



risk-specific
methodology overview

CRITICAL MINERALS

A Structured Framework for Assessing Climate-Driven Risks in ETF Portfolios

Introduction

Critical minerals such as lithium, cobalt, and copper **face climate-related pressures** that are expected to **reduce availability** and **increase price volatility**. For companies that depend on these inputs, supply shocks could weaken financial performance and, in turn, **weigh on ETF valuations** and **returns** relative to the market expectations that prevailed at the time of initial investment.

This assessment focuses exclusively on **forward-looking** drivers not yet reflected in market prices. Drivers already in force are assumed to be at least partly priced in and are therefore excluded.

The current document is an overview version of the methodology, prepared for external distribution. It sets out what the framework does and why it was designed this way, without reproducing its underlying mechanics. The full methodology is available upon request at hello@kilda.app.

Critical minerals mapping

In this initial release, Kilda's mapping covers a focused set of five critical minerals: lithium, cobalt, nickel, copper, and rare earth elements.

The selection follows two criteria. Each mineral is consumed across **multiple industries** rather than confined to a single sector, and global supply for each is **concentrated** in a small number of producing countries, many of which carry material exposure to climate-related drivers.

Coverage will expand as authoritative data for additional minerals matures. Bulk commodities that are mined widely and sourced through diversified supply chains fall outside the framework, since they are far less vulnerable to the disruptions assessed here.

Policy drivers

Policy drivers arise from **regulatory and legislative changes** that constrain access to, or increase the cost of, critical minerals. In this initial release, three types of policy driver are assessed.

- **Export restrictions** reflect controls that governments place on critical minerals, often tied to national strategies for clean energy and advanced manufacturing, reserving supply for domestic use and creating lasting pressure on global pricing and availability.
- **Biodiversity and land-use restrictions** limit or fragment access to mineral deposits, whether physically or through extended permitting, introducing long-term barriers to supply.
- **Community and Indigenous rights enforcement** captures consent requirements, litigation, and local mobilisation that raise the threshold for project approval and extend the time required to clear it. The category records only the supply-chain implications; no value judgment regarding Indigenous peoples or affected communities is implied.

Extreme weather drivers

Extreme weather drivers arise from **acute events and chronic shifts** in climate patterns that could disrupt the supply and pricing of critical minerals.

In this initial release, three drivers are used, each chosen because it is measurable and projection-ready, and all drawn from the Climate Impact Explorer under the NGFS Current Policies scenario. Relying on one source and one scenario keeps the climate inputs consistent across all minerals and countries.

- **Annual maximum 5-day precipitation** captures the severity of intense downpours bearing on producing regions.
- **Daily maximum wet-bulb temperature** measures heat stress in outdoor mining operations, combining temperature and humidity into a single indicator.
- **Area under extreme drought** captures the extent to which producing regions are exposed to severe dry conditions.

Analysis

In this section, each mineral is carried from producer mapping, through **driver tagging and severity-likelihood scoring**, to an aggregated mineral-country result, and finally to the production-weighted risk score that links it to company exposures.

Mapping minerals to producing countries

For each mineral, the set of countries that together account for the large majority of global mine output is identified. Concentrating on this set keeps the analysis focused on the geographies that actually **drive supply**, while a consistent selection rule ensures that the mapping is **reproducible** from one mineral to the next.

Production figures are taken from the USGS Mineral Commodity Summaries, the primary source, and are cross-checked against the British Geological Survey for verification. Where the two disagree, the discrepancy is flagged and resolved on a consistent basis.

Tagging future policy drivers

For each mineral-country combination, the relevant future policy drivers are identified and tagged against the three categories described earlier.

Identification relies exclusively on **free, authoritative sources** such as government legal notices, legislative records, and official consultation papers, supported by a standardised source list and search protocol that is maintained and updated regularly.

Only **forward-looking measures** are recorded: a driver qualifies where it represents a new measure or a material tightening of an existing one, while measures already in force are treated as current operational conditions and excluded.

Tagging future extreme weather drivers

For each mineral-country combination, the relevant future extreme weather drivers are likewise identified and tagged against the three indicators described earlier.

The analysis uses **forward-looking** projections for each indicator, drawn from the Climate Impact Explorer under the NGFS Current Policies scenario to a 2030 horizon, and considers both the central projection and the range of uncertainty around it. Working from a common, transparent data source keeps the climate component **consistent across every mineral and country** in the framework.

Scoring framework for future policy drivers

Each policy driver is assessed along two dimensions.

- Severity reflects the degree to which the driver, if realised, would **disrupt future supply** of the mineral or materially **raise its costs**.
- Likelihood reflects the directional confidence that the **driver will materialise or intensify**.

Both dimensions are expressed as ordered classifications rather than precise probabilities, which keeps the assessment honest about the qualitative nature of policy judgment while still allowing drivers to be compared on a common basis.

Each assessment is grounded in the documented evidence gathered during tagging.

Scoring framework for future extreme weather drivers

The same two dimensions are applied to extreme weather drivers, with the definitions adapted for climate projections.

- Severity reflects the **projected change** in each indicator by 2030, with larger changes signalling greater potential to disrupt supply or raise costs.
- Likelihood reflects the directional confidence that the **hazard will worsen**, read from the range of the underlying projection.

As with policy drivers, both dimensions are expressed as ordered classifications rather than precise probabilities, so that climate and policy results can later be combined on a shared footing.

Aggregate scoring

Aggregation brings the individual assessments together in stages.

First, the severity and likelihood of each driver are combined into a single result for that driver.

Next, the drivers within each category are combined into one category-level result, so that policy and climate exposure are each summarised in their own right.

Finally, the two category-level results are combined into a single mineral-country result.

Proceeding in stages keeps the logic **transparent**.

Where an extreme weather indicator is not climatically relevant for a producing country, it is **excluded** from the category-level result rather than assigned a placeholder score, so that a severe and relevant hazard is **not diluted** by indicators that do not apply. Where no indicator is relevant, the category-level result defaults to low exposure.

Linking companies to mineral-producing countries

This section links company-level mineral exposures to the producing countries that supply those minerals, and assigns a production-weighted risk result to each company-mineral pair.

The process runs in three steps.

Step 1: Mineral to producing-country mapping (supply side)

The first step establishes, for each mineral, the **producing countries** that account for the large majority of global mine output, applying the same coverage logic used earlier.

The mapped list is cross-checked against the British Geological Survey so that any material discrepancies can be flagged, with the primary source retained as the reference where they differ. This anchors the **demand-side analysis** that follows in a verified picture of where each mineral actually comes from.

Step 2: Company to mineral exposure (demand side)

The second step establishes which minerals each company structurally depends on.

A company's sector, industry, and primary market are drawn from free, authoritative disclosures and registries, and a standardised industry-mineral exposure map is then applied.

That map is built from **open, sectoral evidence** on the minerals each industry relies on, documented at the sector level so that the mapping remains source-based and reproducible. No company-specific private data is used.

Step 3: Company to mineral and producing-country risk

Reliable company-specific trade-flow data for critical minerals are not publicly available, and supply chains are heavily concentrated upstream in a small number of producing countries.

For this reason, the third step links each company's mineral exposure to the primary producing countries rather than to inferred import origins. Industry dependency, producer concentration, and the forward-looking result already assigned to each producing country are then combined, weighted by each country's share of production, to give a single production-weighted result for the company-mineral pair.

Weighting by production share ensures that the countries that matter most to supply carry the most influence over the outcome.

Portfolio aggregation

Per-mineral risk is aggregated to portfolio-level outputs in two stages. Each company is first assigned a single risk score derived from its mineral-level results, and ETFs are then summarised through paired coverage and intensity figures.

Company risk score

Once a company is mapped to its relevant critical minerals, and each mineral carries an aggregate result, a **single risk score** is constructed for the company.

The score is designed to satisfy four principles.

The worst result dominates, so that the presence of higher-risk exposure is never masked by lower-risk exposure.

The score is also sensitive to breadth, reflecting how many minerals are flagged rather than the worst case alone. It sits on a fixed range, from no mapped exposure at one end to highest-risk exposure across all tracked minerals at the other.

And it is transparent by construction: a structured coding of results and counts rather than a calibrated estimate of financial loss.

The score is reported on a familiar 0–100 scale, with companies falling into ordered bands that preserve the ranking from no exposure through to the highest-risk exposure.

ETF score construction

For each ETF, company-level scores are aggregated through **two complementary figures**.

Coverage measures the share of the fund's weight that is mapped to a company score, so that the portion of the portfolio the assessment can actually speak to is always visible; holdings with no mapped exposure reduce coverage rather than being silently absorbed.

Intensity then measures the average risk level of that covered portion.

Reporting the two figures as a pair preserves the distinction between how much of a portfolio is exposed and how severe the exposure is on average, which a single blended number would obscure.

Limitations and future development

This methodology is in its initial release, and several constraints apply at this stage.

Mineral coverage is limited to five entries and will expand as authoritative data matures.

Only policy drivers among the transition-risk categories are currently assessed, with the remaining categories to be addressed elsewhere.

The extreme weather analysis relies on a single climate scenario, the NGFS Current Policies scenario, assessed to a 2030 horizon, and additional scenarios and longer horizons will be incorporated in future iterations.

The industry-mineral exposure map operates at the sector level, and precision will improve as reliable company-specific supply-chain data becomes available.

Finally, the policy severity and likelihood assessments are qualitative, so consistency between analysts depends on a maintained library of reference cases.

Conclusions

This framework provides a **transparent assessment** of forward-looking critical-minerals exposure for companies and ETFs.

Country-level mineral risks are expressed as ordinal colours, company exposures as a single score, and ETF outputs as paired coverage and intensity figures, with the pairing preserving the distinction between portfolio breadth and the average risk of the covered portion.

The framework is intended for use as one input within a wider investment due-diligence process.

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