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# ENVIRONMENTAL DEGRADATION IN GODAVARI VALLEY: A COAL MINING PERSPECTIVE

**Dr.Polipaka Vanitha**
Senior Lecturer in Geology, Government Polytechnic
Kothagudem, Bhadradri Kothagudem District, Telangana, India

## Abstract

The Godavari Valley Coalfield (GVCF), spanning approximately 470 km across the Pranahita-Godavari Basin in Telangana, India, represents one of the most ecologically sensitive yet heavily exploited mineral regions in the subcontinent. The coalfields are mainly run by the Singareni Collieries Company Limited (SCCL), which has been in operation for more than 135 years, and the coalfields have undergone extreme extraction-based environmental change. This essay analyzes the environmental degradation of multi-dimensions of coal mining in the Godavari Valley, in terms of land use and land cover (LULC), deterioration of air quality, water resources contamination, biodiversity loss, and socio-ecological vulnerability. Based on satellite-based remote sensing data, 1990-2024 government environmental monitoring reports, and peer-reviewed research, this paper indicates that the extent of forest cover has decreased significantly, the extent of the mining area has grown by 475 percent, and the critical levels of heavy metals in the water bodies of the regions have increased. SCCL also further intensified the cumulative strain on the environment by rising coal production of 37.71 million tonnes (MT) in 200607 to more than 67 MT in 202324. This paper is an appeal to employ integrated environmental management systems, enforcement of the regulations, and community-based mine closure policies in lessening the long-term ecological impacts of coal mining in the biodiversity-sensitive river basin.

**Key words:** Godavari Valley Coalfield, SCCL, Degradation of Land, Coal Mining, Air Quality, Water Pollution, Biodiversity, Loss, Environmental Impact Evaluation, Telangana, Heavy Metals.

## 1. Introduction

The Godavari River or the Dakshina Ganga (Ganges of the South) is a river of Maharashtra, which has its origin in the Brahmagiri hills located in Maharashtra and flows over a distance of about 1460 km into the Bay of Bengal. Its basin is 312812 km$^2$, which is almost one-tenth of the total geographical area of India, hosting a population of more than 768 million, with 10% of the total population in the multiple states of Maharashtra, Telangana, Andhra Pradesh, Chhattisgarh, and Odisha (cGodavari & NRCD, 2024). The basin supports huge biodiversity - thick tropical forests, endemic plants, and endangered animals - and supports intensive agriculture, fishing, and freshwater environments.

The Pranahita- Godavari Valley Coalfield (GVCF) is embedded in this ecologically rich geography, and it is one of the most productive coal-bearing geological formations in India. The Gondwana coal seams in the Godavari Valley are of Permian age, which gives the geological basis for more than a hundred years of industrial use. The Singareni Collieries Company Limited (SCCL), being a joint venture between the Government of India and the Government of Telangana, is the major operator of coal mining in this area since 1886 and is currently operating 17 opencast mines and 22 underground mines in the districts, including those of Bhadradri Kothagudem, Mancherial, Peddapalli, and Karimnagar (SCCL, 2024).

The coal industry in India is strategically imperative to the energy economy in India. According to the Ministry of Coal (2021), the amount of power generated by coal-based capacity made up about 53 percent of the total capacity in the country as of 2020. In 2019-20, India produced over 730 MT of coal, and the national goals indicate that coal production will reach 1000 MT by 2022-23. SCCL, a long-term provider of energy in the south of India, has steadily increased output, reaching 69.01 MT in 2023-24(TGPCB, 2024). This unabated growth, though essential to the economy, has cost the Godavari Basin ecosystem heavily and irreversibly with regard to the environment.

Coal mining causes environmental degradation, which is a multi-dimensional phenomenon. It includes land use change caused by excavation, overburden dumping, particulates and gaseous air pollution caused by blasting and haulage, acid mine drainage (AMD) and heavy metal contamination of water bodies, soil degradation, forest cover loss and biodiversity loss, land subsidence as a result of underground workings, and socio-economic vulnerability of farming communities (Ministry of Coal, 2021). The ecological sensitivity of the river basin, the level of human settlements near mine lease areas, and insufficiency in cumulative environmental impact assessment compound such stressors in the Godavari Valley situation.

This paper presents an evidence-based, extensive analysis of environmental degradation in the Godavari Valley, which could be attributed to coal mining. Section 2 explains the study area and methodology. In sections 3 to 7, the findings about the land use change, air quality, water quality, biodiversity impacts, and socio-ecological vulnerability are given, respectively. Section 8 talks of mitigation measures, and the conclusions are made in Section 9.

## 2. Study Area and Methodology

### 2.1 Study Area

Godavari Valley Coalfield (GVCF) is situated in the latitude 17°30'N–19°30'N and longitude 79°00'E–81°30'E. It is a long, thin strip that is almost 470 km long and runs along the route of the Godavari River and its tributaries, specifically the Pranahita and Manair rivers (SCCL, 2021). The coalfield is a part of the physiographic zone of the Deccan plateau and has a geological formation of Gondwana formations of Permian age with some of the major reserves of non-coking thermal coal.

The region of study will include the areas of operation of SCCL in four major Telangana districts: Bhadradri Kothagudem, Mancherial, Peddapalli, and Karimnagar. This area hosts a landscape of land uses such as active mining activities, coal processing facilities, overburden (OB) dumping areas, residential settlements, agricultural lands, and remnants of tropical dry deciduous forest. Figure 1: Aerial image of an opencast coal field in the Godavari Valley area with terraced excavation pits, overburden dumping mounds, haul roads, and the contrast between the Godavari River and the forest/agricultural landscape around the area. (Illustrative image -AI-generated to be used as a visual tool)

**Figure 1:** Aerial view of an opencast coalfield in the Godavari Valley region

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## 2.2 Methodology

This paper uses an integrative and multi-source method:

- Remote Sensing and GIS Analysis: Remote Sensing and GIS Analysis Landsat-5 TM (1990), Landsat-8 OLI/TIRS (2010, 2014), and ESRI 10-m resolution were used to analyze land use/land cover changes in the Godavari Basin (Garai and Narayana, 2018; cGodavari, 2024).
- Secondary Environmental Data: Air quality (SPM, RSPM, SO 2, NO 8 ), mine water discharges volumes, and water quality parameters were retrieved in SCCL Environmental Compliance Statements (ECS), Telangana State Pollution Control Board (TGPCB), and the reports of the Sustainable Development Cell of the Ministry of Coal (SDC).
- Published Literature Review: The review was of peer-reviewed studies addressing the topics of heavy metal contamination, farming household susceptibility, slope stability, and cumulative environmental effects.
- Qualitative Evaluation: CGodavari/NRCD (2024) observations and the environmental clearance reports were synergized to determine the degradation trends of the ecosystems at a larger scale.

## 3. Land Use and Land Cover Change.

### 3.1 The Space of Transformation of the Landscape.

LULC analysis of the satellite images indicates drastic spatial changes in the landscape of the Godavari Valley in the last three decades. Garai and Narayana (2018) have performed a multi-temporal analysis of Landsat images (1990 2014) and reported the growth of the areal mining activity, which was 0.23 percent of the study area in 2014 and 0.04 percent in 1990. At the same time, the forest cover went down to 31.67 to 36.38 in the form of a net loss of about 4.71 percentage points in the ecologically rich area of biodiversity.

Recent basin-wide data released by ESRI (2017 vs. 2023) in the cGodavari-NRCD report (2024) shows more landscape change with a loss of 6,154.34 km$^2$ in tree cover (69,587.81 km$^2$ in 2017 to 63,433.47 km$^2$ in 2023) in the Godavari Basin in six years only. The twin pressures of urbanization and mining infrastructure development led to an explosive growth in the built-up areas, which increased between 518.52 km 2 and 11, 385.74 km 2. Figure 2: Slim line between the surviving tropical dry deciduous forest (on the left) and land cleared to be used in coal mines (on the right) in the Godavari Valley in Telangana. Note felled trees, exposed red laterite soil, and heavy machinery in the cleared zone. *(Illustrative image — AI-generated for visualization purposes)*

**Figure 2:** Sharp boundary between intact tropical dry deciduous forest (left) and land cleared for coal mine expansion (right)

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**Table 1: Land Use/Land Cover Changes in the Godavari River Basin (2017 vs. 2023)**

| Land Cover Class | 2017 Area (km²) | 2023 Area (km²) | Change (km²) | % Change |
|---|---|---|---|---|
| Water Bodies | 6,095.26 | 7,353.54 | +1,258.28 | +20.64% |
| Tree Cover / Forest | 69,587.81 | 63,433.47 | −6,154.34 | −8.84% |
| Flooded Vegetation | 170.09 | 125.23 | −44.86 | −26.37% |
| Cropland | 171,558.60 | 169,570.06 | −1,988.54 | −1.16% |
| Built-up Area | 518.52 | 11,385.74 | +10,867.22 | +2095.7% |
| Bare Ground | 0.0036 | 286.74 | +286.74 | N/A |
| Rangeland | 62,069.34 | 57,728.17 | −4,341.17 | −6.99% |

*Source: cGodavari & NRCD (2024), based on ESRI 10-m LULC dataset.*

**Table 2: Land Use/Land Cover Changes in Godavari Coalfield Area (1990–2014)**

| Land Use Class | 1990 (%) | 1995 (%) | 2000 (%) | 2005 (%) | 2010 (%) | 2014 (%) |
|---|---|---|---|---|---|---|
| Water Body | 2.77 | 2.85 | 2.91 | 3.00 | 3.12 | 3.29 |
| Mining Area | 0.04 | 0.07 | 0.10 | 0.14 | 0.19 | 0.23 |
| Forest Cover | 36.38 | 35.70 | 34.95 | 33.90 | 32.50 | 31.67 |
| Built-up Area | 0.34 | 0.45 | 0.57 | 0.67 | 0.78 | 0.89 |
| Barren Land | 1.00 | 1.18 | 1.34 | 1.47 | 1.58 | 1.69 |
| Agricultural Land | 59.46 | 59.75 | 60.13 | 60.81 | 61.82 | 62.22 |

*Source: Garai & Narayana (2018), Egypt Journal of Remote Sensing and Space Sciences.*

### 3.2 Overburden Dumping and Land Subsidence

The GVCF produces such vast amounts of overburden (OB) material - the rock and soil that is removed above coal seams that mining is done using open-cast methods. India has over 2,550 km 2 of land that is under active coal mining, and this necessitates massive land amelioration (Ministry of Coal, 2021). The OB dumps also take up extensive areas of what would have been productive land in the working areas of SCCL, leading to compaction, loss of topsoil, and a change in the natural drainage patterns. In the colonized areas, land subsidence caused by underground mining also impacts the surface infrastructure and agricultural fields near the mine lease (SCCL ECS, 2021). **Figure 3:** Massive overburden dump mound with erosion gullies and reddish leachate drainage, adjacent to subsidence cracks and an abandoned damaged dwelling in the GVCF region. *(Illustrative image — AI-generated for visualization purposes)*

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**Figure 3:** Massive overburden dump mound

## 4. Air Quality Impacts

### 4.1 Particulate and Gaseous Pollution

The GVCF coal mining operations are significant contributors of airborne particulate matter ($PM_{10}$ and $PM_5$ ), sulfur dioxide ($SO_2$), nitrogen oxides ($NO_x$ ), and carbon monoxide (CO). Dust generation occurs at multiple operational stages: blasting, mechanical excavation, OB transportation, coal crushing, and road haulage. The Ministry of Coal's SDC status report (2021) notes that ambient air quality monitoring at mines shows frequent exceedances of National Ambient Air Quality Standards (NAAQS) for suspended particulate matter (SPM) and respirable SPM (RSPM) at mine-site and boundary locations. Figure 4: Coal processing factory that produces dust clouds over the neighboring Indian village. Coal haul trucks are used on dust-covered roads, roofs of residential buildings that can be seen under grey layers of coal dust - this is the everyday life of people surrounding GVCF mines. *(Illustrative image — AI-generated for visualization purposes)*

**Figure 4:** Coal processing plant emitting thick dust plumes over an adjacent Indian village.

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**Table 3: Ambient Air Quality Parameters at GVCF Mining Zones (Representative Data)**

| Parameter | NAAQS Standard (Industrial) | Mine Boundary Range | Residential Colony Range | Status |
|---|---|---|---|---|
| $PM_{10}$ (µg/m³) | 100 | 180–340 | 120–210 | Exceeds Standard |
| $PM_{2.5}$ (µg/m³) | 60 | 95–160 | 75–130 | Exceeds Standard |
| $SO_2$ (µg/m³) | 80 | 25–60 | 18–40 | Within Standard |
| $NO_x$ (µg/m³) | 80 | 30–75 | 25–55 | Marginal |
| CO (mg/m³) | 4.0 | 1.5–3.8 | 1.2–2.5 | Within Standard |

*Source: SCCL Environmental Compliance Statements (ECS, 2021); Ministry of Coal SDC Report (2021); TGPCB monitoring data.*

There are continuously 1.8-3.4 times the NAAQS allowable limit of particulate matter in the mine boundaries, which is a serious respiratory health hazard to mine workers and the surrounding communities. Deposition of coal dust on agricultural fields of agriculture has been known to lower the quality of soil and crop yield in villages with a 5-km radius of the active opencast activities (Extensionjournal.com, 2024).

### 4.2 Coal Fires and Methane Emissions

Another underreported yet dispersed environmental and safety threat is underground coal fires that occur in the GVCF. Land subsidence due to fires leads to collapses of roofs and adds to the local air quality impairment by the constant discharge of CO, $CO_2$, and $SO_3$ (Springer, 2024). Emitted in underground drilling, methane ($CH_4$ ) is a powerful greenhouse gas (GWP = 25), and it contributes to the carbon footprint in the region and increases the effect of climate change on the hydrological conditions of the Godavari basin.

## 5. Water Resource Contamination

### 5.1 Mine Water Discharge

Coal mines face serious environmental challenges in water management. The mine water generated by both the opencast and underground operations contains heavy metals, suspended solids, and acidic compounds, which are released into the environment unless treated properly. Treatment and use of mine water are reported throughout the operations of SCCL, but the overall amount of discharge and the effectiveness of the treatment are still discussed on the regulatory level (Ministry of Coal SDC, 2021). **Figure 5:** Acid mine drainage (AMD) discharging from a mine pipe into a Godavari tributary, causing vivid orange-brown iron hydroxide contamination of riverbanks. Dead fish on the water surface illustrate the acute aquatic ecological impact. *(Illustrative image — AI-generated for visualization purposes)*

**Figure 5:** Acid mine drainage (AMD) discharging from a mine pipe into a Godavari tributary

**Table 4: Mine Water Generation and Utilization at SCCL (2019–20 to 2022–23)**

| Year | Total Mine Water Generated (ML) | Water Utilized (ML) | Utilization Rate (%) | Discharged to Environment (ML) |
|---|---|---|---|---|
| 2019–20 | 12,450 | 8,715 | 70.0% | 3,735 |
| 2020–21 | 13,200 | 9,504 | 72.0% | 3,696 |
| 2021–22 | 14,380 | 10,784 | 75.0% | 3,595 |
| 2022–23 | 15,100 | 11,778 | 78.0% | 3,322 |

*Source: Ministry of Coal, Sustainable Development Cell (SDC) Status Reports 2020–21, 2022–23; SCCL ECS documents.*

**5.2 Heavy Metal Contamination**

A critical environmental concern in the GVCF is the contamination of soil and water with heavy metals from mining operations. The recent work of integrating machine learning and positive matrix factorization (PMF) in source apportionment of heavy metals in the region of the Godavari Valley coalfields showed that heavy metals were acutely contaminated in various categories of land uses (RSC Advances, 2024). They were found to be Cobalt (Co) and Cadmium (Cd), which were the most uniformly enriched elements, and the pollution indices showed surpassances that are ecologically and human-health negative.

**Table 5: Heavy Metal Concentrations in Soils Near GVCF Mining Sites vs. Background Levels**

| Heavy Metal | Background Level (mg/kg) | Mining Area Average (mg/kg) | Control Area Average (mg/kg) | Enrichment Factor |
|---|---|---|---|---|
| Cobalt (Co) | 11.6 | 48.2 | 14.3 | 4.15× |
| Cadmium (Cd) | 0.35 | 2.87 | 0.48 | 8.2× |
| Lead (Pb) | 20.0 | 67.4 | 23.1 | 3.37× |
| Chromium (Cr) | 60.0 | 142.6 | 65.3 | 2.38× |
| Arsenic (As) | 5.5 | 19.8 | 6.1 | 3.60× |
| Iron (Fe) | 38,000 | 56,200 | 40,100 | 1.48× |
| Manganese (Mn) | 525 | 1,240 | 560 | 2.36× |

*Source: RSC Advances — Integrated Machine Learning and Positive Matrix Factorization study, Godavari Valley Coalfields (2024 publication, data from 2022–24 sampling); Extensionjournal.com farming household study (2024).*

**5.3 Water Quality Degradation in Godavari Tributaries**

According to the cGodavari-NRCD (2024) report, mining activities are one of the major sources of pollution in Godavari tributaries, and in this case, they are due to acid mine drainage (AMD) and suspended sediment loading. Streams of the Godavari passing over and below coal mining regions (Segments 21-26 cGodavari study) have high turbidity, biological oxygen demand (BOD), and concentrations of heavy metals. The contamination profile is further complicated by industrial wastewater discharge into the Godavari by a complex of thermal power based on SCCL coal. Soil degradation indicators in mining areas show significantly elevated values (0.91) compared to control areas (0.38), while water quality indices in mining proximal zones (0.92) are dramatically worse than non-mining control areas (0.40), as documented in vulnerability studies of farming households in GVCF coalfields (Extensionjournal.com, 2024).

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## 6. Biodiversity and Ecosystem Impacts

### 6.1 Forest Loss and Habitat Fragmentation

A large part of the Eastern Ghats biodiversity hot spot is found in the Godavari Valley. Located at Andhra Pradesh, bordering the lower Godavari Valley, Papikonda National Park has more than 2531 species of plants, 173 of which are endemic, and charismatic megafauna, such as Bengal tigers, Indian leopards, and sloth bears (cGodavari, 2024). The Coringa Wildlife Sanctuary is the home of the second-largest mangrove ecosystem in India, which supports 27 species of mangroves and is a refuge for migratory birds.

The growth of coal mining in forested lands requires that the Ministry of Environment and Forests (MoEFCC) grant forestry clearance (FC), though the cumulative loss of habitat through the growth of mine leases, transportation corridors, township development, and creation of OB dumps has led to a lot of habitat fragmentation. The existing forest cover of 31.67% that is left in the study area of the coalfield (2014) is broken to pieces, making it impossible to provide ecological connectivity to the movement of large mammals, watershed processes, and so on (Garai & Narayana, 2018).

**Figure 6:** Before-and-after conceptual documentation of biodiversity loss in the Godavari Valley. Left: thriving Eastern Ghats forest ecosystem with Bengal tiger, Mahseer fish, and rich bird diversity in clear riverine habitat. Right: the same landscape devastated by coal mining — barren pit, dead fish in contaminated murky water, no wildlife. *(Illustrative image — AI-generated for visualization purposes)*


**Figure 6: Before-and-after conceptual documentation of biodiversity loss in the Godavari Valley**

**Table 6: Biodiversity Indicators — Impact Assessment in GVCF Region**

| Indicator | Status Before Mining (Baseline) | Current Status | Trend |
|---|---|---|---|
| Forest Cover (% of study area) | 36.38% (1990) | 31.67% (2014) | ↓ Declining |
| Fish Species in Godavari (No.) | >80 species | ~60–65 species | ↓ Declining |

| | | | |
|---|---|---|---|
| Terrestrial Bird Species (No.) | ~220 recorded | ~180–190 | ↓ Declining |
| Mangrove Area in Delta (ha) | ~35,000 | ~27,000–30,000 | ↓ Declining |
| Reptile/Amphibian Diversity | High | Moderate | ↓ Declining |
| Soil Biodiversity Index (mining vs. control) | 1.00 (baseline) | 0.42 (mining area) | ↓ Severely degraded |

*Source: cGodavari & NRCD (2024); Garai & Narayana (2018); compiled from published literature.*

### 6.2 Aquatic Ecosystem Disruption

The river Godavari serves the commercial and ecological potential of such fish as Indian Major Carps (Catla catla, Labeo rohita, Cirrhinus mrigala), Deccan Mahseer (Tor khudree), and the commercial fish Pulasa (Tenualosa ilisha). These fisheries are put under stress by heavy metal loading, high turbidity, and thermal pollution due to mine-related thermal plants, with less success in spawning and even less success in survival of juveniles. The pH conditions (pH < 5.5) caused by acidification of tributaries that received AMD are fatal to delicate aquatic invertebrates that constitute the base of the aquatic food web.

## 7. Socio-Ecological Poverty of Agricultural Communities

### 7.1 Livelihood Impacts

The compound vulnerabilities encountered by farming households in the GVCF coal mining areas include land acquisition, crop failures attributed to dust deposits and water pollution through irrigation, health impacts of air pollution, and low agricultural productivity attributed to soil erosion. In a systematic study of farming households in GVCF Telangana, farming households located near the mines were found to be far more susceptible to these vulnerabilities (0.64) than the non-mining control regions (0.28), which is facilitated by degradation of land and water, health effects, and agricultural income loss (Extensionjournal.com, 2024).

Figure 7: A farming family of Indians in their dust-covered, worn-out crop fields in Telangana, where an SCCL mine and overburden dump are intruding in the background. This image illustrates the direct intersection of industrial extraction and agricultural livelihood vulnerability. *(Illustrative image — AI-generated for visualization purposes)*

**Figure 7:** An Indian farming family standing in their coal-dust-coated

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**Table 7: Vulnerability Comparison — Mining vs. Control Area Farming Households**

| Vulnerability Dimension | Mining Area Score | Control Area Score | Difference |
|---|---|---|---|
| Soil Degradation Index | 0.91 | 0.38 | +0.53 |
| Water Quality Index (degradation) | 0.92 | 0.40 | +0.52 |
| Sensitivity Score | 0.64 | 0.28 | +0.36 |
| Crop Yield Loss (%) | 28–35% | 5–8% | +23–27% |
| Health Expenditure (₹/year/household) | 18,500–22,000 | 6,800–8,200 | +11,700–13,800 |

*Source: Extensionjournal.com (2024), Farming household vulnerability in coal mining regions, Godavari Valley Coalfields, Telangana.*

### 7.2 Displacement and Social Disruption

Expansion of land to accommodate the mines has caused the community to be displaced, especially the tribal and agricultural communities, who rely on forests and rivers as their means of subsistence. The socio-cultural effects, the loss of sacred groves, destruction of traditional fishing rights, pollution of drinking water sources are aspects of the environmental crisis in the Godavari Valley, which are intangible yet significant in scale. SCCL activities as part of its Corporate Social Responsibility (CSR) and Community Development (CD) programs, although significant, have not fully covered the social debt of more than 100 years of extraction.

## 8. Growth and Environmental Pressure Trajectory of Coal Production.

### 8.1 Production Escalation

This has significantly increased the coal production capacity of SCCL in the last 20 years due to the pressure of energy demand in the country. This trend of growth is directly proportional to the increased environmental effects on the dimensions discussed above.

**Table 8: SCCL Coal Production Trend (2003–2024)**

| Year | Coal Production (Million Tonnes) | No. of Active Mines | Operational Area (approx. ha) |
|---|---|---|---|
| 2003–04 | 28.50 | 33 | ~45,000 |
| 2006–07 | 37.71 | 37 | ~55,000 |
| 2010–11 | 44.50 | 39 | ~62,000 |
| 2015–16 | 60.28 | 41 | ~72,000 |
| 2019–20 | 64.50 | 42 | ~78,000 |
| 2022–23 | 67.00 | 43 | ~82,000 |
| 2023–24 | 67.50 | 43 | ~84,000 |
| 2024–25 | 69.01 | 39* | ~85,000 |

**Reduction reflects exhaustion of reserves at several mines. Source: Garai & Narayana (2018); Ministry of Coal SDC Report (2021); TGPCB (2024); SCCL Annual Reports.*

## 9. Mitigation Strategies and Policy Recommendations

### 9.1 Current Mitigation Measures

Some of the environmental mitigation measures that have been put in place by SCCL and the Ministry of Coal include: sprinkling of haul roads and OB dump surface water to suppress dust emission; plantation drive (99.6 million trees planted at subsidiaries of CIL as of March 2020); mine water treatment using settling pond before surface discharge; green belt development of 10 m width around mine boundaries; and gradual reclamation of exhausted mine voids. The Mine closure

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escrow funds (9,000000/ha in the case of OC mines; 150000/ha in the case of UG mines) give certain economic support to post-closure rehabilitation (Ministry of Coal, 2021).

Figure 8: SCCL mine reclamation project: workers in safety vests planting saplings on a geo-net armored OB dump slope, where a solar-powered mine office and a green belt can be seen below the still operating mine pit in the background. *(Illustrative image — AI-generated for visualization purposes)*

**Figure 8:** SCCL mine reclamation effort

### 9.2 Critical Gaps and Recommendations

Nevertheless, there are still critical gaps:

1. Cumulative Environmental Impact Assessment (CEIA): There are other EIA studies done on individual mines that do not reflect the cumulative environmental burden. An obligatory CEIA of all the mines of the GVCF should be commissioned and renewed every five years (MoM of EAC Meeting, 2024).
2. Real-Time Air Quality Monitoring Networks: Ambient air quality monitoring stations (CAAQMS) should be established continuously at the boundary of the mine and in the impacted villages and made publicly available on the real-time dashboard.
3. Zero Liquid Discharge to Mine Water: The aim of the regulation by 2030 is to have zero discharge of mine water into natural waterways, but all mine water should be recycled in the operations.
4. Ecological Compensation Funds: Under the community forestry, a special ecological compensation fund in proportion to the amount of forest cover cleared should be used to reforest the degraded lands with native species.
5. Community-Inclusive Mine Closure: Closure and post-mining land use plans need to be prepared in a manner that has a serious involvement of the displaced and affected communities, and the plans need to incorporate the goals of livelihood restoration and ecological restoration.
6. Heavy Metal Remediation: Phytoremediation schemes involving the use of metal-tolerant indigenous plants (e.g., Vetiver zizanioides, Typha latifolia) are advised to be used in the mine-impacted contaminated soils and water bodies.

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## 10. Conclusion

The Coalfield of Godavari Valley is at a crossroads. Since the beginning of its 135 years of existence, the southern Indian industry and economic growth would not have been the same without its abundant deposits of coal, making SCCL an essential element in its energy supply. However, the ecological account of this mining adds up to losses in all ecological sectors, including land, air, water, and biodiversity, which jeopardize the ecological sustainability and human livelihood in the long term of the Godavari Basin.

This paper has demonstrated, through quantitative data synthesis and literature review, that: forest cover in the coalfield region has declined by over 4.7 percentage points between 1990 and 2014, with basin-wide tree cover loss of 8.84% between 2017 and 2023; mining area extent has increased by 475% over 24 years; ambient $PM_{10}$ levels at mine boundaries consistently exceed NAAQS by 1.8–3.4 times; heavy metals including Cd, Co, and Pb show 3–8-fold enrichment in mining-adjacent soils; farming households near mine operations exhibit sensitivity indices and health expenditure burdens far exceeding those in non-mining areas; and coal production grew from 28.5 MT to 69.01 MT between 2003–04 and 2024–25, with corresponding intensification of all environmental pressures.

As India navigates its energy transition — committing to expanded renewable capacity while coal remains the bedrock of power supply through 2030 and beyond — the Godavari Valley must not be left as an ecological sacrifice zone. The dual imperatives of energy security and ecological justice demand that SCCL, the Government of Telangana, the Ministry of Coal, and the Ministry of Environment, Forest and Climate Change (MoEFCC) collectively adopt a transformative governance approach: one that mandates cumulative environmental impact assessments, enforces real-time pollution monitoring, transitions toward zero liquid discharge from mine operations, deploys community-based ecological restoration programs, and ensures that no mine is closed without a binding, community-inclusive land rehabilitation plan.

Godavari River is not only an economic asset, but it is a source of life to more than 76 million inhabitants, a reservoir of inestimable biodiversity, and a cultural heritage that is of immeasurable worth. The facts that have been used in this research enable one to understand that incremental environmental management is not adequate any longer. An ecological paradigm shift to a holistic governance of the GVCF is not only desirable, but mandatory, not as a development impediment, but as its precondition. The research directions that should be undertaken in the future are longitudinal health impact studies of the mining-impacted communities, fine-scale hydrological modeling of the AMD propagation in Godavari tributaries, and evaluation of the post-closure land use to inform just transition planning in this ecologically paramount and socially vulnerable area.

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