Building Climate-Resilient Critical Mineral Supply Chains in the Philippines

Lead supervisor: Dr Pablo Brito-Parada, Imperial College London

Co-supervisors: Dr Yves Plancherel, Imperial College London; Dr Robin Armstrong, Natural History Museum

Project Highlights:

- Maps how extreme weather and natural hazards threaten the stability of the Philippines' critical mineral supply chains.
- Uses geospatial and network analysis to identify infrastructure chokepoints and simulate cascading disruptions.
- Delivers a decision-support framework to balance global transition mineral demand with local environmental sustainability.

Overview:

The global transition to a low-carbon economy relies heavily on critical minerals like nickel, cobalt, and copper to power electric vehicles, battery storage systems, and renewable energy infrastructure. However, their supply chains are increasingly vulnerable to severe climate-induced disruptions. This fully funded PhD project focuses on the Philippines, a global producer of energy transition metals that simultaneously faces extreme multi-hazard exposure, including devastating typhoons, intense rainfall, landslides, flooding, and major seismic activity.

As a doctoral researcher, you will address a critical gap in resource security by shifting the analytical focus from mere geological availability to environmental risk and supply chain resilience. You will develop an integrated geospatial and systems-based framework to analyse how physical environmental hazards translate into network-level instability. Methodologically, the project combines advanced Earth observation, GIS mapping, and probabilistic hazard modelling with network analysis to identify critical logistical chokepoints and simulate cascading disruptions from local mine sites to global export gateways.

Crucially, this research bridges economic geology and environmental systems science. Beyond tracking physical supply risks, you will evaluate the environmental constraints of mineral production by incorporating land-use change, watershed sensitivity, and biodiversity overlap into the models. This ensures that future supply chain resilience is built with full consideration of local environmental carrying capacities, ecosystem services, and sustainability thresholds.

This interdisciplinary project offers an exceptional opportunity to conduct high-impact research at the direct intersection of climate risk science, industrial ecology, and resource governance. You will produce actionable decision-support tools, interactive spatial maps, and digital dashboards designed to inform resource policy, infrastructure investment, and sustainable mining governance.

Methodology:

This interdisciplinary project will employ a range of methods combining geospatial analytics, hazard modelling, network science, and policy analysis.

1. Using GIS, remote sensing, and trade data, the spatial structure of Philippine critical mineral supply chains will be mapped, identifying key logistical nodes and infrastructure chokepoints.
2. Probabilistic hazard layers will be overlaid with mineral infrastructure datasets to generate multi-hazard exposure and systemic vulnerability indices.
3. Remote sensing and multicriteria spatial modelling will be used to assess key environmental constraints, considering land-use change, watershed sensitivity, and biodiversity overlap.
4. Network flow modelling will be used to simulate disruption scenarios, such as extreme weather events or port shutdowns, evaluating cascading impacts and overall system recovery capacity.
5. The project will integrate quantitative models with qualitative considerations from key stakeholders, producing a practical decision-support framework for climate-resilient mineral supply chain planning.

Possible Timeline

Year 1: Supply Chain Mapping & Hazard Exposure: Develop the foundational geospatial database mapping the Philippines' critical mineral infrastructure, transport networks, and export corridors. Overlay probabilistic hazard data, such as typhoons, flooding, and seismicity, to generate initial exposure indices and pinpoint logistical chokepoints.

Year 2: Environmental Assessment & Scenario Simulation: Evaluate ecological constraints through remote sensing by analysing land-use change, watershed sensitivity, and biodiversity overlap around mining sites. Simulate disruption scenarios (e.g. extreme weather events or port shutdowns) using network flow models to quantify cascading impacts across the supply chain.

Year 3: Framework Integration: Synthesise the spatial, environmental, and network models into an interactive Climate-Resilient Critical Mineral Supply Chain Framework. Finalise policy analysis and decision-support tool.

Training and skills:

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

Partners and collaboration (including CASE):

The student will be co-supervised by academics from Imperial College and the Natural History Museum. This supervisory team has a strong track record of successful collaboration on multidisciplinary projects in sustainable mining. The student will receive guidance across the various technical, geological, and environmental aspects relevant to the project. Industry collaborators will have a strong interest in the results, and the student will engage with relevant stakeholders in the Philippines.

Further reading:

Heydari, M., Mitchell, P., Cullen, L., Andrieu, B., Cabrera Serrenho, A., Cullen, J. (2025). A systematic review of resilience in the critical minerals supply chains, needed for the low-carbon energy transition. Renewable and Sustainable Energy Transition (8), 100127.

Marove, C.A., Tabelin, C.B., Balaram, V., Kalantzakos, S. (2026). The hidden costs of the clean energy transition: Uncovering the environmental and human health impacts of critical minerals supply chains and strategic pathways to sustainability—a critical review. Minerals Engineering (247) 110442.

Niri, A.J., Poelzer, G.A., Pettersson, M., Rosenkranz, J. (2025). Evaluating battery minerals future supply through production predicting in the context of the green energy transition. Resources Policy 103, 105526.

Further details:

Please get in contact with Dr Pablo Brito-Parada (p.brito-parada@imperial.ac.uk) to discuss a potential application.

Please visit https://target.le.ac.uk/ for additional details on how to apply.