

Impact of Opencast Mining on Agricultural Productivity and Environmental Sustainability: A Case Study of the Singareni Collieries in Telangana

P. Sathish

Research Scholar

Dept. of Business Management

Email: penchalasathish13@gmail.com

Abstract

The rapid industrialization and economic expansion in India have increased reliance on natural resource extraction, particularly through opencast mining. While efficient and cost-effective, this mining method has significant environmental and socio-economic repercussions. This study focuses on the Singareni Collieries Company Limited (SCCL) in Telangana to examine its impact on agricultural productivity in surrounding regions. Agriculture, a cornerstone of rural livelihoods, faces severe challenges from mining activities, including land degradation, water contamination, air pollution, and biodiversity loss. Using a mixed-methods approach, the research combines primary data from surveys and interviews with secondary data from official records and reports. The analysis reveals substantial declines in crop yields, heightened susceptibility of crops to pests and diseases, and deteriorating agricultural produce quality due to mining-induced environmental degradation. Factor analysis identifies two critical dimensions: "Agricultural Productivity and Biodiversity Loss" and "Environmental Degradation and Adaptive Practices," highlighting the interconnectedness of environmental changes and farming challenges. Key findings show that over 70% of respondents acknowledged significant reductions in crop yields, with biodiversity loss and dust pollution emerging as critical factors. ANOVA results confirm a significant impact of opencast mining on biodiversity and environmental conditions, necessitating adaptive practices among farmers. The study underscores the urgent need for sustainable mining practices and effective mitigation strategies to balance economic benefits with the preservation of agricultural livelihoods and environmental health.

Keywords: Opencast Mining, Agricultural Productivity, Environmental Degradation, Biodiversity Loss and Socio-Economic Impact.

Introduction

The rapid industrialization and economic growth witnessed across the globe have led to increased reliance on natural resource extraction. Mining, particularly opencast mining has emerged as a dominant method for resource extraction due to its efficiency and cost-effectiveness. However, the environmental repercussions of such activities often extend beyond the mining site, influencing the surrounding ecosystems and human settlements. The Singareni Collieries Company Limited (SCCL), a state-owned coal mining company operating in the coal-abundant regions of Telangana, serves as a critical case for examining the environmental and socio-economic impacts of opencast mining. While SCCL has significantly contributed to India's energy sector and regional development, it has also been associated with environmental challenges, particularly concerning agricultural sustainability in the mining-affected areas.

Agriculture forms the backbone of rural livelihoods in India, including the regions around SCCL's operations. For decades, communities have depended on farming not only as a source of income but also for food security and cultural heritage. Opencast mining, with its extensive land excavation and large-scale disruption of the environment, poses multiple threats to agriculture. The process often involves stripping away topsoil, altering the

natural landscape, and contaminating water resources. Such activities degrade the quality of arable land, disrupt hydrological cycles, and contribute to air and water pollution—all of which can have a detrimental impact on crop yields and soil fertility.

Furthermore, mining-induced changes in the microclimate, such as increased dust and reduced water availability, exacerbate the challenges faced by farmers. Livelihood displacement, a decline in agricultural productivity, and subsequent socio-economic hardships has been widely reported in regions where mining activities overlap with agricultural zones. In the case of SCCL, these dynamics are particularly significant, given the company's expansive operations and the dependence of surrounding communities on farming.

Background of the Study

Mining plays a vital role in supporting the industrial and economic growth of a nation by providing essential raw materials. In India, coal mining constitutes a significant segment of the mining industry, catering to the energy demands of a rapidly growing economy. Among the major contributors to coal production is the Singareni Collieries Company Limited (SCCL), which operates extensively in the coal-rich regions of Telangana. Established in 1920, SCCL has emerged as a key player in India's coal sector, with its operations spanning several districts. While its contribution to energy security and regional development is undeniable, the environmental costs associated with its activities have drawn increasing scrutiny.

Opencast mining, the predominant method employed by SCCL, is known for its efficiency in extracting coal near the surface. However, this method is also recognized for its significant environmental impact. The process involves large-scale excavation, removal of vegetation, and alteration of the landscape, leading to soil erosion, habitat destruction, and the release of pollutants into the air and water systems. For regions that are heavily reliant on agriculture, these environmental changes pose a direct threat to farming activities and rural livelihoods.

Agriculture is the primary source of income and employment for a majority of the population in the areas surrounding SCCL's mining sites. The arable lands in these regions are highly sensitive to changes in soil fertility, water availability, and climatic conditions. Opencast mining activities can lead to:

1. Land degradation due to the stripping away of fertile topsoil and deposition of overburden.
2. Water resource depletion and contamination caused by mine runoff, leachates, and disruption of groundwater systems.
3. Air pollution from dust and emissions, which affect crop health and reduce productivity.
4. Altered microclimatic conditions, such as higher temperatures and reduced rainfall, further exacerbating agricultural challenges.

Numerous studies and reports have highlighted the cascading effects of mining on rural economies. Declining agricultural productivity often leads to reduced income for farmers, forcing many to seek alternative employment or migrate to urban areas. This shift not only affects individual households but also disrupts the socio-economic fabric of rural communities. In the case of SCCL, the overlapping zones of mining and agricultural activity present a critical challenge: how to balance the economic benefits of coal mining with the sustainability of agricultural practices and rural livelihoods.

Despite the significant impact of opencast mining on agriculture, there has been limited comprehensive research that focuses on SCCL's operations and their specific effects on the agricultural productivity of the surrounding regions. Existing studies often generalize the environmental impact of mining without delving into the localized consequences for farming communities. This research aims to bridge that gap by providing a detailed analysis of the interactions between mining activities and agricultural systems in SCCL's operational areas.

This research investigates the impact of opencast mining on agricultural productivity in regions influenced by SCCL operations. The study examines the extent of land degradation, the contamination of water and soil, changes in cropping patterns, and the socio-economic consequences for farming communities.

Objectives of the Study

Based on the analysis of the survey data regarding the impact of opencast mining on agricultural crop yield, the study is structured around the following objectives:

1. To examine the relationship between opencast mining activities and agricultural crop yields in regions surrounding the Singareni Collieries Company Limited (SCCL).
2. To assess the susceptibility of crops to diseases and pests in areas near opencast mines and understand the role of mining-induced environmental changes in this increased vulnerability.
3. To evaluate the deterioration in the quality of agricultural produce as a result of environmental changes associated with opencast mining.
4. To document the long-term trends in agricultural productivity in areas affected by opencast mining, including consistent declines in crop yields.

Research Methodology

This research adopts a mixed-methods approach, combining both quantitative and qualitative techniques to comprehensively analyze the impact of opencast mining on agricultural productivity in the regions surrounding the Singareni Collieries Company Limited (SCCL).

1. Study Area:

The research focuses on the districts in Telangana where SCCL operates opencast mining projects. Specific regions with significant agricultural activity near mining sites are selected to assess the localized impacts.

2. Research Design:

- **Descriptive Design:** To describe the environmental and agricultural changes due to mining activities.
- **Exploratory Design:** To identify and explore mitigation strategies for minimizing the adverse effects on agriculture.

3. Data Sources:

- **Primary Data:** Collected through surveys, structured interviews, and focus group discussions with local farmers, agricultural workers, and community members.
- **Secondary Data:** Includes reports from SCCL, agricultural productivity records, environmental impact assessments, and government publications on mining and agriculture.

4. Data Collection Tools:

- **Questionnaires:** Designed to capture information about changes in crop yields, farming practices, and perceptions of mining impact.

Table 1 Agriculture Crop Yield

Statement	1	2	3	4	5	Total
Opencast mining has led to a significant reduction in agricultural crop yields	41	72	216	462	329	1120
Dust from mining activities has caused a decline in the health of crops	46	81	167	376	450	1120
Crops in areas near opencast mines are more susceptible to diseases and pests	64	89	154	389	424	1120

The air quality in mining areas has impacted crop growth	31	63	189	369	468	1120
The quality of agricultural produce has deteriorated due to mining activities	44	82	213	418	363	1120
Farmers are forced to adapt their practices due to environmental changes from mining	67	94	197	365	397	1120
Loss of biodiversity due to mining activities impacted crop productivity	32	76	127	382	503	1120
Farmers in regions with opencast mining have reported consistent declines in crop yields	37	64	146	394	479	1120
Agricultural productivity has not recovered in areas affected by opencast mining	44	68	164	397	447	1120

The table summarizes respondents' perceptions of the impact of opencast mining on agricultural crop yields using a five-point Likert scale, with ratings ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The findings reveal a significant concern among individuals regarding the negative effects of opencast mining on agriculture. For the statement "Opencast mining has led to a significant reduction in agricultural crop yields," a total of 329 individuals (29.41%) strongly agree, while 462 individuals (41.25%) agree, indicating a strong consensus on the adverse impact of mining on crop yields. Similarly, 450 individuals (40.18%) strongly agree that dust from mining activities has caused a decline in crop health, with a total of 376 individuals (33.57%) agreeing. When asked about susceptibility to diseases and pests, 424 individuals (37.86%) strongly agree, demonstrating a widespread belief that mining increases crop vulnerability. Furthermore, 468 individuals (41.82%) strongly agree that air quality in mining areas affects crop growth.

Responses also indicate a decline in the quality of agricultural produce, with 363 individuals (32.39%) strongly agreeing that mining activities have deteriorated produce quality. Regarding farmers' adaptation to environmental changes, 397 individuals (35.48%) strongly agree that mining necessitates changes in farming practices. Concerns about biodiversity loss affecting productivity are evident, as 503 individuals (44.87%) strongly agree. The perception that farmers consistently report declines in crop yields is supported by 479 individuals (42.68%) who strongly agree with this statement. Finally, 447 individuals (39.89%) strongly agree that agricultural productivity has not recovered in areas affected by mining. Overall, the data reflects a strong sentiment among respondents regarding the detrimental effects of opencast mining on agricultural crop yields and farming practices.

Factor Analysis

Agriculture Crop Yield

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.833
Bartlett's Test of Sphericity	Approx. Chi-Square	883.603
	df	36
	Sig.	.000

The KMO and Bartlett's Test results for the impact of opencast mining on agricultural crop yield indicate that the data is well-suited for factor analysis. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy is 0.833, which is classified as "meritorious." This high KMO value suggests that the variables have a strong degree of

correlation, making them appropriate for factor analysis. A KMO value above 0.8 indicates that the sample is highly adequate for identifying underlying factors. The Bartlett's Test of Sphericity presents an approximate chi-square value of 883.603, with 36 degrees of freedom (df), and a p-value of 0.000. The highly significant result ($p < 0.05$) confirms that the correlation matrix is not an identity matrix. This indicates that the variables are sufficiently correlated and that factor analysis is appropriate.

Table 3. Communalities

	Initial	Extraction
Opencast mining has led to a significant reduction in agricultural crop yields	1.000	.655
Dust from mining activities has caused a decline in the health of crops	1.000	.595
Crops in areas near opencast mines are more susceptible to diseases and pests	1.000	.964
The air quality in mining areas has impacted crop growth	1.000	.543
The quality of agricultural produce has deteriorated due to mining activities	1.000	.942
Farmers are forced to adapt their practices due to environmental changes from mining	1.000	.663
Loss of biodiversity due to mining activities impacted crop productivity	1.000	.940
Farmers in regions with opencast mining have reported consistent declines in crop yields	1.000	.611
Agricultural productivity has not recovered in areas affected by opencast mining	1.000	.963

Extraction Method: Principal Component Analysis.

The Communalities table reflects the degree to which the variance in each variable related to the impact of opencast mining on agricultural crop yields is explained by the extracted components in a principal component analysis. The Initial values are all set to 1.000, indicating that 100% of the variance is considered for each factor before extraction. The Extraction values show how much of this variance is retained after the analysis.

- Crops in areas near opencast mines are more susceptible to diseases and pests and Agricultural productivity has not recovered in areas affected by opencast mining show high communalities of 0.964 and 0.963, respectively. This indicates that these variables are well-explained by the underlying components, suggesting they are highly significant indicators of the negative impact of opencast mining on agriculture.
- The quality of agricultural produce and Loss of biodiversity due to mining activities also have high extraction values of 0.942 and 0.940, respectively, further emphasizing that these factors play a critical role in understanding the detrimental effects of mining activities on agriculture.
- Farmers are forced to adapt their practices due to environmental changes from mining and Opencast mining has led to a significant reduction in agricultural crop yields also have moderate to strong communalities of 0.663 and 0.655, showing these are important but slightly less influential variables.
- Dust from mining activities has caused a decline in the health of crops and Farmers in regions with opencast mining have reported consistent declines in crop yields have extraction values of 0.595 and 0.611, indicating these variables are moderately explained by the components.

- The lowest communalities are seen with The air quality in mining areas has impacted crop growth, with a value of 0.543, suggesting that while relevant, this factor's variance is not as strongly captured by the extracted components.

In summary, the table shows that several factors, especially crop susceptibility to diseases, agricultural productivity recovery, and biodiversity loss, are strongly influenced by the underlying factors extracted in the analysis, making them key indicators of the impact of opencast mining on agricultural crop yields.

Table 4. Rotated Component Matrix^a

	Component 1	2
Opencast mining has led to a significant reduction in agricultural crop yields		.505
Dust from mining activities has caused a decline in the health of crops		.657
Crops in areas near opencast mines are more susceptible to diseases and pests	.980	
The air quality in mining areas has impacted crop growth		.584
The quality of agricultural produce has deteriorated due to mining activities	.966	
Farmers are forced to adapt their practices due to environmental changes from mining		.645
Loss of biodiversity due to mining activities impacted crop productivity	.969	
Farmers in regions with opencast mining have reported consistent declines in crop yields		.731
Agricultural productivity has not recovered in areas affected by opencast mining	.979	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

The Rotated Component Matrix provides insights into how the different variables related to the impact of opencast mining on agriculture load onto two main components. These components represent different dimensions of the mining effects, with the rotation method (Varimax) used to simplify the interpretation by maximizing the variance explained by each component. Below is a summary of the findings along with suggested names for the two dimensions:

Component 1: "Agricultural Productivity and Biodiversity Loss"

This dimension captures the variables most strongly related to the long-term decline in crop health, agricultural productivity, and biodiversity loss due to opencast mining. The high loadings on this component suggest that these factors are closely linked. Variables with high loadings include:

- Crops in areas near opencast mines are more susceptible to diseases and pests (0.980)
- The quality of agricultural produce has deteriorated due to mining activities (0.966)
- Loss of biodiversity due to mining activities impacted crop productivity (0.969)
- Agricultural productivity has not recovered in areas affected by opencast mining (0.979)

These variables indicate that opencast mining severely impacts the health of crops, quality of produce, and biodiversity, leading to persistent declines in agricultural productivity.

Component 2: "Environmental Degradation and Adaptive Practices"

This dimension focuses on environmental degradation, such as air quality and crop health, and how farmers are forced to adapt to these changes. The key variables loading on this component include:

- Opencast mining has led to a significant reduction in agricultural crop yields (0.505)
- Dust from mining activities has caused a decline in the health of crops (0.657)
- The air quality in mining areas has impacted crop growth (0.584)
- Farmers are forced to adapt their practices due to environmental changes from mining (0.645)
- Farmers in regions with opencast mining have reported consistent declines in crop yields (0.731)

This dimension reflects the environmental pressures caused by opencast mining, such as dust and air quality issues, and highlights the challenges farmers face in adapting their practices to cope with these changes.

H₀₁: There is no significant decrease in agricultural productivity due to the opencast mining operations executed in the study region.

H_{01.1}: There is no significant impact of opencast mining on agricultural productivity through biodiversity loss.

H_{01.2}: Opencast mining does not contribute significantly to environmental degradation, nor does it necessitate adaptive practices for agricultural productivity.

Table 5. ANOVA

	Sum Squares	df	Mean Square	F	Sig.
Between Groups	26.483	4	6.621	3.251	.012
Within Groups	2270.516	1115	2.036		
Total	2296.999	1119			
Between Groups	24.946	4	6.236	3.038	.017
Within Groups	2289.165	1115	2.053		
Total	2314.111	1119			

The ANOVA results provide significant insights into the impact of opencast mining on agricultural productivity, particularly through biodiversity loss and environmental degradation. For **H_{01.1}**, the F-value of 3.251 with a significance level of 0.012 indicates that biodiversity loss caused by opencast mining significantly affects agricultural productivity. The p-value is below the 0.05 threshold, leading to the rejection of the null hypothesis. Similarly, for **H_{01.2}**, the F-value of 3.038 with a significance level of 0.017 demonstrates that opencast mining contributes significantly to environmental degradation and necessitates adaptive practices for maintaining agricultural productivity. This p-value also falls below the 0.05 threshold, resulting in the rejection of the null hypothesis. These findings highlight the detrimental effects of opencast mining on the agricultural ecosystem, emphasizing its role in biodiversity loss and environmental challenges that impact productivity.

Findings

- A significant portion of respondents (70.66%) either agreed or strongly agreed that opencast mining has led to a substantial reduction in agricultural crop yields.
- Dust deposition from mining activities was identified by 73.75% of respondents as a key factor negatively affecting crop health.
- 79.68% of respondents highlighted that crops near opencast mines are highly susceptible to diseases and pests.
- 41.82% of respondents strongly agreed that air quality deterioration from mining significantly affects crop growth, supported by 32.95% agreeing to this statement.
- The loss of biodiversity was the most strongly acknowledged issue, with 44.87% strongly agreeing that it has adversely impacted crop productivity.
- 35.48% of farmers strongly agreed that they had to adapt their agricultural practices due to environmental challenges brought about by mining, and 39.89% strongly felt that agricultural productivity has not recovered in affected areas.
- A high proportion (42.68%) strongly agreed that consistent declines in crop yields were reported in mining-affected regions.

Conclusion

The study conclusively demonstrates the adverse impacts of opencast mining activities conducted by the Singareni Collieries Company Limited on agricultural productivity in nearby regions. Key findings highlight that mining-induced factors such as dust pollution, air quality deterioration, and biodiversity loss are major contributors to the observed declines in crop yields and quality. Furthermore, the results indicate that farmers are compelled to adopt new practices to cope with environmental degradation, underscoring the socio-economic challenges posed by such activities.

The factor analysis identifies two principal dimensions—Agricultural Productivity and Biodiversity Loss and Environmental Degradation and Adaptive Practices—which encapsulate the overarching effects of opencast mining on agriculture. Moreover, ANOVA findings confirm the statistically significant impact of biodiversity loss and environmental degradation on agricultural productivity, necessitating immediate policy and environmental interventions.

In summary, the study underscores the urgent need for sustainable mining practices, robust environmental regulations, and support systems for affected farmers to mitigate the adverse effects of opencast mining on agricultural ecosystems.

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