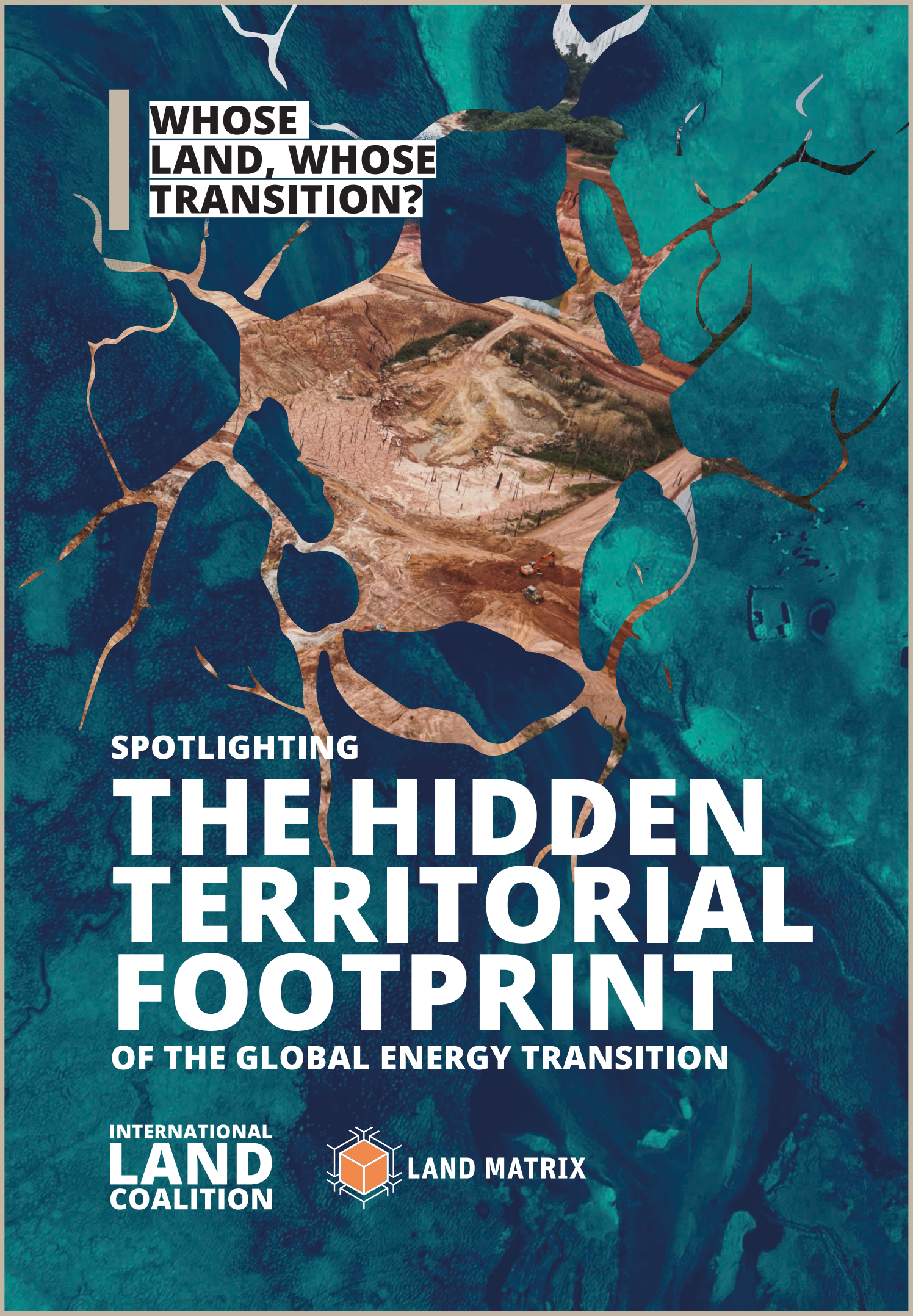

WHOSE LAND, WHOSE TRANSITION?
SPOTLIGHTING
THE HIDDEN TERRITORIAL FOOTPRINT
OF THE GLOBAL ENERGY TRANSITION
INTERNATIONAL LAND COALITION
LAND MATRIX

*Conceived & initiated by:*
The Land Matrix Initiative and International Land Coalition

*Co-lead partners:*
Landesa, The Global Land Programme, LandMark,
The Environmental Justice Atlas

*In collaboration with:*
CoRe, Business and Human Rights Centre, CIRAD, IWGIA, NAMATI, Community Land Scotland, OXFAM, CIFOR & ICRAF in action, Turkana Indigenous People Action for Development (TIPD), Comissão Pastoral da Terra (CPT)

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# EXECUTIVE SUMMARY

By exploring the intersection of geospatial datasets pertaining to the renewable energy expansion, transition minerals, Indigenous and local community lands and territories, and key conservation and biodiversity areas, this research establishes a preliminary assessment of the spatial extent of overlap, potential land rights risks, and environmental justice issues associated with forecasted projects.

## KEY MESSAGES

- Across every stage of implementation (from early speculative claims to active construction and operating facilities), renewable energy and transition mining projects currently registered carry a massive spatial footprint, potentially impacting 328 million hectares of land globally – an area equivalent to the size of India.
- Intended projects – those currently slated as being in the early phases of exploration and planning and which are estimated to take between 8 and 20 years to become operational – make up a staggering 80% of the total mapped energy transition footprint. In 2025, roughly 230 million people worldwide resided within the footprint of these intended energy projects.
- With 50% of transition mineral concessions (120 million hectares) and 25% of renewable energy projects (40.5 million hectares) overlapping with mapped Indigenous and local community lands, the energy transition presents a significant risk to these groups.
- Since prospective projects overlap with 50 million hectares of protected areas and key biodiversity areas, the energy transition also threatens carbon sinks and biodiversity, risking major habitat loss and 4 to 15+ gigatonnes of potential $CO_2$ emissions.
- The extensive footprint of transition mineral exploration (191 million hectares) should not be discounted just because many projects never become operational. Early-stage exploration is already a primary driver of community conflict and often the first stage of rights violations.
- At the same time, this presents a decisive window of opportunity for action and policy reform, precisely because the majority of renewable energy and transition mineral projects are still in early planning or exploration phase, rather than active operations. Now is the time for policymakers to enforce social and ecological safeguards – before land deals are finalised.

# CONTEXT

The concept of an energy transition emerged in late 20th-century energy policy to describe the necessary shift away from fossil fuels towards alternative energy sources. Several decades later, in 2023, it achieved unprecedented international policy consensus at the United Nations Climate Change Conference (COP28) in Dubai, where state parties adopted the landmark UAE Consensus (IRENA et al., 2024; State of Climate Action, 2025). This multilateral consensus represented a historic milestone by securing a collective commitment from the global community to transition away from fossil fuels in a just, orderly, and equitable manner while formalising collective global targets to triple renewable energy capacity to at least 11,000 gigawatt (GW) and double the annual rate of energy efficiency improvements by 2030 (IRENA et al., 2024; State of Climate Action, 2025).

However, despite these noble intentions and ambitious advocacy narratives, scholars emphasise that the energy transition has not been a purely technical swap of energy technologies (Peña Niño et al., 2025; Sharma et al., 2025). Instead, it constitutes a massive extractive expansion that reorganises land use, resource flows, and geopolitical power relations (Peña Niño et al., 2025; Harlan et al., 2024; Hermwille et al., 2025; Lang et al, 2024), often resulting in conflict. Worse still, in 2020, the World Bank estimated that over the next 30 years, 3 billion tonnes of minerals and metals would need to be extracted to drive the global energy transition and avoid global temperature rises over 2°C (Word Bank, 2020). Similarly, the International Energy Agency (2021) calculated that the extraction of critical metals and minerals could quadruple between 2020 and 2040. To put this in perspective, building a typical electric vehicle requires six times the mineral inputs of a conventional internal combustion engine car, while an onshore wind plant demands nine times more mineral resources than a natural gas-fired facility of equivalent capacity (OECD, 2022; UNEP, 2024).

Compounding matters, the operational reality of so-called "green" production models remains poorly understood, selective, and restricted to a handful of materials and jurisdictions (Maus & Werner, 2024). Life-cycle evaluations and supply-chain accounting concentrate on national-level statistics or cross-border trade metrics, while generally obscuring where extraction physically unfolds (Berthet et al., 2024; Stepanov et al., 2024). In so doing, they create a false impression of the energy transition, where its externalities on ecosystems, hydrology, and local livelihoods are painted abstractly at best, if acknowledged at all (Berthet et al., 2024). Likewise, existing relations to land and tenure arrangements are also frequently disregarded by policy and investment frameworks.

This creates the risk, in the rush to secure transition materials, that the populations with the weakest statutory recognitions and legal protections become the bearers of the most severe impacts of transition-driven extraction and infrastructure development (Blondeel et al., 2026; IWGIA, 2024; Owen et al., 2023).

In light of these dynamics, there is a pressing need for in-depth accounting and analysis of the transition's territorial impact. Yet regulatory focus has often suffered from carbon tunnel vision, leaving land and resource use poorly documented under current energy transition pathways (Berthet et al., 2024; Lèbre et al., 2024, Martín-Díaz, 2026). To combat this vacuum, those communities and organisations that are most directly impacted have begun to gather evidence on the impacts of the accelerated expansion of energy infrastructure and material extraction as they mobilise to resist the socio-environmental, economic, and health impacts, land dispossession, displacement, and violence related to these projects (Hanaček et al., 2024; Scheidel et al., 2020, 2023; Temper et al., 2020). For instance, since 2011, the Environmental Justice Atlas (EJAtlas), a collaborative mapping initiative led by academics and civil society organisations, has documented over 4,600 cases of socio-environmental conflicts where communities, organisations, and networks have publicly denounced the impacts related to extractive projects, including mines, solar and wind farms, and dams (Llavero-Pasquina et al., 2024; Walter et al., 2024; Scheidel et al., 2020; Temper et al., 2020). In this way, they have helped spotlight the otherwise hidden impacts of the energy transition.

While these place-based accounts are crucial to helping expose localised vulnerabilities, advocacy and regulatory oversight remain constrained by vast gaps in regional data. Despite their tremendous value in documenting local impacts, relying on case studies leaves systemic blind spots across frontline geographies where extractive concessions and clean-energy infrastructure expand unmonitored. This evidence gap directly undermines the implementation and accountability mechanisms of the multilateral climate agenda. At COP30, Parties to the Paris Agreement took a notable step forward by formally recognising "*the importance of the rights of Indigenous Peoples and of obtaining their free, prior and informed consent in accordance with the United Nations Declaration on the Rights of Indigenous Peoples*" (Decision -/CMA.7, para. 12(i)), alongside a decision to develop a just transition mechanism due for consideration at CMA.8 (para. 25). While this acknowledgment stops short of establishing a binding mandate or enforceable safeguards, closing the data gap as the new mechanism is operationalised will be critical to translating this recognition into concrete rights protections and real accountability.



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# GUIDING RESEARCH QUESTIONS AND METHODOLOGY

Given the existing knowledge gap, a fundamental two-part question relating to environmental justice at a global scale remains unanswered:

> *What lands are being targeted to fuel the energy transition, and who is carrying its downstream costs?*

In attempting to answer this question, this report provides a critical baseline assessment of the spatial footprint of the global energy transition by bringing together extensive coverage of transition mineral projects from S&P Global[1] – the leading commercial mining intelligence provider – with state of the art geospatial data on renewable energy projects from the Global Energy Monitor (GEM). By mobilising global gridded population data provided by the Global Human Settlement Layer (GHSL), information from LandMark's global map of Indigenous Peoples' and local communities' (IPs' & LCs') territories, along with data on protected areas[2] and key biodiversity areas (KBAs)[3], the report provides preliminary estimates of the number of people residing within the land footprint of energy projects forecasted over the next 20 years. It also shows the extent to which Indigenous Peoples, local communities, and conservation areas are bearing the risks and potential impacts of energy-related investments.

This analysis was initiated by the Land Matrix Initiative and the International Land Coalition and is the result of a collaborative endeavour between LandMark, Landesa, the Global Land Programme (GLP), EJAtlas, Collaborating for Resilience (CoRe), and the Business and Human Rights Centre (BHRC). It is further supported by a large body of partners brought together as part of the Knowledge Alliance on Land (KAL)[4].

1 The S&P Global database covers more than 37,000 mining concessions worldwide. The service tracks asset-level information, production costs, and exploration budgets, and is aimed as a corporate support tool for the identification and evaluation of mining prospects and investment opportunities.

2 World Database on Protected Areas (WDPA)

3 World Database of Key Biodiversity Areas (WDKBA)

4 The Knowledge Alliance on Land (KAL) is a collaborative initiative stemming from the International Land Coalition uniting research institutes, non-governmental organisations, multilateral bodies, and coalitions to bridge the critical divide between the recognised importance of land rights and the fragmented way evidence is produced and applied.

Through this work, we aim to help identify and halt "green" dispossession, defend customary land rights, and ensure that the global race towards net-zero does not reproduce colonial patterns of injustice and dispossession (Lang et al. 2023).

We acknowledge that the datasets used in this study are not fully comprehensive and only portray what is known or accessible at the date of analysis. In terms of IPs' & LCs' territories, many remain unmapped. Definitions of indigeneity and local communities also vary across countries and regions. It is therefore important to note that the absence of data in a given area does not necessarily indicate the absence of Indigenous or community land. Likewise, population data from the GHSL as well as data from both the World Database on Protected Areas (WDPA) and the World Database of Key Biodiversity Areas (WDKBA) may be incomplete in certain regions. The same is true for mining data from S&P and renewable energy project data from GEM. The findings should thus be taken as an indication of potential risk. More information on our methodological approach can be found in the technical appendix.



# RESULTS

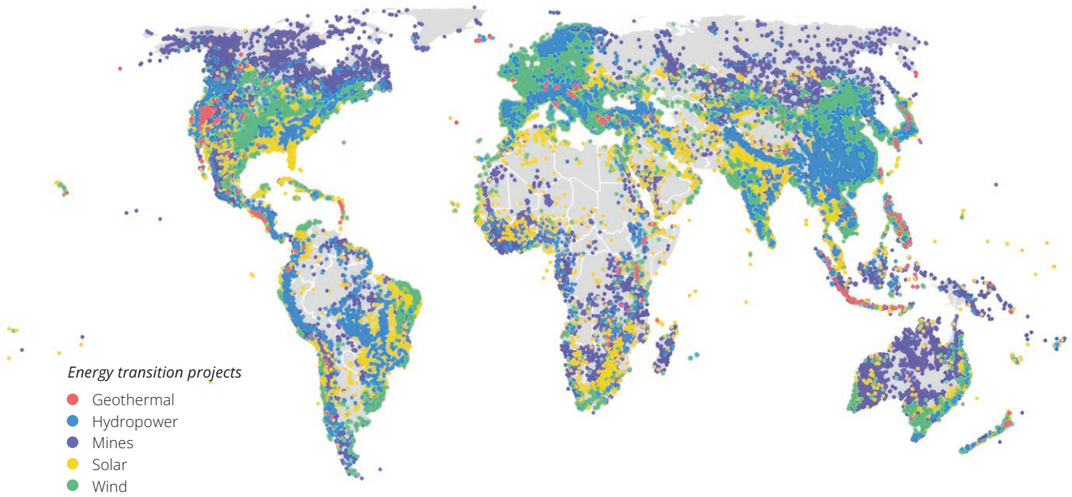
## UNCOVERING THE SCALE OF TRANSITION INVESTMENTS AND THE LANDS THEY CLAIM

### THE EXPANDING LAND FOOTPRINT OF THE ENERGY TRANSITION

Combining GEM and S&P Metals and Minerals datasets exposes the extensive territorial reach of the global energy transition: 145,866 existing or proposed renewable energy installations, including geothermal, hydropower, solar, and wind, cover an estimated aggregate footprint of ***159 million hectares*** (roughly equivalent to the land area of Ukraine – see Figure 1).

Accounting solely for energy installations captures only half of the energy transition footprint. Transition minerals (the copper, lithium, nickel, cobalt, graphite, and rare earths required to build low-carbon technologies) add another ***239 million hectares*** over ***17,182 projects***.[5] The total footprint obtained by dissolving both layers, avoiding double counting, and excluding offshore installation, provides a land area of 328 million hectares[6].

*Figure 1.* Locations (map of project points) of all renewable energy and transition mines projects identified.




***Note:*** This map does not show the actual project area. Points are enlarged for visibility at global scale.

5 S&P Global tracks only industrial mining projects, meaning this data excludes the substantial share of transition mineral production driven by informal, artisanal, and illegal mining (Boafo & Arthur-Holmes, 2025; UNODC, 2025).

6 Renewable energies and transition mines footprints overlap in some cases. To avoid double counting territories, this number was obtained by dissolving our entire dataset.

To formulate grounded, actionable policy interventions, this footprint must be disaggregated across the operational lifecycle, distinguishing between actively producing installations (that is, operational), installations under development or construction, and intended projects that are in the earlier stages of evaluation and planning. The timeframes for these stages differ between renewable energy and mining projects (Figure 1).

Examining the data through this phased lifecycle lens reveals a markedly different reality of deployment maturity across generation technologies. Indeed, for renewable energy installation, just over a third (35%) of the 145,866 recorded projects are operational and 7% are in the development or construction stage. The bulk of renewable installations are prospective, with 46% of the total renewables land footprint (73 million hectares) being in the evaluation and planning stage. For transition minerals projects, the relative size of the projected expansion footprint is even more stark: operational mines and mines under construction and development account for 3 million hectares, representing only 1% of the total mapped mining footprint. Looking at a longer timeframe, those mining projects currently in the evaluation and planning stage (21% of all mining projects) and those in the earliest exploration on site phase[7] (by far the largest share of projects, with 78%) will account for 51 and 191 million hectares, respectively, to the energy transition footprint[8]. While only a fraction of mineral exploration projects result in operational mines, it is important not to consider these solely as a source of possible future impacts. Early-stage resource exploration is a frequent cause of conflict with communities in the areas that stand to be affected. Where such projects occur on Indigenous lands, unless consent has been obtained, this already constitutes a violation of Indigenous rights. Under Article 32(2) of the UN Declaration on the Rights of Indigenous Peoples (UNDRIP), States are explicitly required to obtain Free, Prior, and Informed Consent (FPIC) "*prior to the approval of any project affecting their lands or territories*", particularly in connection with mineral, water, or other resource extraction (UNGA, 2007).

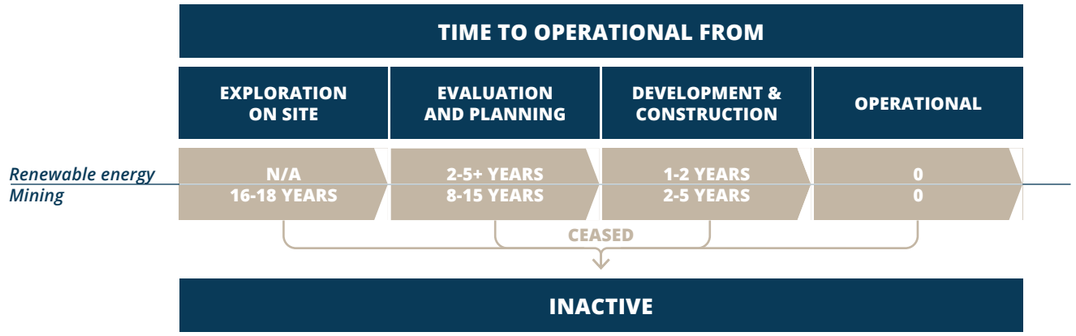
Overall, intended projects – meaning those under evaluation and planning as well as, for mining, where there is "exploration on site" – make up 25% of the total number of reported projects across GEM and S&P Global, and represent 80% of the total mapped energy transition footprint. According to residential population data provided by the GHSL, ***roughly 230 million people lived within the footprint of those 40,731 intended projects in 2025***. Intended wind energy projects alone accounted for over half (53%, or 123 million people) of this preliminary estimate. Despite representing a larger share of the projected energy transition footprint compared to wind projects, fewer people (25%, or 58 million) resided within the footprint of intended critical mineral mining projects in the same year. Solar and hydropower projects further accounted for 26 million (11%) and 24 million (10%) people, respectively, residing within the projected energy transition footprint.

7 "Exploration on site" is an implementation stage category reserved for the mining sector. A project that is undergoing "exploration on site" can be expected to take 16-18 years to become operational (S&P Global Market Intelligence, 2022; IEA, 2024).

8 Due to spatial overlaps across implementation stages, the individual category figures exceed the total dissolved surface area of the dataset.



*Figure 2.* Typical timeframes for each stage of the operational lifecycle, for renewable energy projects and mining projects. (Franks et al., 2014; IEA, 2024; World Bank, 2020; S&P Global Market Intelligence, 2022).




## RENEWABLE ENERGY PROJECTS OVERLAPPING WITH IPs' AND LCs' LANDS

Over the aggregate land footprint of renewable energy projects (159 million hectares), 25% of this total (roughly the size of Paraguay), overlaps directly with indicative or precisely mapped IPs' & LCs' lands (Figure 3).[9] Within this territorial intersection lie 4.3 million hectares of precisely mapped Indigenous territories, with utility-scale wind farms alone occupying an estimated 83% of that area.

For this overlap with IPs' & LCs' lands, and breaking down by status of implementation, hydropower assets are overwhelmingly operational, with 73% in active production, while solar and wind power are predominantly prospective. Only 30% of documented solar and 29.5% of wind projects are actively operating today. Development and construction phase account for 12% of solar and 12% of wind capacity, while the remaining 49% of solar and 50% of wind assets linger in the early evaluation and planning phase. Among geothermal projects overlapping IPs' & LCs' lands, 19% are operational, 37% are in the evaluation and planning phase, and, of note, a large share (37%) of geothermal projects are "inactive" and were never built.

Based on current industry lead times, projects under planning and evaluation will typically take 3-8 years to reach commercial operation, if they materialise at all (S&P Global Commodity Insights, 2023).

9 Figure 3 is based on IPs' & LCs' lands as registered on LandMark. See ***https://www.landmarkmap.org/data-methods/data-completeness*** to know more about data coverage. Furthermore the term 'indicative' IPs' & LCs' lands refers to those lands included in LandMark's Indicative Areas of Indigenous and Local Community Lands layer. Per LandMark, this layer "shows areas where Indigenous and community lands likely exist, but the data on the precise delimitation, recognition and/or documentation status of these are not available at this time." For additional details, see the LandMark methodology (***https://landmarkmap.org/data-methods/methodology***).

*Figure 3.* Locations (map of project points) of renewable energy projects intersecting indicative and mapped IPs' & LCs' lands by implementation status and global region. Note: This map does not show the actual project area. Points are enlarged for visibility at global scale.

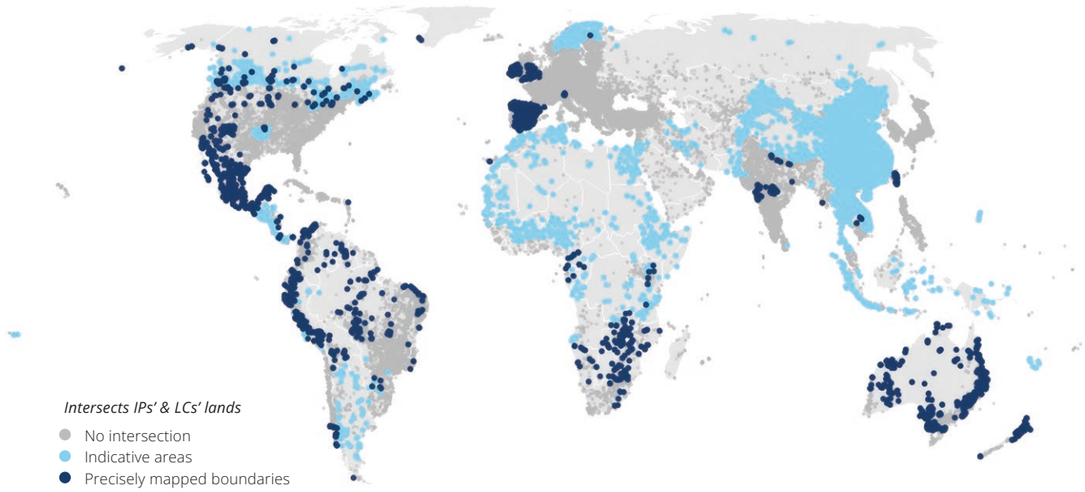
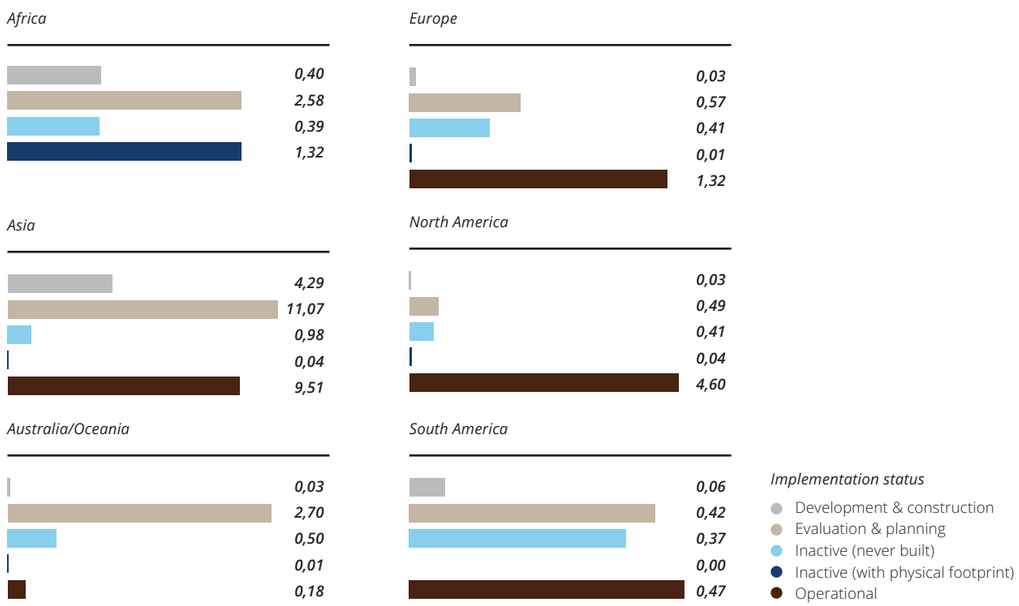



*Figure 4.* Cumulated surface (Mha) of renewable energy projects intersecting with IPs' & LCs' lands by implementation status and world region




Spatially, indicative community lands comprise 73% (11 million hectares) of the area targeted by planned wind projects, while 18% (2.8 million hectares) overlaps precisely with delineated Indigenous Peoples' lands and territories.

Conversely, projects categorised under development or construction (expected to enter commercial service within the next two years) cannot be understood merely as an imminent, prospective wave of expansion. Because ground operations and site preparation are already underway, these projects represent materialised and hardening impacts: land access has often already been restricted, customary occupants and resource users displaced or excluded, and localised environmental degradation initiated long before full commercial commissioning. Figure 4 illustrates the regional distribution of these dynamics, showing that projects in the development and construction phase represent a substantially higher share of the portfolio in Asia and South America.

Within this near-term pipeline, the exposure of community lands is acute: 93% of solar capacity under construction (166,000 hectares) and 94% of wind projects under construction (3.7 million hectares) overlap indicative community lands. Across all renewable technologies combined, this pattern remains persistent: 56% of operational facilities, 72% of projects in planning, and a striking 92% of projects under construction are situated on indicative community lands. In addition, 38% of active projects are located on indicative Indigenous lands[10].

## TRANSITION MINERAL PROJECTS OVERLAPPING WITH IPs' AND LCs' LANDS

Across the 239 million hectares of transition mineral projects, 50% of mineral concessions (120 million hectares) overlap with Indigenous or local community lands, with 75.9 million hectares falling within strictly demarcated boundaries (Figure 5).[11]

As with renewable energy projects, these aggregates reflect an evolving horizon of risk that spans disparate stages of mining projects' lifecycles. Currently, operational projects account for an estimated 1.1 million hectares of transition mineral extraction, over half of which is situated on indicative and precisely mapped Indigenous lands. The immediate horizon brings targeted expansion: factoring in projects currently in the development and construction stage, sites slated for commercial operation within the next 2-5 years (World Bank, 2020; S&P Global Market Intelligence, 2022), adds an additional 84,000 hectares, with an overwhelming 92% targeting community lands.

Looking further ahead into the mid- and long-term project pipeline reveals where the pressures are accumulating. Concessions in early stages (that is, evaluation and planning), typically taking 8-15 years to reach production (Franks et al., 2014; IEA, 2024), account for 20.8 million hectares to the global energy transition footprint[12].

10 This percentage represents the share of encroached Indigenous Peoples and local community (IPLC) land within a given implementation stage that falls specifically on indicative community lands. For example, operational renewable energy (RE) facilities overlap with a total of 17.3 million hectares (Mha) of IPLC lands, of which 9.7 Mha are indicative community lands, yielding 56% (9.7 / 17.3 Mha).

11 Despite differing methodological approaches, this result is consistent with previous findings by Owen et al. (2023).

12 Here again, due to spatial overlaps across implementation stages, category surface areas are non-additive and cannot be summed.

*Figure 5.* Locations (map of project points) of transition mines projects intersecting indicative and mapped IPs' & LCs' lands by implementation status and global region. Note: This map does not show the actual project area. Points are enlarged for visibility at global scale.

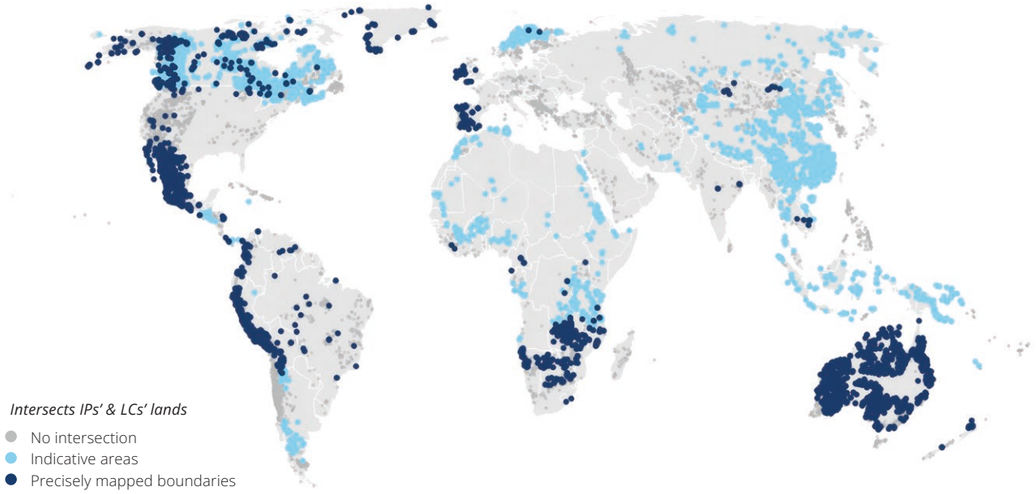
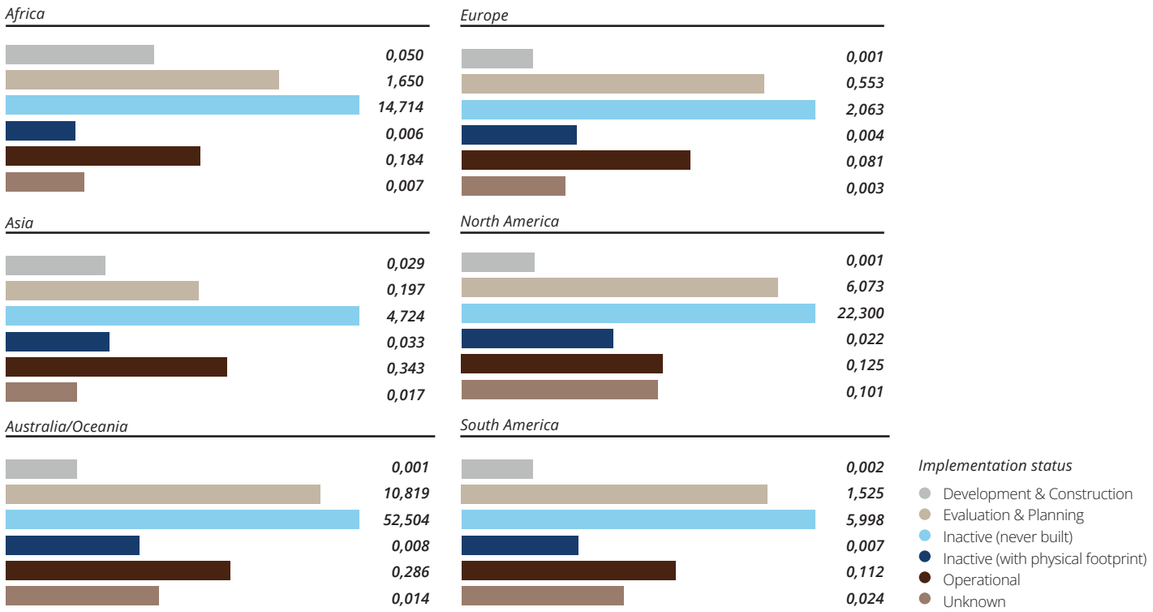



*Figure 6.* Cumulated surface (Mha) of transition mines projects intersecting with IPs' & LCs' lands by implementation status and world region






Strikingly, 90% of the project footprint within this 8-15-year planning horizon overlaps only with Indigenous lands, including 56.5% (11.8 million hectares) on precisely mapped territories. As illustrated in Figure 6, projects in this development phase account for more than 1.5 million hectares across Africa and South America alone. Beyond that, exploration on site, with lead times of 16-18 years (S&P Global Market Intelligence, 2022; IEA, 2024), encompasses another 102 million hectares, not including inactive or unclassified sites. In this outer reach of the pipeline, roughly 79.5% of identified exploration areas intersect only with Indigenous Peoples' territories, with 54% of these being documented on precisely mapped community lands.

### EJATLAS INSIGHTS: EXTRACTION CONFLICTS AND IMPACTS

As of September of 2026, ***about 11% of all conflicts documented in the EJAtlas were directly related to the extraction of metals and minerals for renewable energy technologies***. Ongoing research signals how these extraction conflicts are related to a broad range of environmental, social, and economic impacts. The impacts most frequently reported refer to surface water pollution, loss of landscape, loss of livelihood, violations of human rights, soil contamination, deforestation, land dispossession, groundwater pollution or depletion, and biodiversity loss. About a third of cases document air pollution, increased corruption, and displacement. In addition, ***36% of these cases have reported some form of violence such as criminalisation, repression, or violent targeting of activists. Moreover, about 14% of the cases report the death of environmental defenders in the context of these struggles***.

## MAPPING THE ENERGY TRANSITION FOOTPRINT ACROSS PROTECTED AREAS AND KEY BIODIVERSITY AREAS

By cross-referencing global energy and mining datasets with the October 2026 releases of the WDPA and WDKBA inventories, this section seeks to quantify this spatial exposure and assess the extent to which transition infrastructure poses an encroachment risk across globally significant ecosystems.

Including protected areas and KBAs in this analysis does not validate top-down or exclusionary conservation approaches. Rather, it serves to investigate a critical risk of the "green" transition: the potential contradiction of siting utility-scale renewables and transition-mineral extraction within ecologically sensitive and legally protected zones, which could compromise conservation baselines and intensify pressures on customary lands. Moreover, while protected areas and KBAs overlays allow for standardised global quantification, this initial scope is constrained by time and resource limitations.

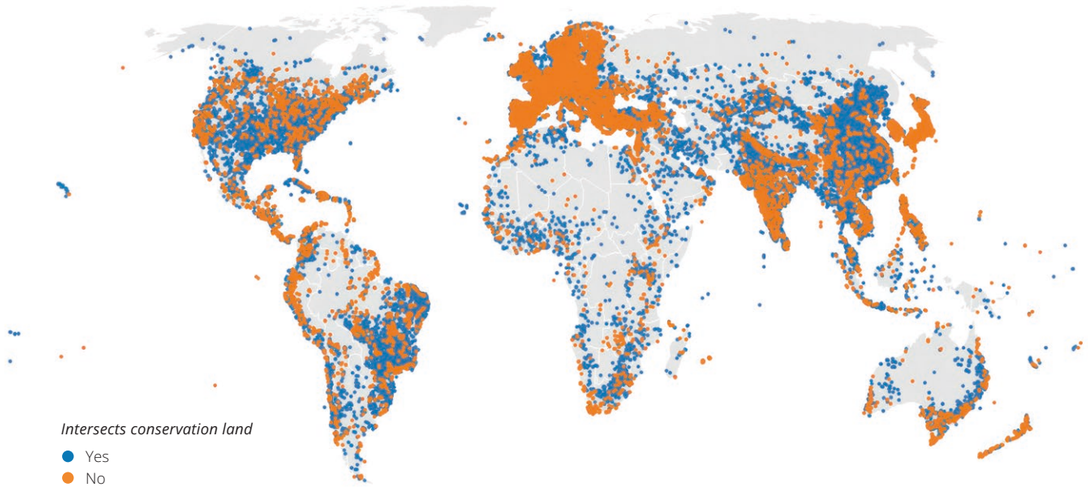
Further, although over 40% of the total KBAs lie on IPs' & LCs' territories, these inventories do not fully capture the immense proven conservation and carbon-storage value of customary lands managed outside formal state reserves (Reytar et al., 2024). Indeed, empirical evidence overwhelmingly confirms the efficacy of IPs & LCs as ecological stewards (Garnett et al., 2018; Dawson et al., 2021). Consequently, while this section establishes an initial baseline of spatial exposure across formally designated areas, complete accounting requires future frameworks to integrate other effective area-based conservation measures (OECMs) and community-led conservation domains, ensuring that IP & LC stewardship is neither ignored nor compromised by transition infrastructure.

Across all project stages, utility-scale renewable energy infrastructure accounts for 11.2 million hectares of spatial overlap with protected areas from the WDPA. Disaggregating this spatial footprint clarifies where ecological damage has already materialised versus where future pressures are accumulating. Less than half of this area, or 5.2 million hectares, consists of energy assets already operating on the ground, while another 37.5% (4.2 million hectares) sits in evaluation and planning stages with anticipated commissioning within near-term development cycles. By generation technology, utility-scale wind accounts for 52% of the protected-area renewable footprint (5.8 million hectares) due to expansive turbine arrays and access road networks, followed by hydropower at 45.5% (5.1 million hectares) through reservoir inundation and hydrological disruption.

Applying this spatial analysis to KBAs highlights a parallel vulnerability across ecosystems that frequently lack formal statutory protections. Renewable energy deployment within KBAs demonstrates an even more immediate physical reality: 44% of registered overlapping projects (6.6 million hectares) are fully operational today, while an additional 42% (6.3 million hectares) reside in evaluation and planning. Figures 7 and 8 illustrate the combined overlap of renewable energy projects on protected areas and KBAs and their regional discrepancies.

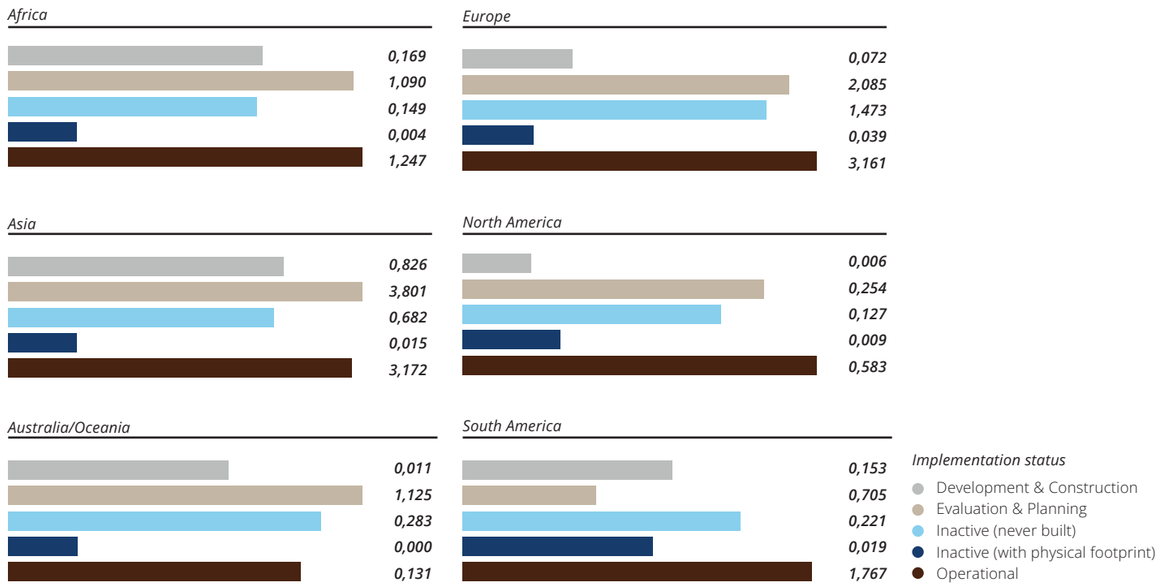
Concurrently, approximately 32 million hectares of mining concessions intersect legally recognised protected areas under the WDPA framework, exhibiting an operational profile markedly different from that of renewable energy. Active mining operations directly encroach on 126,000 hectares of legally protected terrain, compounded by 34,000 hectares of legacy degradation from closed or inactive sites. The medium-term threat is marked by assets in evaluation and planning stage, which represent 15.2% of the total overlap, accounting for 4.9 million hectares of habitat fragmentation with estimated production timelines of 8-15 years. The speculative exploration frontier accounts for 84.2% of the overlap footprint between protected areas and transition minerals projects, locking 27.6 million hectares of legally protected land into long-term resource-extraction pipelines, with potential lead times approaching 20 years.

*Figure 7.* Locations (map of project points) of renewable energy projects intersecting with protected areas and/or KBAs.




***Note:*** This map does not show the actual project area. Points are enlarged for visibility at global scale.

*Figure 8.* Cumulated surface (Mha) of renewable energy projects intersecting with IPs' & LCs' lands by implementation status and world region



Because over 30 million hectares linger in pre-construction stages (evaluation and planning or exploration on site), this extractive threat remains a speculative trajectory rather than a completed outcome, presenting a crucial regulatory window to enact statutory safeguards and recalibrate national land-allocation priorities before irreversible development occurs.

The immediate footprint on KBAs totals nearly 280,000 hectares across operational mines and active construction sites. An additional 2.8 million hectares of critical biodiversity habitat are targeted by mining projects in the evaluation and planning phase (slated for operation within 8-15 years), while early exploration concessions envelope 12.6 million hectares of KBAs on an estimated 16- to 20-year horizon.

Figures 9 and 10 illustrate the combined spatial overlap of mining projects with protected areas and KBAs alongside notable regional divergences.

Considering potential future land use change across both the mining and renewables sectors, intended projects overlap 50 million hectares of protected areas or KBAs. Over one-third of these lands are located within forest biomes, threatening massive natural carbon sinks, including over 7 million hectares of tropical forests. Conversion of these lands risks the release of 4-15+ gigatonnes (Gt) of CO2 from biomass and organic soils, a volume equivalent to approximately one to four times the total annual greenhouse gas emissions from deforestation in recent years (~4 Gt CO2/year).[13, 14]

Together, these metrics establish that without binding spatial zoning, mandatory exclusion zones, and the legal recognition of customary tenure, the physical expansion of renewable energy installations and transition mineral extraction risks undermining the very biodiversity thresholds and climate mitigation goals established under the Kunming-Montreal Global Biodiversity Framework and the Rio Conventions.

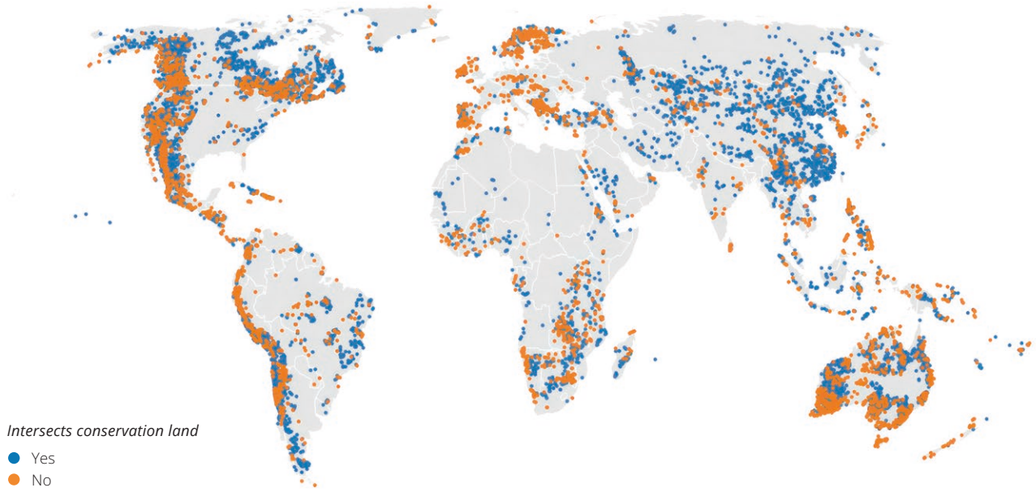
> *The EJAtlas also provides insights into the role of socio-environmental mobilisations in advancing biodiversity conservation globally. Documented mobilisations frequently occur within high-priority conservation areas and directly challenge environmental threats to biodiversity targets. However, evidence also indicates that mobilisations facing repressive outcomes are often concentrated in regions of high biodiversity, underscoring the risks faced by movements driving biodiversity protection in critical regions (Walter, et al 2026).*

13 Based on 2025 global deforestation emissions of 3.9 Gt $CO_2e$; see Forest Declaration Assessment (2026)

14 Intended mining projects account for 78% of these potential emissions, with the remaining 22% from intended renewable energy projects.

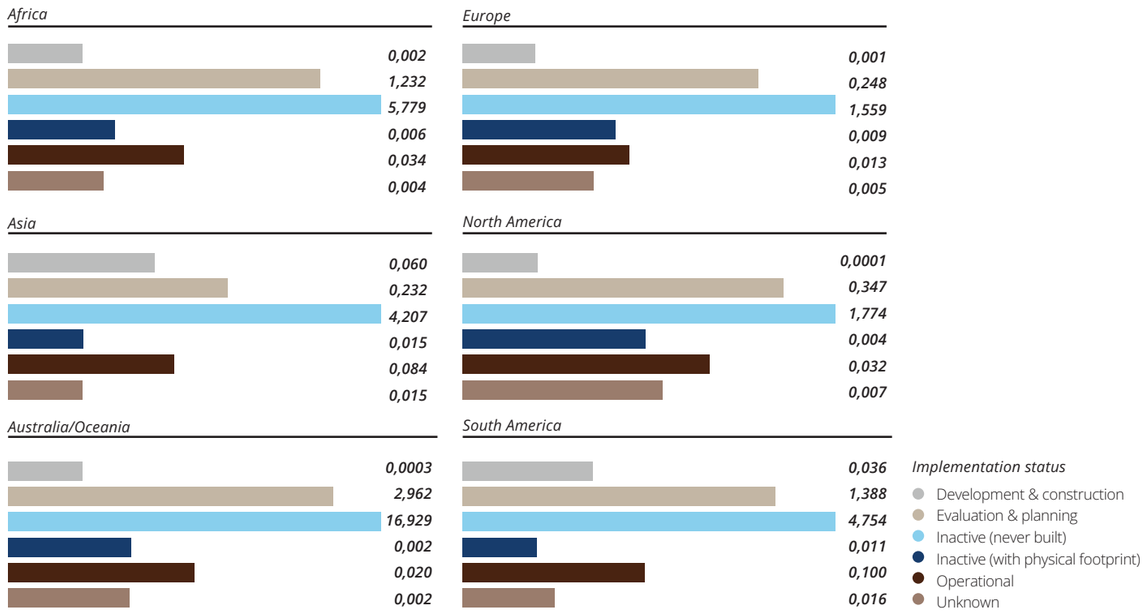


*Figure 9.* Locations (map of project points) of transition mineral projects intersecting with protected areas and/or KBAs by implementation status and global region.




***Note:*** The map does not show the actual project area. Points are enlarged for visibility at global scale.

*Figure 10.* Cumulated surface (Mha) of transition mines projects intersecting with IPs' & LCs' lands by implementation status and world region

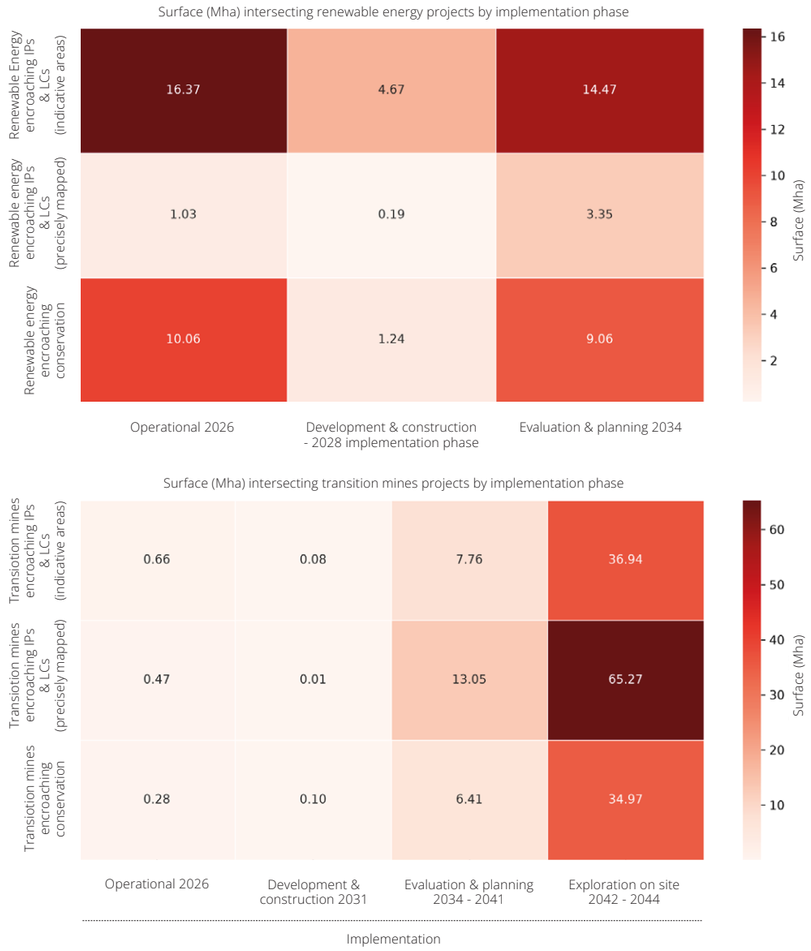


# KEY TAKEAWAY

## AND RECOMMENDATIONS

The global transition to a low-carbon economy is driving a new wave of large-scale investments that threatens to reproduce the destructive patterns of traditional extractivism under a "green" banner. Decarbonisation is not an abstract, weightless process: it is deeply material and spatial.

***Figure 11.*** Trajectories of encroachment: phased lifecycle footprints of renewable energy and transition mining projects on IPs' & LCs' lands and conservation areas




Commercial concessions for renewable energy installations and transition mineral mining may cover up to a staggering 328 million hectares globally, with immense tracts overlapping directly with the customary territories of Indigenous Peoples, smallholders, and pastoralists. Yet this represents only a baseline of currently mapped and announced projects; within a few years, an entirely new set of concessions is expected to expand this footprint even further.

The analytical strength of Figure 11 lies in deconstructing what is often treated as a uniform, aggregate footprint into distinct operational horizons. By separating active, producing assets from near-term construction pipelines and multi-year exploration frontiers, the figure moves beyond a static snapshot of territorial risk. It demonstrates that the spatial dynamics of the energy transition do not land all at once: while advanced construction projects are already generating tangible exclusions and localised environmental harms, the overwhelming majority of concessions remain in early planning and feasibility stages.

Crucially, early project phases are far from benign, and access restrictions, speculative land deals, and community divisions routinely erupt during the initial planning and exploration periods. Disaggregating the data across these stages underscores that regulatory safeguards and the formal recognition of customary rights must be deployed immediately during these early stages, utilising this actionable 8-15-year window of opportunity proactively.

To ensure that the transition away from fossil fuels does not come at the expense of rural communities and vital ecosystems, intervention must be anchored in two urgent systemic priorities:

### 1. Close the transparency deficit through independent, multi-dimensional land monitoring

One-off, corporate-driven impact assessments routinely fail to capture the cumulative land footprint of commercial investments. Tracking land deals requires independent, systematic, and ground-truthed monitoring that follows concessions across their full lifecycles:

» *Focus on land investments (the 8-15-year horizon):* Public transparency is critical long before bulldozers arrive. Governments and civil society must systematically track land lease applications, commercial negotiations, and exploratory mining claims as they emerge. By cross-referencing company concessions against community-held lands (using tools like LandMark) and key biodiversity hotspots, prospective land conflicts and tenure disputes can be exposed years before investment decisions are locked in.

» *Monitor processes of investments and impacts:* Independent monitoring must track the real-world, cumulative socio-ecological consequences of active operations on the ground, specifically documenting: (i) severe water depletion and competition over local hydrological basins (particularly from mineral extraction); (ii) fragmentation and loss of customary grazing corridors, pastoral routes, and smallholder farming lands; and (iii) violations of tenure rights, uncompensated land alienation, displacement, the closing of civic space, and violence against land and environmental defenders, requiring enforceable protection aligned with the Escazú Agreement and the UN Declaration on Human Rights Defenders, alongside corporate zero-tolerance policies on reprisals throughout the supply chain.

**2. Strengthen land governance and enforce people-centred tenure rights**

Preventing "green grabs" requires transforming how national governments allocate and govern land, placing tenure security at the heart of national development and climate strategies:

» *Integrate land rights and spatial planning into climate commitments:* National climate targets (such as Nationally Determined Contributions and National Adaptation Plans) must not remain blind to land tenure. State parties must integrate open spatial baselines into climate policy, translating international just transition mandates into domestic legal reality and ensuring that climate finance does not create new territorial sacrifices.

» *Legally protect untitled customary lands and enforce the right to withhold consent:* Core protection against land dispossession rests on the absolute recognition, respect, and enforcement of legitimate customary and collective tenure rights; regardless of whether formal registration or legal title exists. The absence of formal title must never diminish or invalidate customary claims. While participatory legal recognition and titling can strengthen security when aligned with existing community governance systems, governments must prioritise protecting legitimate landholders as they are. Concurrently, consent and consultation safeguards must be legally mandated at the earliest stages of exploration and concession negotiations rather than treated as an administrative formality: for Indigenous Peoples, this requires enforcing FPIC, including the binding right to withhold consent, as rooted in their right to self-determination under UNDRIP and ILO Convention 169, while for local communities, it requires guaranteeing meaningful consultation and legitimate tenure protections in accordance with the VGGT[15].

15 See UNDRIP Articles 3, 10, 19, 29, and 32; ILO Convention No. 169 (1989); and FAO Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (FAO, 2012).



» *Replace top-down exclusion mandates with community-led spatial planning and self-determination:* Governments must move away from top-down, blanket exclusion mandates on customary lands, which risk once again sidelining IPs & LCs from deciding their own land use. While strict regulatory prohibitions against industrial extraction remain necessary for primary forests and ecologically fragile protected zones, spatial planning on ancestral lands must be driven by Indigenous self-determination. Through community-led spatial governance (such as Ancestral Domain Sustainable Development and Protection Plans), IPs & LCs must hold authority to demarcate protected areas, direct customary land use, and determine whether, where, and under what terms renewable energy projects may operate within their domains.

» *Anchor benefit-sharing and co-ownership models in prior tenure recognition and community governance contro*l: While shifting away from top-down, predatory land deals towards models like community land trusts, equity sharing, and multi-functional land co-use can offer alternative economic pathways, financial benefit-sharing is not a substitute for rights recognition, meaningful consent, or protection against displacement. Policies must clearly distinguish between economic participation (revenue sharing or equity stakes) and actual decision-making control over ancestral lands, territories, and project lifecycles. Furthermore, because the efficacy of shared-ownership frameworks varies widely across different customary tenure and governance contexts, these models must not be presented as a universal fix, but rather as optional mechanisms that can only operate fairly where tenure rights and community self-determination are already securely established.

Building directly on these priorities, the next phase of our collaborative research will move from macro-spatial tracking to grounded reality, linking the global investment trends identified here with localised, place-based observations from spotlighted projects to examine how these pressures translate into lived socio-ecological impacts on the ground.

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This work is grounded in a spirit of collaboration, trust, and shared ownership. All contributions provided through the Knowledge Alliance on Land will be used to strengthen collective analysis, inform cross-case learning, and amplify the visibility of members' experiences, practices, and evidence.

We are committed to full and transparent recognition of contributions. All inputs, in the form of case studies, data, analysis, or insights, are duly acknowledged below. In all instances of cross-case analysis and synthesis, we ensure that sources are clearly cited and that the primary authors and originating organisations are systematically credited. No contribution will be used without appropriate attribution. By engaging in this process, members contribute to a collective knowledge product that remains firmly rooted in, and accountable to, those who generate it, ensuring both visibility and integrity of each contribution. Main authors are identified by*

**Land Matrix Initiative (LMI)**

» *Role*: Project co-lead, core data partner, mapping lead, and regional investigations.

» *Key contributions*: Provided large-scale land transaction data and led the 2026 data campaign on mining overlaps with Indigenous and community lands; produced global GIS maps and spatial datasets; co-authored the synthesis report.

» *Contributors*:Jeremy Bourgoin* (project coordination), Marie Gradeler* (geospatial analysis & co-author), Nikka Rivera (policy support, backstopping), Christoph Kubitza (backstopping), Lucas Seghezzo (thematic expert), Lucia Cuellar (thematic expert), Gabi Sonderegger (backstopping), Danya-Zee Pedra (editing, communication).

**World Resources Institute (WRI) & LandMark co-secretariat**

» *Role*: Project co-lead and core data partner.

» *Key contributions*: Provided guidance on Indigenous and local communities datasets; supported development of geospatial methods.

» *Contributors*: Katie Reytar (project coordination), Jessica Webb (project design).

**International Land Coalition (ILC) & LandMark co-secretariat**

» *Role*: Project co-lead, data analysis, and report synthesis.

» *Key contributions*: Co-led the overarching report writing, project coordination, and case study design; provided commercial mining market data (S&P Global); conducted global spatial mapping and data verification.

» *Contributors*: Jeremy Bourgoin (project coordination), Jeremy Kalsron* (geospatial consultant), Johanna von Braun* (advocacy expert), Eva Hershaw (project design), Matteo Sposato (coordination support).

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» *Role*: Project co-lead, research design, coordination, and field investigations.

» *Key contributions*: Helped shape the study's core research questions; coordinated partner workflows; co-wrote the global synthesis; led field case studies in Mexico and Brazil.

» *Contributors*: Lindsay 'Bar' Barbieri* (project coordination), Ariane de Bremond (research design support).

**Landesa**

» *Role*: Project co-lead, methodology design, GIS support, and case study documentation.

» *Key contributions*: Co-designed the case study questionnaire framework; contributed geospatial technical analysis; co-managed project timelines; drafted project briefs.

» *Contributors*: Curtis Tripp* (project coordination), Yifan Song* (content and editing support), Corey Creedon* (content and editing support), Nayna Jhaveri, Krista Jacobs (research design).

**Environmental Justice Atlas (EJAtlas)**

» *Role*: Project co-lead, core data partner, methodology design, data analysis, and report synthesis.

» *Key contributions*: Provided technical spatial expertise; advisory backstopping on environmental conflicts.

» *Contributors (project coordination):* Mariana Walter* (EJAtlas–Institut Barcelona d´Estudis Internacionals), Arnim Scheidel* (EJAtlas–Institut Ciencias i Tecnologias Ambientals UAB), Olivia del Giorgio* (Institut Ciencias i Tecnologias Ambientals UAB), Sara Mingorría (Basque Country University) . EJAtlas acknowledges the support of the Institut Català International per la Pau (ICIP).

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» *Role*: Core data partner

» *Key contributions*: Provided technical support; updated data on the Transition Mineral Tracker.

» *Contributors*: Blanca Racionero Gomez (study design, backstopping), Caroline Avan (Backstopping), Azminah Jhetam (study design).

**Food and Agriculture Organization of the United Nations (FAO)**

» *Role*: Strategic & policy guidance, research design, and synthesis writing.

» *Key contributions*: Guided conceptual design; provided high-level institutional backstopping; contributed to drafting the overarching policy analysis and recommendations.

» *Contributors*: Ward Anseeuw (study design), Antoine Hochet (study design, backstopping).

**International Work Group for Indigenous Affairs (IWGIA)**

» *Role*: Strategic & policy guidance, research design, Indigenous rights oversight, and multi-country documentation.

» *Key contributions*: Advised on research framing; documented field experiences of Indigenous communities facing transition pressures across 10 countries (Argentina, Bolivia, Canada, Chile, Colombia, India, Nepal, Peru, Sweden, and Tanzania).

» *Contributor*: David Berger (study design, backstopping).

**French Agricultural Research Centre for International Development (CIRAD)**

» *Role*: Research design and support

» *Key contributions*: Supported data extraction, network analysis, research design, and synthesis drafting.

» *Contributors*: Roberto Interdonato (data science), Quentin Grislain (research design), Elodie Valette (backstopping).

**Collaborating for Resilience (CoRe)**

» *Role*: Research design and support

» *Key contributions*: Contributed to the design of the global research and the case study framework

» *Contributor*: Samuel Tabory (research design), Blake Ratner (study design, backstopping)

**OXFAM**

» *Role*: Research design and case study support

» *Key contributions*: Contributed to the design of the global research and case study framework; provided multiple case studies.

» *Contributor*: Bertram Zagema (research design and case study support)

**NAMATI**

» *Role*: Research design and case study support

» *Key contributions*: Contributed to the design of the global research and case study framework; provided multiple case studies.

» *Contributors*: Erin Kitchell (research design), Carlos Asunsolo (case study support).

**CIFOR & ICRAF in action**

» *Role*: Research design and support

» *Key contributions*: Contributed to the design of the global research and case study framework

» *Contributor*: Anne Larson (research design)

**Comissão Pastoral da Terra (CPT)**

» *Role*: Case study development

» *Key contributions*: Led local field investigations and documented field experiences of communities facing transition pressures in the State of Pernambuco (Brazil's Northeast).

» *Contributor*: Mariana Vidal (case study coordination)

**Community Land Scotland**

» *Role*: Case study development

» *Key contributions*: Conducted the European community land case study in Scotland

» *Contributor*: Josh Doble (case study coordination)

**Turkana Indigenous People Action for Development (TIPD)**

» *Role*: Case study development

» *Key contributions*: Led local field investigations and community reporting in Kenya

» *Contributor*: Geoffry Ariong (case study coordination)

# TECHNICAL APPENDIX

## HARMONISED SPATIAL MODELLING, ASSET TRACKING, AND CUSTOMARY TENURE OVERLAP ANALYSIS

### DATA SOURCES AND HARMONISATION

To assess the spatial footprint of the global clean energy transition, this study compiles an integrated spatial database combining utility-scale renewable energy infrastructure and critical transition mineral extraction sites across international jurisdictions.

***Renewable energy infrastructure***

Project-level asset records covering solar photovoltaic (PV), concentrated solar power (CSP), and onshore and offshore wind, hydropower, and geothermal generation were assembled primarily from Global Energy Monitor (GEM, 2024). This baseline was enriched with specialised regional inventories, including Landesa, the Red Amazónica de Información Socioambiental Georreferenciada (RAISG, 2023), the U.S. Wind Turbine Database (USGS et al., 2024), and the U.S. Large-Scale Solar Photovoltaic Database (USPVDB; USGS & LBNL, 2023). Threshold limits from primary repositories were preserved (for example, utility-scale solar PV ≥ 1 MW), excluding sub-threshold entries to maintain empirical consistency. Where regional datasets provided validated satellite-verified coordinates, these geometries superseded centroid points while preserving GEM baseline attributes.

***Transition minerals extraction***

Extractive operations were sourced from the S&P Metals & Mining database (S&P Global Commodity Insights, 2023), filtering for 33 transition minerals and rare earth elements (REEs) identified by the International Energy Agency (IEA, 2021, 2022) as foundational to clean-energy technologies. Attributes recorded include primary and secondary commodities, operational status, ownership structure, and confirmed land extent.

Taxonomy alignment: Disparate industry terms across databases were standardised against a unified lifecycle taxonomy. Macro-regional classifications and national jurisdictions were structured according to the United Nations Geoscheme (UNSD, 1999).



| LIFECYCLE STAGE | IMPLEMENTATION STATUS | OPERATIONAL DEFINITION |
|---|---|---|
| Intended | Evaluation & planning | Publicly announced, proposed, or undergoing technical, environmental, and permitting reviews. Zero on-site physical transformation; land retains baseline land use. |
| Intended | On-site exploration | Subsurface testing and geophysical investigation underway (drilling, seismic profiling, trenching). Disturbance is temporary, localised, and largely reversible. |
| Active | Development & construction | Permanent engineering underway (site clearance, earthworks, civil infrastructure, plant assembly, and impoundment). Substantial land conversion actively executing. |
| Active | Operational | Fully commissioned and actively generating or extracting as intended, including phased expansions, satellite units, and repurposed facilities. |
| Ceased | Inactive (with footprint) | Operations suspended or permanently decommissioned (care-and-maintenance, closed, abandoned). Altered terrain and physical structures remain on site. |
| Ceased | Inactive (never built) | Formally cancelled, abandoned, or stalled indefinitely prior to breaking ground. Zero permanent physical works or land conversion executed. |
| Unknown | Unknown | Implementation status cannot be confirmed from available corporate or regulatory records. |

### SPATIAL MODELLING AND PROJECT GEOMETRIES

Because spatially explicit boundary polygons are documented for fewer than 10% of energy and mining assets worldwide, restricting analysis solely to delineated perimeters would severely underestimate cumulative land demand. As such, a tiered geometric attribution hierarchy was implemented to estimate affected areas, albeit with an acknowledged trade-off in spatial accuracy:

***Observed boundaries and clustered hulls***

Where discrete turbine coordinates were available, such as the United States wind turbine database (USWTDB), multi-point convex hulls were calculated for clusters of two or more turbines. For critical mineral sites, point locations were matched against satellite-delineated global mining land-use perimeters (Cheng et al., 2026; Maus et al., 2022; Tang & Werner, 2023; Xiao et al., 2025). Where an individual mining polygon contained multiple concessions, proportional circular buffers were distributed to prevent geographic over-attribution. Hydropower reservoirs were integrated from Landesa digitisations, OpenStreetMap, the Global Dam Watch database (Mulligan et al., 2020), and regional hydropower surveys (Sperring et al., 2025).

***Empirical capacity-to-area scaling***

Where explicit boundary polygons were unavailable, circular buffers were centred on point coordinates using power densities calculated based on samples of projects of known area and capacity. Solar PV was scaled at 1.6227 ha/MW, CSP at 2.3300 ha/MW, and onshore wind at 34.2500 ha/MW (Nøland et al., 2022). Geothermal footprints were calculated using the Van Zalk & Behrens (2018) model (Area = P / [PDe × CF]) with an electrical power density of 2.24 We/m$^2$ and a capacity factor of 0.742. Hydropower project surface area does not scale linearly in relation to installed capacity, and was therefore instead derived from an empirical log-transformed regression [log10(Area_ha) = α + β·log10(Capacity_MW)] calibrated on a global sample of over 1,200 hydropower projects with known reservoir areas (Landesa, forthcoming).

***Sectoral median imputation***

For projects lacking documented capacities or surface areas, conservative median buffer radii derived from confirmed sectoral distributions were assigned: critical minerals (1,994.60 m, applied to 19,333 projects), hydropower (2,007.35 m, applied to 11 projects).

***Methodological note***

Centroid buffers represent aggregate known or estimated land demand rather than specific project boundaries.

## IPs' & LCs' LANDS OVERLAYS

Customary, collective, and Indigenous territories were identified using the LandMark global database (LandMark, 2024), capturing documented titles, government-recognised domains, customary claims, and indicative community lands.

***Voronoi tessellation and spatial extent bounding***

Where LandMark records community lands as point features, territorial influence zones were modelled using Voronoi tessellation constrained by geographic buffers (Okabe et al., 2000). Buffer thresholds were established using national median communal parcel sizes, defaulting to the global median in jurisdictions lacking baseline cadastre data.

***Complementary coverage integration***

To prevent spatial underrepresentation in regions with limited reporting transparency, datasets from Garnett et al. (2018) were incorporated strictly where LandMark data was absent or restricted to point tessellations.

***Overlay analysis and elimination of double-counting***

To assess potential encroachment, the harmonised energy transition layer was intersected with the consolidated IPs & LCs boundary coverage. To resolve overlapping spatial claims resulting from adjacent buffered assets (such as adjacent wind arrays or co-located solar and mining concessions), spatial dissolve procedures were executed across overlapping project perimeters.



Granular sub-sector trends were computed from undissolved layers, while net territorial footprints reflect dissolved, non-overlapping spatial boundaries.

***Carbon stock and conversion emissions modelling in conservation areas***

To quantify the potential climate feedback of expanding renewable energy infrastructure and transition mineral extraction into critical carbon sinks, a geospatial carbon accounting approach was applied to projects intersecting conservation areas:

***Conservation spatial subsetting and layer flattening***

The analysis targeted energy and mining project areas which overlapped protected areas and/or KBAs. To capture projects indicating prospective land conversion, the layer was filtered for projects in the implementation stage of "Intended" (aggregating formal evaluation, planning, and on-site exploration). Outputs represent the net footprint and emissions from only those project areas overlapping either protected areas or KBA designations (or both).

***Biome intersection***

The filtered spatial layer was intersected with a global terrestrial biomes layer from Dinerstein et al. (2017), delineating the footprint across 14 major global biomes and calculating the surface area in hectares (ha) per biome-project class combination.

***IPCC-tier carbon stock estimation***

Terrestrial biomass carbon stocks were calculated using Tier 1 reference values from the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories across all 14 delineated biomes. For each biome, reference values (low, medium, and high estimates) were compiled or calculated across the following parameters:

- Above-ground biomass (A): Tonnes dry matter per hectare (t d.m./ha);
- Below-ground biomass (B): Tonnes dry matter per hectare (t d.m./ha);
- Total living biomass (C): Sum of above- and below-ground dry matter (C=A+B);
- Living biomass carbon stock (D): Converted using the standard carbon fraction of dry matter (0.47): D=Cx0.47 (tC/ha)
- Litter carbon stocks (E): Tonnes carbon per hectare (tC/ha)
- Dead wood carbon stocks (F): Tonnes carbon per hectare (tC/ha)
- Total carbon stock density (G=D+E+F): Total carbon per hectare from living and dead organic sources.[16]
- Presumed conversion emissions per hectare (H): Committed carbon dioxide equivalent emissions per hectare resulting from complete clearance/conversion of vegetative biomass, based on the stoichiometric molecular conversion factor ():

16 Soil organic content was not included in these carbon stock calculations.

***Committed emissions computation***

Low, medium, and high emission factors (were joined to the biome-project area data. Potential emissions were totalled across sectoral splits and development stages (specifically isolating renewable energy and mining development in the “Intended” stages). Spatial dissolve and union operations were utilised across all aggregations to eliminate double-counting where multiple prospective project polygons or buffers intersect the same biome boundary. Potential emissions estimates are presented in this text as brackets, based upon the low and high emissions factors.



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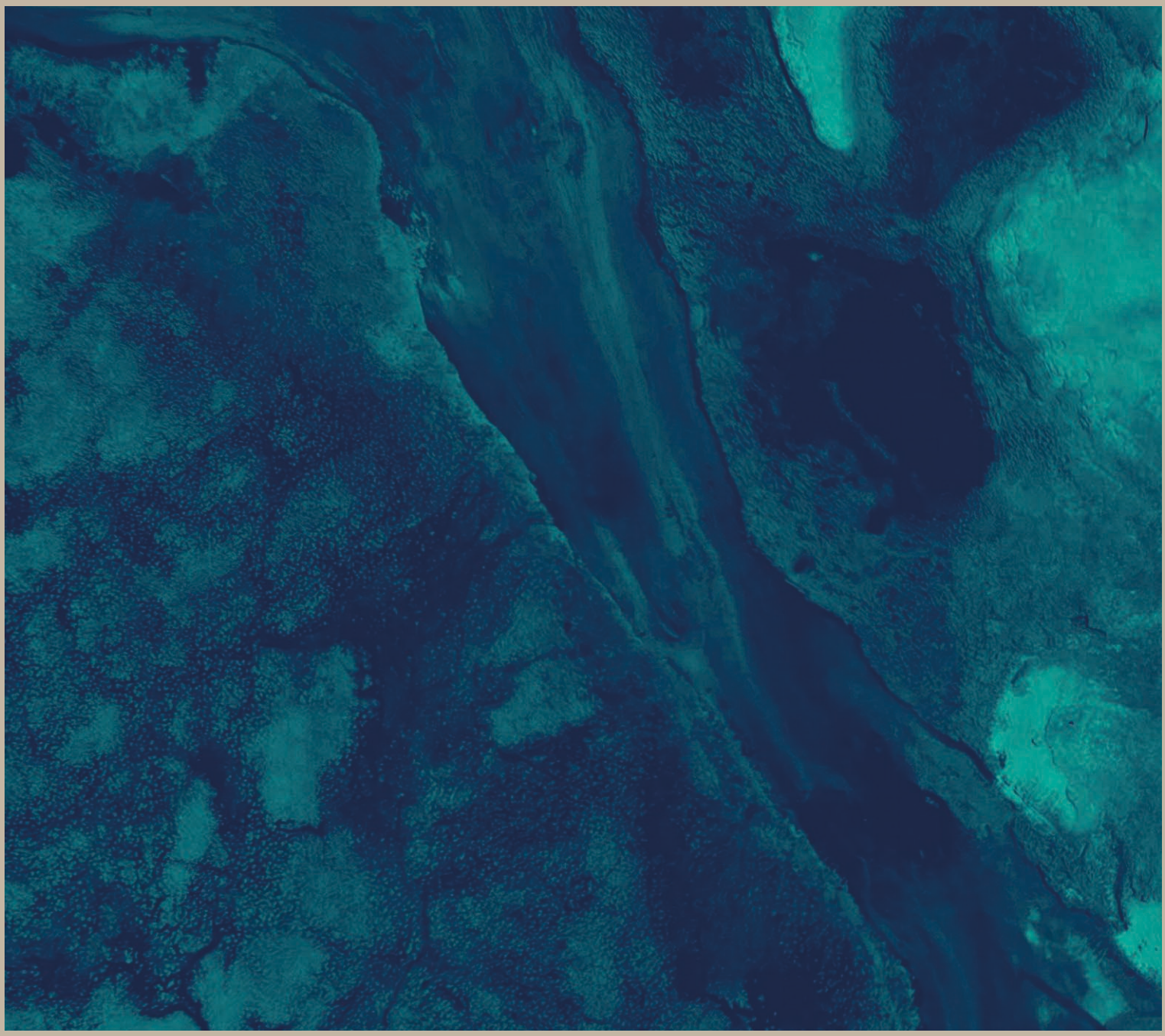
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