

# FVI Ecological Score – Implementable Formulas Using Available Data

This guide maps the exact datasets you uploaded to concrete, operational formulas for the Ecological Score. Where a metric requires unavailable attributes (e.g., spatial overlays), I provide a minimal, clearly-labeled manual input that you can fill now and replace later with GIS outputs.

## Datasets detected

- global\_mining\_area\_per\_country\_v1.csv — columns: COUNTRY\_NAME, ISO3\_CODE, AREA, N\_FEATURES
- New\_Deforestation\_Fronts\_wgs[1].csv — columns: X, Y, Name, Notes, ID\_no, Area\_ha
- coal-ash-sites\_current.xlsx — appears to contain reference/metadata; site-level sheet may be missing in this copy
- Global-Coal-Plant-Tracker-January-2025.xlsx — sheets: About, Units, Proposal summaries, CO2 parameters (includes Country/Area, Fuel type, Capacity (MW), Net generation (GWh/yr), gCO2/kWh by coal grade, Annual CO2)

## Global conventions

- Use a single reference year (e.g., 2023) when combining with time series. Aggregate plant rows to country level where needed.
- Keys: ISO3 country codes; for GCPT plant data, use Country/Area and sum by country.
- Normalization: for composite scoring later, normalize each submetric to 0–100 (higher = worse) via percentile ranks or min–max and winsorize outliers.

## ECOLOGICAL 1 — Land Disturbance Intensity (Mining)

**Goal:** Quantify land disturbance from coal mining using country mining area and scale by activity.

### Datasets & fields

- global\_mining\_area\_per\_country\_v1.csv → fields: ISO3\_CODE, COUNTRY\_NAME, AREA (km<sup>2</sup> or ha; confirm), N\_FEATURES (# mining polygons).
- Global-Coal-Plant-Tracker-January-2025.xlsx → sheet 'CO2 parameters': fields: Country/Area, Capacity (MW) and/or Net generation (GWh/year).

### Transforms

- Aggregate GCPT plants to country totals: Capacity\_GW[c] =  $\Sigma$  Capacity(MW)/1000; Gen\_GWh[c] =  $\Sigma$  Net generation (GWh/yr).
- Ensure AREA in common units (convert ha→km<sup>2</sup> if needed: km<sup>2</sup> = ha / 100).

### Formulas (math)

- LandIntensity\_cap[c] = AREA[c] / Capacity\_GW[c] (km<sup>2</sup> per GW)
- LandIntensity\_gen[c] = AREA[c] / Gen\_GWh[c] (km<sup>2</sup> per GWh)

### Excel-style (conceptual)

= AREA[c] / (SUMIFS(CapacityMW, Country,c)/1000) or = AREA[c] / SUMIFS(NetGenGWh, Country,c)

## ECOLOGICAL 2 — Mining Site Density (Pressure Proxy)

**Goal:** Density of mining features relative to coal activity.

### Datasets & fields

- global\_mining\_area\_per\_country\_v1.csv → N\_FEATURES.
- GCPT 'CO2 parameters' → Capacity (MW) or Net generation (GWh/yr).

### Formula (math)

- SiteDensity\_cap[c] = N\_FEATURES[c] / Capacity\_GW[c] (sites per GW)

- $\text{SiteDensity\_gen}[c] = \text{N\_FEATURES}[c] / \text{Gen\_GWh}[c]$  (sites per GWh)

## ECOLOGICAL 3 — Deforestation Front Exposure (with minimal manual mapping)

**Goal:** Exposure of coal activity to active deforestation fronts.

### Datasets & fields

- New\_Deforestation\_Fronts\_wgs[1].csv → fields: Name, Area\_ha (front polygon areas).
- GCPT 'CO2 parameters' → Country/Area, Capacity (MW) or Net generation (GWh/yr).

### Minimal manual input

- Create deforestation\_fronts\_country.csv with: Name, Country (ISO3). Each front can map to multiple countries if it spans borders.

### Transforms

- Join fronts→countries; compute  $\text{FrontArea\_byCountry}[c] = \sum \text{Area\_ha}$  for fronts mapped to c.
- Compute  $\text{ActivityWeight}[c] = \text{Capacity\_GW}[c]$  (or  $\text{Gen\_GWh}[c]$ ).

### Formula (math)

$$\text{DeforestExposure}[c] = (\text{FrontArea\_byCountry}[c] / \sum_c \text{FrontArea\_byCountry}[c]) \times (\text{ActivityWeight}[c] / \sum_c \text{ActivityWeight}[c])$$

### Excel-style (conceptual)

$$= (\text{FrontArea}_c / \text{SUM}(\text{FrontArea}_*)) * (\text{CapacityGW}_c / \text{SUM}(\text{CapacityGW}_*))$$

**Note:** This yields a 0–1 share. Rescale to 0–100 for scoring. Replace manual mapping later with a GIS overlay of plant/mine buffers with deforestation polygons.

## ECOLOGICAL 4 — Coal Ash Residuals Risk (Proxy)

**Goal:** Relative risk from coal ash ponds/landfills.

### Datasets & fields

- coal-ash-sites\_current.xlsx → if a site sheet exists: fields should include Country/State, Site name, Status/Incidents.

### If site sheet not present

- Create coal\_ash\_sites\_by\_country.csv: Country (ISO3), Sites\_count, Incidents\_count.

### With GCPT

- Capacity\_GW[c] or Gen\_GWh[c] as activity denominator.

### Formula (math)

$$\text{AshRisk}[c] = (\text{Sites\_count}[c] + w_{\text{incident}} \times \text{Incidents\_count}[c]) / \text{Capacity\_GW}[c]$$

Where  $w_{\text{incident}} > 1$  (e.g., 5) to upweight incident histories.

## ECOLOGICAL 5 — Fuel Ecological Penalty (Grade-based Proxy)

**Goal:** Penalize countries whose coal plants predominantly burn lignite/low-rank coal (associated with higher local pollutants and land footprints).

### Datasets & fields

- GCPT 'CO2 parameters' → fields: Fuel type, Capacity (MW) or Net generation (GWh/yr).

### Transforms

- Define penalty weights:  $w_{\text{lignite}}=1.2$ ,  $w_{\text{subbit}}=1.1$ ,  $w_{\text{bituminous}}=1.0$  (tuneable).
- Compute country-level weighted penalty:  $\text{FuelPenalty}[c] = \sum_i (w_{\text{fuel}(i)} \times \text{Activity}_i) / \sum_i \text{Activity}_i$

### Formula (math)

- `FuelPenalty[c] ∈ [1.0, 1.2]`; map to 0-100 by linear scaling for the composite.

## Composite assembly

Normalize each submetric to 0–100 (higher=worse), winsorize outliers, then combine with weights (e.g., Land 30%, Site density 15%, Deforestation 25%, Ash risk 15%, Fuel penalty 15%).

These are fully operational with the files above (plus two tiny manual tables). As you add GIS layers (protected areas, water stress), we can replace proxies with direct measurements.