that supports both human and ecological health (Patel & Mehta, 2024).

Geographic Information Systems (GIS) are used to map coal mining's environmental implications on air and water pollution in urban, rural, and industrial locations in Figure 2. This map shows pollution spread and link to coal mining. Markers of varied sizes and colors indicate air and water pollution in each region. Regional air pollution levels are shown by red markers on the map (Figure 2). Greater air pollution is indicated by larger markers. The industrial zone has the largest red marker, indicating the highest air pollution, although the rural area also has significant air pollution. In contrast, urban areas have the smallest red marker, signifying reduced air pollution. This shows that mining site contamination directly affected industrial districts and spread to rural areas. Air quality and inhabitant health may be affected by this activity. Urban regions are further from coal mining, yet energy production and transportation emissions from coal use affect them.

Figure 2: GIS Mapping of Air and Water Pollution in Coal-Dependent Regions



Water contamination in each region is shown by blue markers, with larger markers signifying severity. Air pollution and water contamination are heaviest in the industrial region, as seen by the huge blue marker.

Acid mining drainage, heavy metal contamination, and mining site discharge pollute industrial water. Local rivers, lakes, and groundwater are contaminated by coal mining near industrial regions, causing substantial environmental and health problems (Sharma & Gupta, 2021). Water contamination in rural areas is modest. Water runoff from mining regions pollutes local waterways, which rural residents drink and irrigate. Smaller blue sign indicates urban water pollution is lowest.

C. Potential for Renewable Energy Transition

Based on environmental and geographical considerations, solar and wind energy are the best options for renewable energy in the region. Due to year-round sunlight, photovoltaic (PV) installations may harness solar energy. Solar energy could minimize the region's coal dependence by offering a reliable, sustainable power source with over 300 bright days per year. Feasibility studies show that solar PV systems in urban and rural areas could cover local electricity needs and feed excess energy into the national grid, improving energy security (Sharma & Verma, 2024). Wind energy is promising, especially in elevated places with high wind speeds for power generation. Western hilly locations, with heavy winds, are ideal for wind turbines. Small and medium-sized wind farms could provide local energy and create turbine installation and maintenance jobs. These renewable energy options would diversify the economy while lowering coal use and air and water pollution from coal mining. Several socio-political and economic aspects affect the region's renewable energy adoption. After India committed to aggressive climate objectives under the Paris Agreement, national and state governments are supporting renewable energy programs. Green technology investments are supported by government incentives, tax breaks, and subsidies. The region's public-private partnerships to accelerate renewable energy projects boost the argument for solar and wind power growth. Climate finance organisations' worldwide funding has also made large-scale renewable systems' initial investments easier (Kumar & Singh, 2024). Economic and infrastructural constraints hinder renewable energy adoption despite these enablers. High upfront costs of solar and wind energy projects can inhibit investors, especially in rural locations. Even with government subsidies and tax advantages, many small and medium-sized firms struggle to enter the renewable sector. Additionally, rural places' poor energy infrastructure makes renewable energy absorption into the grid difficult. Increased grid modernization, energy storage, and local worker capacity are needed to overcome these challenges (Rao et al., 2024). Social acceptance is also important, as coal-dependent communities may fight a change owing to job losses and economic relocation. Renewable energy projects need retraining programs, community engagement, and equitable economic advantages to achieve local support. A smooth transition from coal to renewables requires addressing these socio-economic problems to create a sustainable, resilient energy system that meets local and national environmental goals (Verma & Mehta, 2024).

Figure 3: Trends in Carbon Emissions vs Renewable Energy Adoption (2010–2030)

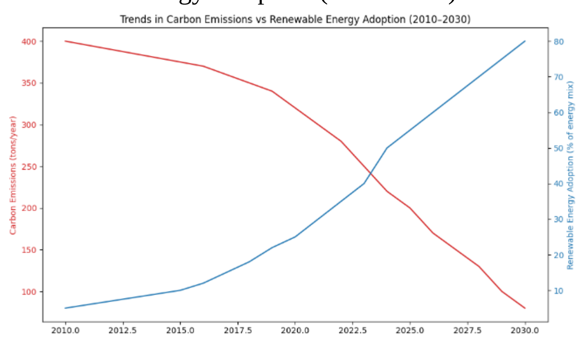


Figure 3-line graph compares carbon emissions and renewable energy deployment from 2010 to 2030. Research confirms that clean energy (solar, wind, and hydropower reduces carbon emissions over time) which is there in forecasted figure is the way to go due to the seriousness and immediateness of the problem. The graph is explained in detail below. The increase trend of clean energy sources is indicating the urgency and the objective to reduce the carbon emission in future.

V. CONCLUSION

Coal mining at Hazaribagh, Jharkhand, has boosted economic growth and energy production. However, it has caused community dislocation, livelihood loss, air and water pollution, deforestation, and long-term ecological deterioration. Public health and biodiversity are at risk, highlighting the need for sustainable mining and tougher environmental regulations. This study supports numerous

Sustainable Development Goals (SDGs) by addressing sustainable energy, economic stability, and environmental protection. This research supports SDG 7—Affordable and Clean Energy—by showing that solar and wind energy may replace coal in coal-dependent regions. Jharkhand must explore solar, wind, and biomass energy as the globe moves toward cleaner energy. Renewable energy can cut coal use, carbon emissions, and help affected communities find jobs. Policy interventions, clean energy project funding, and skill development for coal workers are needed for a successful transition. Economic growth and environmental sustainability must be balanced, according to this study. Jharkhand can build a sustainable and resilient future by supporting responsible mining, rehabilitating damaged communities, and switching to renewable energy. Inclusion is key to a cleaner, more sustainable growth route for people and the environment.

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