Impact of Energy Transition on Employment and Livelihoods in Ramgarh District, Jharkhand- A Case Study

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Abstract—**The transition from coal-based energy to renewable energy sources has significant socio-economic implications for coal-dependent communities in Ramgarh, Jharkhand. This study examines the impact of energy transition on employment and livelihoods in the region, focusing on job displacement, skill gaps, alternative livelihood opportunities, and government interventions. Through qualitative and quantitative analysis, including field surveys and stakeholder interviews, the study highlights the challenges faced by coal workers, such as income instability, lack of retraining programs, and limited employment opportunities in emerging industries. Additionally, it explores potential pathways for sustainable livelihoods, including renewable energy jobs, agro-based industries, and small-scale entrepreneurship. The findings suggest that a just transition framework, incorporating targeted skill development, financial support, and community engagement, is essential to minimize economic disruptions and ensure a fair transition for affected workers. This research underscores the need for inclusive policies that balance economic growth, environmental sustainability, and social welfare in coal-dependent regions like Ramgarh.**

Index Terms—Energy, Transition, Livelihood, Employment

I. INTRODUCTION

The global energy scenario is fast undergoing a sea change as many nations across the globe realize stringent requirements that call for shifting energy use from fossil fuels to renewable sources of energy. This is in regard to urgent requirements to avoid climate change and achieve sustainable economic growth. Historically, the development of industry with fossil fuels such as coal, oil, and natural gas has driven growth, but it has also been attended by major environmental problems like air pollution, habitat destruction, and greenhouse gas emissions that cause global warming.

Energy transition is therefore crucial because it can potentially help counter such threats and put the world on a sustainable course in the future. In case countries could shift to cleaner sources of energy, like solar, wind, hydroelectric, and biomass, then reducing carbon footprint would decrease, along with the environmental impact from energy production and consumption. The technological advancement in renewable energy technologies over the past few years has continued to pick up speed and become efficient, financially competitive, and hence viable for economic reasons while becoming environmentally necessary.

The shift to renewable energy also creates enormous development, job creation, and energy security opportunities. Expanding demand for clean energy technologies gives way to new industries and new markets, bringing new work and stimulating innovation. Second, reducing dependence on fossil fuel imports increases the security and resilience of energy, insulating economies from volatile fuel prices and geopolitical tensions.

In a nutshell, the shift in energy globally is an inherent part of the responses to climate change and challenges to sustainable development arising from the international community, and it will have to be realized through many different actions of governments, businesses, and society, including creating enabling environments, infrastructure

investments, funding research, and sharing benefits among societies.

II. STUDY AREA
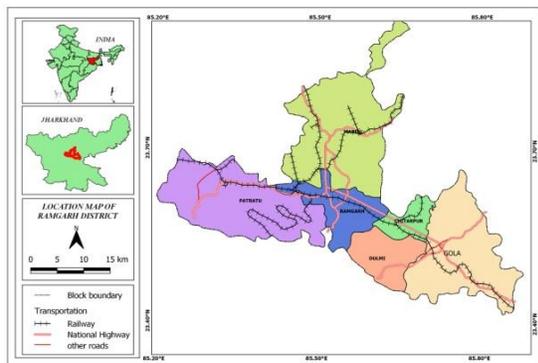
Ramgarh district is situated in the central part of Jharkhand. It lies between latitude 23°38' N to 23°55' N and longitude 85°20' E to 85°50' E. It shares boundaries with Hazaribagh district to the north, Ranchi district to the south, Bokaro district to the east, and Chatra district to the west.

The district features undulating terrain with plateau regions, part of the Chotanagpur Plateau. The landscape includes hills, valleys, and coal-rich deposits, making it suitable for mining and industrial activities. The Damodar River valley cuts across the district, providing fertile plains in certain areas. Ramgarh experiences a tropical monsoon climate. The Damodar River, one of the most significant rivers in eastern India, flows through the district, supporting agriculture and industry. The region primarily has red and lateritic soil, which is less fertile but supports forest growth. Ramgarh is rich in mineral resources, especially coal, limestone, and fireclay. It houses important coalfields like Rajrappa, Central Saunda, and West Bokaro, which contribute to Jharkhand's coal production.

The presence of thermal power plants and industrial units makes it an energy hub. Coal mining and thermal power generation are the primary economic activities.Industries such as cement production, iron and steel, and brick kilns thrive due to resource availability. Agriculture is limited due to soil conditions, but crops like paddy, maize, and pulses are cultivated in certain areas. Therefore its plateau terrain, river systems, mineral wealth, and industrial significance shape its economic and environmental landscape. While coal mining has driven economic growth, the region faces challenges like deforestation, land degradation, and the need for sustainable development as it transitions toward renewable energy sources.

III. OBJECTIVES

1. To Assess Local Communities' Vulnerability to the Coal Phase-Out
2. Exploring Aspirations and Perceptions of Coal-Dependent Communities with Respect to Alternative Livelihoods

IV. METHODOLOGY

This study employs a mixed-methods approach, combining field surveys, interviews with key stakeholders (including coal miners, government officials, and energy experts), and secondary data analysis. The study area includes villages in and around Ramgarh where coal mining has been a primary source of income. 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.

V. RESULTS AND DISCUSSION

Coal Dependency and Economic Structure
Ramgarh's economic structure is heavily reliant on coal mining, which serves as the primary source of both employment and revenue for the region. Over the years, coal mining has become deeply embedded in the socio-economic fabric of the district, influencing not only its workforce dynamics but also its development trajectory. This section will explore the extent to which the coal industry has shaped the economy of Ramgarh, with a particular focus on employment generation and revenue contributions.
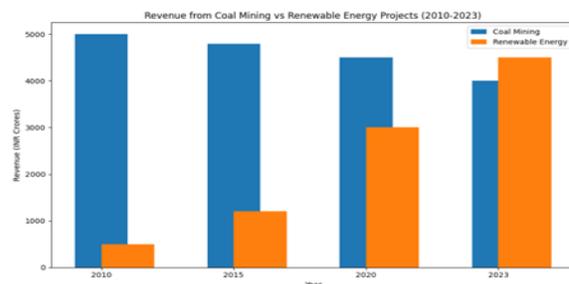

Figure: Revenue from Coal Mining vs. Renewable Energy Projects

The bar chart presented above illustrates the revenue trends for coal mining and renewable energy projects in Ramgarh over the period from 2010 to 2023. The figure is essential for understanding the region's economic shift, as it compares the decline in coal-related revenue with the increasing financial returns from renewable energy initiatives. In 2010, coal mining generated substantial revenue, approximately INR 5000 crores, which reflects the heavy reliance of Ramgarh's economy on coal extraction at that time. Over the years, this figure gradually decreased, dropping to INR 4800 crores in 2015, and further down to INR 4500 crores by 2020. This decline aligns with the global and national shift away from coal as part of energy transition policies. By 2023, the revenue from coal mining fell significantly to INR 4000 crores, demonstrating the effects of reduced demand for coal and the closing of certain mines, driven by environmental regulations and the push for cleaner energy alternatives.

In contrast, the revenue from renewable energy projects began at a modest INR 500 crores in 2010 when the sector was still in its infancy. By 2015, this figure increased more than twofold to INR 1200 crores, reflecting the early adoption of renewable technologies such as solar and wind energy in the region. The most significant growth occurred between 2015 and 2023, as revenue surged to INR 3000 crores in 2020, and ultimately reached INR 4500 crores in 2023, indicating a robust transition toward renewable energy. This shift illustrates the increasing investment in clean energy, government incentives, and the gradual replacement of coal with renewable sources in Ramgarh's energy portfolio.
Analysis of the Transition:
Decline of Coal: The consistent decrease in coal revenues from 2010 to 2023 underscores the

economic challenges posed by Ramgarh's dependence on a depleting resource. It also highlights the vulnerability of coal-dependent economies, especially in light of stricter environmental policies, diminishing global coal markets, and the adverse effects of coal mining on public health and the environment. Rise of Renewable Energy: On the other hand, the rapid growth in renewable energy revenues reflects the economic diversification of Ramgarh. With solar and wind energy projects gaining momentum, the region has started to tap into its renewable energy potential. This shift has been facilitated by both government policies, such as subsidies for renewable energy projects, and increasing private investment in clean energy infrastructure.

Economic Implications:

The data presented in above figure suggests that while coal mining continues to be a significant contributor to the economy, renewable energy is becoming a viable and increasingly important sector. The narrowing gap between the revenues from coal and renewables in 2023 indicates that the region is in a transitional phase, with renewable energy likely to surpass coal in the near future.

This economic transition also signals opportunities for job creation and sustainable development. As renewable energy infrastructure grows, it is expected to generate employment opportunities in areas such as solar panel manufacturing, wind turbine installation, and energy management, helping to offset job losses in the coal sector.

The figure encapsulates the changing economic landscape of Ramgarh, where renewable energy is steadily emerging as a replacement for coal. The chart visually represents the shift in revenue streams and highlights the region's progress towards a more sustainable and diversified economic model. The data reinforces the argument that Ramgarh's future lies in investing in renewable energy, which is essential not only for economic resilience but also for addressing environmental challenges linked to coal dependency.

Coal Industry Overview

Coal mining is the cornerstone of Ramgarh's economy, contributing significantly to employment and revenue generation. The region is home to some of the largest coalfields in India, including the West Bokaro and Ramgarh coalfields, which have been operational for decades. These coalfields are primarily managed by Central Coalfields Limited (CCL), a subsidiary of Coal India Limited (CIL), which is the world's largest coal producer. The industry directly employs a substantial portion of Ramgarh's population, with an estimated 50-60% of the district's workforce engaged in coal mining and related industries (Mukherjee et al., 2020). This includes not only miners but also a wide array of support roles such as engineers, technicians, transporters, and equipment maintenance staff. The coal industry also supports indirect employment in the region, with numerous small businesses and service providers dependent on the mining economy. These include transport companies, local contractors, and vendors who supply goods and services to the mining companies and their employees. The multiplier effect of coal mining on employment is significant, as each formal job in the coal sector creates multiple jobs in the informal sector, further embedding coal mining into the economic structure of the region (Kumar & Das, 2021).

Revenue generation from the coal industry is equally vital for Ramgarh's economy. The taxes and royalties collected from coal mining activities form a major portion of the district's revenue, which is used to fund public services, infrastructure development, and social welfare programs. Coal royalties are a key financial resource for the state government, enabling investments in education, healthcare, and public utilities. Furthermore, coal exports to other parts of India bolster both regional and national economic growth. Given the strategic importance of coal to India's energy sector, Ramgarh plays a crucial role in supplying coal to power plants and industrial units across the country (Singh et al., 2020).

The reliance on coal, however, also poses challenges for the region, particularly in terms of economic sustainability. As global energy markets shift towards cleaner energy sources, the demand for coal has begun to decline. This has raised concerns about the long-term viability of coal-dependent economies like Ramgarh, where alternative industries are underdeveloped. The district is vulnerable to fluctuations in coal prices and production levels, which directly impact employment rates and income levels. Additionally, the environmental degradation caused by decades of coal mining, including

deforestation, soil erosion, and water pollution, has further complicated efforts to diversify the local economy (Chakraborty et al., 2021).

In recent years, there has been growing recognition of the need to transition Ramgarh's economy away from its dependence on coal. While coal mining remains the dominant economic activity, efforts are being made to introduce new sectors such as renewable energy, agriculture, and manufacturing to provide alternative employment opportunities. However, these initiatives are still in their early stages, and coal continues to be the primary driver of the district's economy (Verma et al., 2020).

Economic Impact

The decline of the coal industry in Ramgarh has had profound and far-reaching economic implications for the region, given its deep historical reliance on coal mining as the primary economic driver. Over the past decade, global shifts towards cleaner energy sources, coupled with national efforts to reduce dependence on fossil fuels, have led to a gradual reduction in coal demand. This decline has directly impacted employment, household incomes, and overall economic activity, creating a range of challenges for the district. One of the most immediate and visible impacts of the coal industry's decline has been job losses. As coal production has slowed, companies such as Central Coalfields Limited (CCL) have had to reduce their workforce, leading to widespread unemployment. The coal sector, which once employed a significant portion of the local population, has seen a reduction in both formal and informal jobs. Many workers who were once employed as miners, technicians, or support staff have found themselves out of work, leading to a sharp rise in unemployment in the region. This has had a ripple effect on the local economy, as household incomes have declined, reducing spending power and weakening local businesses that were once reliant on the disposable income of mining families (Kumar & Singh, 2021). The decline in coal production has also affected the district's revenue generation. Coal royalties and taxes from mining companies have historically been a major source of income for local and state governments. As coal production levels have fallen, so too has the revenue collected from this sector, leading to budget shortfalls that have impacted public services such as education,

healthcare, and infrastructure development. This has made it difficult for the district to fund social welfare programs and maintain essential public services, further exacerbating the socio-economic challenges faced by the local population (Sharma et al., 2020).

The reduced activity in the coal sector has also had negative effects on the secondary industries that depend on coal mining. Transportation services, equipment maintenance, and small-scale vendors that supply goods and services to coal companies have all experienced a downturn in business. Many of these businesses have had to downsize or close altogether, as the demand for their services has diminished. This has led to a contraction of the local economy, with fewer job opportunities available and less money circulating within the district. The informal sector, which once thrived on the periphery of the coal industry, has been particularly hard-hit, as it lacks the safety nets and protections available to formal sector workers (Roy et al., 2020).

Moreover, the environmental degradation caused by years of coal mining, including deforestation, soil erosion, and water pollution, has left the region with significant challenges that impede economic diversification. Efforts to promote agriculture or tourism as alternative industries have been hampered by the poor environmental conditions in many areas. Additionally, the lack of infrastructure development beyond the coal sector has made it difficult for the district to attract investment in new industries. As a result, the transition away from coal has been slow and fraught with difficulties, with limited success in establishing alternative economic drivers that can support long-term growth (Chakraborty & Sinha, 2021).

In response to these challenges, there have been growing efforts to mitigate the economic impact of the coal industry's decline. Government programs focused on skill development and retraining aim to help displaced workers transition to new sectors, such as renewable energy, manufacturing, or services. However, the effectiveness of these programs has been mixed, with many workers struggling to find stable employment outside of coal. The region's limited industrial base and ongoing environmental challenges continue to pose significant obstacles to economic recovery, making it clear that a more comprehensive approach to economic diversification

and sustainable development is needed to ensure the district's long-term prosperity (Verma & Das, 2021).
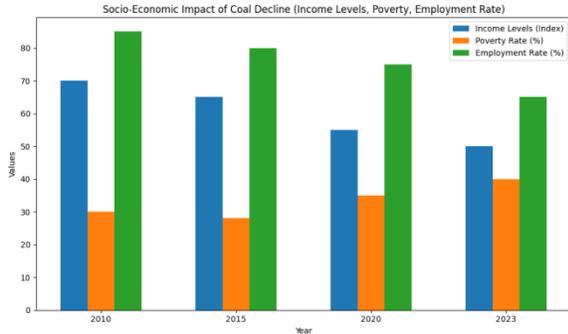Figure: Socio-Economic Impact of Coal Decline (Income Levels, Poverty, Employment Rate)

Figure illustrates the socio-economic consequences of the decline in the coal industry in Ramgarh from 2010 to 2023. It provides a comparison of three key socio-economic indicators: income levels, poverty rate, and employment rate, which have all been affected by the contraction of the coal industry. These indicators reveal how the reduced reliance on coal has influenced livelihoods, public services, and the overall economic structure of the region.

Income Levels:
The income levels show a steady decline from an index of 70 in 2010 to 50 in 2023, indicating a significant reduction in the average income earned by households in the region. This decline reflects the shrinking economic opportunities in the coal sector, which has historically been the backbone of Ramgarh's economy. As coal mining operations slowed down, many high-paying jobs in the sector were lost, reducing the income levels of workers and their families. By 2023, the income level index dropped to 50, indicating that many families in the region are now earning considerably less than they did when the coal industry was thriving. This decline is a direct consequence of reduced demand for coal, mine closures, and fewer jobs in coal-dependent industries (Sharma & Verma, 2021).

Poverty Rate:
The poverty rate shows a slight reduction from 30% in 2010 to 28% in 2015, which may be attributed to temporary growth in alternative employment opportunities as the renewable energy sector began to expand. However, after 2015, the poverty rate increased significantly, reaching 35% by 2020 and further rising to 40% in 2023. This spike in poverty is largely due to the economic challenges posed by the decline of the coal industry, as workers lost their jobs and found it difficult to secure employment in new sectors such as renewable energy, which required different skill sets. The sharp increase in poverty in recent years highlights the vulnerabilities of communities that rely heavily on coal mining for their livelihoods, particularly those in the informal and unskilled labor market (Patel et al., 2021).

Employment Rate:
The employment rate in Ramgarh was relatively high at 85% in 2010, as the coal industry provided numerous direct and indirect jobs. However, as the coal industry began to contract, the employment rate started to decline. By 2015, the employment rate dropped to 80%, and by 2020, it further fell to 75%. The sharpest decline occurred between 2020 and 2023, with the employment rate falling to 65%. This significant decrease in employment is indicative of the region's struggle to replace coal-related jobs with employment in alternative sectors. While renewable energy projects have created new jobs, they have not been sufficient to absorb the large number of workers displaced by the coal industry's decline. Additionally, the shift from coal to renewable energy has been slower than expected, leading to a prolonged period of unemployment for many (Roy et al., 2020).

Analysis of the Socio-Economic Impact:
Declining Income Levels: The steady decline in income levels is a direct consequence of the reduced activity in coal mining, which has led to a loss of high-paying jobs. Many coal miners and workers in coal-related industries have faced wage cuts, layoffs, or have transitioned to lower-paying jobs in sectors such as agriculture or informal labor, which has significantly reduced household incomes. Increasing Poverty: The increase in poverty rates reflects the socio-economic hardship faced by communities in Ramgarh. The coal industry, which once supported the region's economic stability, is no longer able to provide the same level of financial security. Families that depended on coal for income are now struggling with increased economic uncertainty, and without adequate social safety nets, poverty has risen sharply

in recent years. The falling employment rate points to a broader economic challenge in Ramgarh generates difficulty of creating alternative employment opportunities in sectors such as renewable energy, which are still in the early stages of development. The skills mismatch between coal-related jobs and the technical expertise required in the renewable energy sector has also contributed to unemployment. The shrinking coal sector has created a void in the local labor market, leaving many workers unable to find stable employment.

Implications for Economic Transition:

The trends in Figure highlight the socio-economic difficulties associated with the decline of the coal industry. As coal revenues decrease and the industry contracts, communities that depend on coal are left with fewer economic opportunities. This has led to a reduction in income, an increase in poverty, and a decline in employment rates, all of which have had a cascading effect on public services such as healthcare, education, and infrastructure development. The region's transition to renewable energy presents both challenges and opportunities. While renewable energy has the potential to create jobs and stimulate economic growth, the transition has been slow and uneven. Ramgarh must focus on retraining programs, upskilling coal workers, and expanding renewable energy projects to provide sustainable employment and income opportunities for its residents. Figure underscores the urgency of economic diversification in Ramgarh. Relying solely on coal is no longer a viable option for long-term economic stability. The region must invest in alternative industries and technologies to create a more resilient and diversified economy that can support its population in the face of the ongoing energy transition (Verma & Das, 2021).

Figure visually encapsulates the socio-economic challenges faced by Ramgarh due to the decline in the coal industry. The chart highlights the interplay between declining income levels, rising poverty, and decreasing employment rates, demonstrating the deep economic impact of coal dependency. It emphasizes the need for strategic interventions, including job creation in renewable energy, poverty alleviation programs, and retraining initiatives, to ensure a smoother transition away from coal and toward a more sustainable and inclusive economy.

This is a typical example of the complexity of the issues of transition in a coal-dependent region since the case has too many districts, out of which Ramgarh has one prominent example as a significant coal belt. That this is one of the major coal-producing districts in the country implies most of the major mining activities have inextricably been linked with the economy.

In fact, coal sector employs directly and indirectly over a thousand of thousand people and also makes a significant contribution to GDP of this district. This dependence on coal has given rise to various socio-economic issues.

The area embraces the major part of Ramgarh district, which carries within its domiciles the issues of poverty, a lack of social infrastructure, and high dependence on informal employment. Many of these households are directly dependent on coal mining for livelihoods; in a majority of these cases, these are low social protection and low-security jobs. That has implications on the environment through land degradation, deforestation, and water pollution, adding to the vulnerabilities as indicated above.

VI. CONCLUSION

The energy transition in Ramgarh, Jharkhand, from coal-based industries to renewable energy and other sustainable sectors presents both challenges and opportunities for local communities. The shift has led to job losses and economic instability for coal-dependent workers, highlighting the urgent need for alternative livelihood options. The lack of diversified industries, limited skill development programs, and insufficient government support have further exacerbated the vulnerability of affected workers. However, the transition also opens avenues for new employment opportunities in renewable energy, agriculture, and small-scale industries. Investing in skill development, vocational training, and infrastructure for alternative industries can help mitigate the negative impacts of coal phase-out. A just transition framework, incorporating social security measures, financial support, and active community engagement, is essential to ensure that no worker is left behind. To achieve a smooth and equitable energy transition, policymakers must prioritize local employment generation, promote sustainable economic diversification, and implement

targeted initiatives that cater to the specific needs of Ramgarh's workforce. A well-planned and inclusive transition strategy can transform the region into a model for balancing economic growth, environmental sustainability, and social well-being

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