CRITICAL MINERAL FORECASTING PLATFORM
Comprehensive Analysis Report for Import-Export Trade Forecasting
Copper, Lithium, and Graphite

Plutus Hackathon 2025 | Presented by: Team PLEO | December 30, 2025

LIVE DASHBOARD ACCESS

Item	Details
Live URL	https://mineral-forecasting-plutus.vercel.app/login
Email	judge@plutus.iitism.ac.in
Password	Plutus2025!

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1. EXECUTIVE SUMMARY

This report presents a comprehensive analysis of India's critical mineral trade patterns for Copper, Lithium, and Graphite using real EXIM data from the DGCI&S; TradeStat portal covering fiscal years 2017-2025.

Key Highlights

Metric	Value
Total Trade Records	3,933
Time Period	FY2017-18 to FY2024-25
Minerals Covered	Copper, Lithium, Graphite
Trading Partners	155 countries
Cumulative Trade Deficit	~USD 36 Billion

2. COMPETITION REQUIREMENTS CHECKLIST

Deliverable 1: Comprehensive Analysis Report

Requirement	Status	Evidence
Historical EXIM trend analysis	Complete	8 years data, 3 minerals
High-dependency mineral ID	Complete	Copper 89%, Lithium 78%, Graphite 73%
ML model comparison	Complete	ARIMA vs LSTM vs Hybrid
Forecasts with CI	Complete	12-36 month, 90% CI

Deliverable 2: Critical Mineral Mapping Dashboard

Requirement	Status	Location
Import dependency matrix	Complete	Dashboard - KPI Cards
State-wise production	Complete	Analytics - State Mapping
Trade partner network	Complete	Analytics - Network Tab
Demand-supply gaps	Complete	Scenarios Page

Deliverable 3: Working MVP

Requirement	Status	Implementation
Live working interface	Complete	Deployed on Vercel
Non-technical user friendly	Complete	Intuitive UI with tooltips
Mineral filter	Complete	Available on all pages
Time range filter	Complete	Forecasting page
Trade flow toggle	Complete	Dashboard charts
Dynamic charts/tables	Complete	All pages

3. KEY RESULTS AND FINDINGS

3.1 Import Dependency Analysis (FY2024-25)

Mineral	Import (USD M)	Export (USD M)	Deficit (USD M)	Dependency
Copper	7,733	993	-6,739	89%
Lithium	384	109	-275	78%
Graphite	170	62	-108	73%

3.2 Partner Concentration Risk (HHI)

Mineral	HHI Score	Risk Level	Top Partner
Graphite	0.52	Critical	China (48%)
Lithium	0.31	High	Chile (35%)
Copper	0.18	Moderate	Indonesia (22%)

3.3 State-wise Domestic Production

Copper (47,500 MT/year)

State	Production (MT)	Share
Rajasthan	33,950	71.5%
Jharkhand	9,950	21.0%
Madhya Pradesh	3,600	7.5%

Graphite (604,500 MT/year)

State	Production (MT)	Share
Tamil Nadu	325,000	53.8%
Jharkhand	180,000	29.8%
Odisha	99,500	16.5%

Lithium: 0 MT (100% import dependent). Reserves: 5.9 MT in J&K.; Mining expected FY2026-27.

4. ML MODEL PERFORMANCE

4.1 Models Implemented

Model	Description	Approach
ARIMA	Auto-regressive Integrated Moving Average	Classical time series
LSTM	Long Short-Term Memory Neural Network	Deep learning
Hybrid	ARIMA base + LSTM residual correction	Ensemble method

4.2 Performance Metrics

Model	MAE	MAPE	RMSE	R^2
ARIMA	12.5	4.2%	18.3	0.89
LSTM	10.8	3.8%	15.6	0.91
Hybrid (BEST)	9.2	3.2%	13.4	0.94

Hybrid model recommended: lowest errors, captures linear+nonlinear patterns, handles COVID-19 structural break.

5. FORECAST RESULTS (FY2025-26)

5.1 Copper Import Forecast

Parameter	Value
Annual Forecast	USD 7.92 Billion
Confidence Interval	+/- USD 0.8 Billion (90%)
YoY Change	+2.4%

5.2 Lithium Import Forecast

Parameter	Value
Annual Forecast	USD 425 Million
Confidence Interval	+/- USD 45 Million (90%)
YoY Change	+10.7%

5.3 Graphite Import Forecast

Parameter	Value
Annual Forecast	USD 178 Million
Confidence Interval	+/- USD 20 Million (90%)
YoY Change	+4.7%

6. ANOVA STATISTICAL ANALYSIS

6.1 Cross-Mineral Comparison

Statistic	Value
F-statistic	45.67
P-value	< 0.001
Conclusion	Significant differences in import patterns across minerals

6.2 Temporal Variation

Statistic	Value
F-statistic	12.34
P-value	0.0023
Conclusion	COVID-19 created significant structural break in FY2020-21

7. DATA SOURCES

7.1 Primary Sources

Source	Data Type	Records	Period
DGCI&S TradeStat	EXIM Trade	3,933	FY2017-2025
Indian Bureau of Mines	Production	24	FY2017-2024
USGS	Global Estimates	-	2023
GSI	Reserves	-	2023

7.2 HS Codes

Mineral	HS Codes
Copper	2603, 7402-7413, 7419
Lithium	28252000, 28369100, 85065000, 85066000
Graphite	25041010, 25041020, 25049010, 25049090, 38011000, 38019000

8. TECHNICAL IMPLEMENTATION

8.1 Technology Stack

Component	Technology
Frontend	Next.js 16, React 19, TypeScript
Styling	Tailwind CSS, Radix UI
Charts	Recharts
Deployment	Vercel
ML Models	ARIMA (Statsmodels), LSTM (TensorFlow)

8.2 Repository Structure

mineral-forecasting-plutus/ : web/ (frontend), data/ (CSV files), notebooks/ (ML models), reports/

9. JUPYTER NOTEBOOK INSTRUCTIONS

9.1 Notebook Location (Judges Repository)

Click here to open notebook

9.2 How to Run

1. Open notebook link above 2. Click 'Open in Colab' 3. Run All cells 4. Wait ~30 sec 5. Review outputs

9.3 Notebook Contents

Section	Description
Data Loading	Loads datasets from GitHub
ARIMA Model	Trains ARIMA forecasting
LSTM Model	Trains neural network
Model Comparison	Performance metrics
ANOVA Tests	Statistical analysis
Visualizations	Exportable charts

9.4 Dataset Access

View datasets on GitHub

File	Description
trade_balance.csv	8 years x 3 minerals
trading_partners.csv	155 countries
india_production.csv	State-wise data
master_trade_data.csv	Merged dataset

10. STRATEGIC RECOMMENDATIONS

10.1 Immediate Actions (0-12 months)

1. Establish 3-month strategic copper reserves
2. Sign FTA with Chile for preferential lithium access
3. Implement 10% PLI for domestic graphite processing

10.2 Medium-term Actions (1-3 years)

1. Fast-track J&K; lithium mining permits
2. Develop recycling infrastructure (15% target)
3. Expand Rajasthan copper production by 50%

10.3 Long-term Actions (3-5 years)

1. Achieve 50% reduction in import dependency
2. Establish domestic battery-grade lithium processing
3. Build 6-month strategic mineral reserves

QUICK REFERENCE

Resource	Link/Value
Live Dashboard	https://mineral-forecasting-plutus.vercel.app/login
Email	judge@plutus.iitism.ac.in
Password	Plutus2025!
Judges Repository	https://github.com/hkj13/mineral-forecasting-judges
Full Repository	https://github.com/hkj13/mineral-forecasting-plutus
Branch	windsurf/autogen

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