Carbon Emission Tracking & Afforestation Monitoring Platform

Presented by

Impana E20221CBD0027
B Navya 20221CBD0031
Konki Mithil 20221CBD0022

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Abstract

Coal mining remains a vital energy source in India but contributes significantly to carbon emissions, undermining the nation's commitment to net-zero targets. Traditional approaches for emission tracking are largely manual, inefficient, and lack scalability. This project introduces a web-based Carbon Emission Tracking and Afforestation Monitoring Platform designed to quantify activity-wise emissions from coal mines and compare them against natural carbon sinks. The platform integrates real-time geospatial data, automated emission factor calculations, and AI-driven recommendations for afforestation and clean technologies. A user-friendly dashboard visualizes emissions, absorptions, and gaps, while also enabling carbon credit estimation. This solution aims to provide policymakers and industries with a digital decision-support tool that drives India's transition toward carbon neutrality.

Literature Review

Several studies emphasize the urgent need for monitoring industrial emissions in developing countries.

- Global Context: Research indicates that coal mining contributes nearly 40% of industrial carbon emissions worldwide. Existing global platforms such as the Carbon Disclosure Project (CDP) and UNFCCC inventories provide high-level data but lack mine-specific granularity, especially in developing nations.
- Indian Context: India's coal mines contribute a large share of national CO_2 emissions, yet centralized digital tools remain limited. Current methods rely on manual reporting, periodic surveys, or third-party audits, which are prone to delays and inaccuracies.
- Technological Interventions: Prior works have explored satellite-based forest monitoring (Global Forest Watch, Google Earth Engine) and carbon footprint calculators. However, these solutions do not integrate both emission quantification and afforestation planning tailored for Indian coal mines.
- Research Gap: A unified, India-specific digital system that combines emission tracking,

carbon sink analysis, and afforestation recommendations is missing. This project fills that gap by offering a holistic, modular platform that supports sustainable coal mining practices.

System Design

The platform follows a modular web-based architecture ensuring scalability and real-time insights.

1. Frontend
- React + Vite
- Tailwind CSS
- Chart.js

2. Backend
- Python (Django + FastAPI)
- Custom Calculation Modules
- JWT Authentication

3. Database
- MySQL hosted on Railway

4. Geospatial & Satellite
- Leaflet.js
- Google Earth Engine API

5. Authentication
- Firebase Auth (Role-based login)

6. User Flow
1. Secure login
2. Data entry
3. Emission calculation
4. Carbon sink retrieval
5. Gap analysis
6. Dashboard visualization
7. Exportable reports

Algorithm Details

The core algorithm integrates activity-based emission factor models with carbon sink analysis:

1. Data Input: User selects activity and inputs parameters (fuel type, distance, methane volume, etc.).
2. Emission Calculation:

- Diesel: Emissions = Quantity × EF
- Electricity: Emissions = kWh × 0.82
- Transportation: Emissions = Tons × Distance × ModeEF
- Fugitive Methane: Emissions = Volume × 0.716 × GWP(28)
- Deforestation: Emissions = Hectares × 300,000
- Coal Extraction: Emissions = Quantity × 2.42

3. Report Generation: Activity name, calculated emissions, method, timestamp.
4. Visualization: KPI Dashboard, Pie Chart, Bar Chart, contextual comparisons.
5. Carbon Sink Analysis: Satellite overlays, afforestation potential zones.
6. PDF Export: html2canvas + jsPDF.
7. Insights: Trees required, equivalent car km, recommendations.

Module Description

1. Authentication Module: Role-based login via Firebase.
2. Home & About Module: Overview and project goals.
3. Data Entry Module: Input mining and activity data.
4. Emission Report Module: Calculates and visualizes emissions.
5. Sink Analysis Module: Geospatial forest data and absorption insights.
6. Recommendation Module: AI-driven afforestation and carbon credit suggestions.
7. Visualization & Export Module: Charts, KPIs, PDF export.