

A photograph of several wind turbines in a desert landscape under a clear blue sky. The turbines are white with three blades each. The ground is dry and sandy with some small desert plants. The sky is a gradient of blue. A semi-transparent red rectangle is overlaid on the top left, and a solid red rectangle is on the top right.

**Just Energy Transition in Coal Regions**

# Stories of Revived Lands

Repurposing Mine Sites: Global Examples from Post-Mining Areas

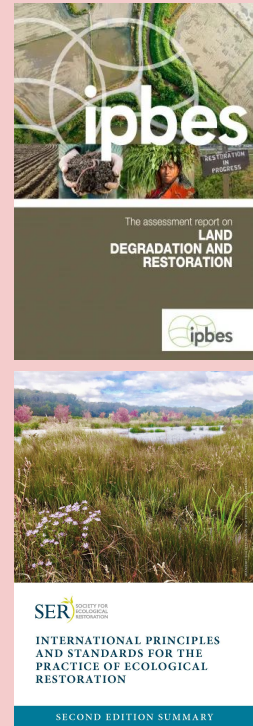
September 2025

## Repurposing Mine Sites: Turning Degraded Land into New Opportunities

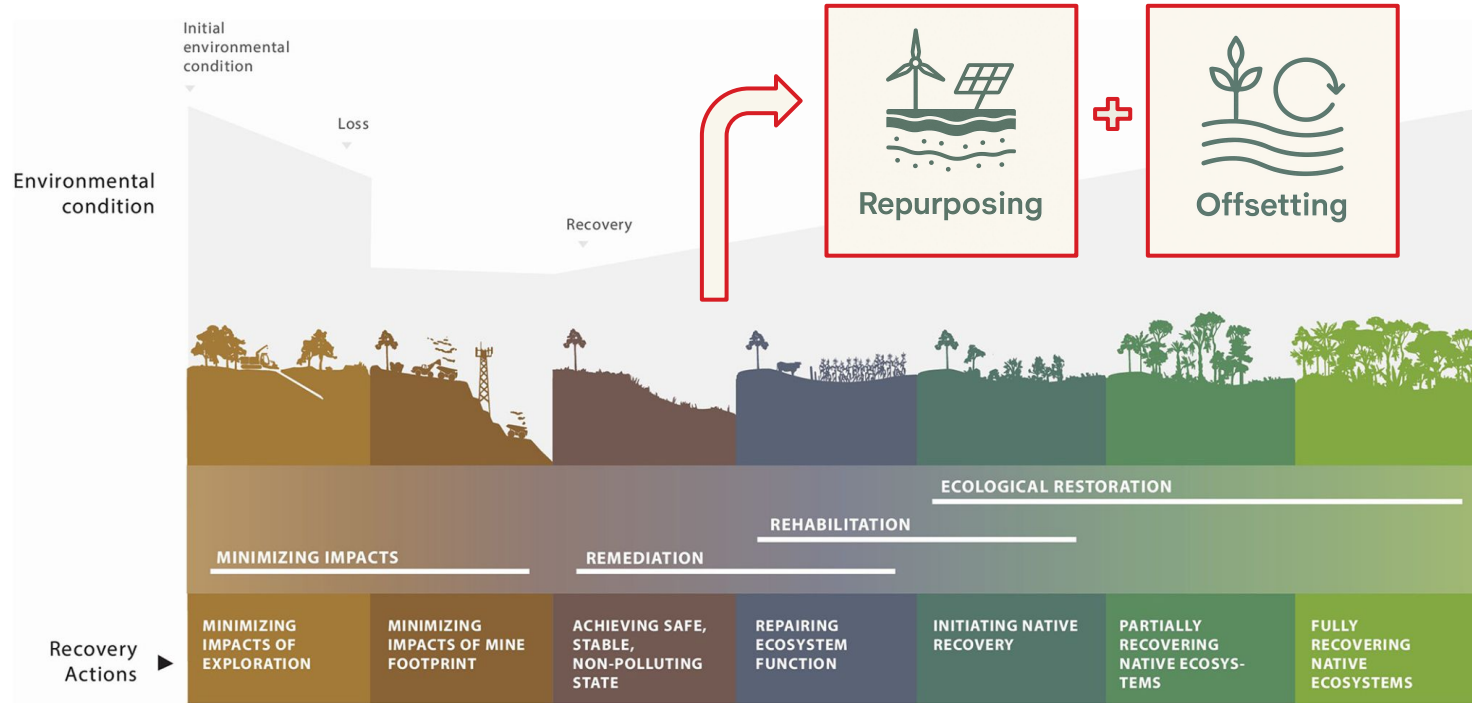
Any effort to recover an ecosystem from degradation, or to restore degraded land for other purposes, is defined as ecosystem restoration. These restoration actions are designed either to support natural recovery processes and fully restore the ecosystem to a self-sustaining living system, or to create a stable, safe, arable area that is suitable for human or industrial use. Transforming closed mines into such hubs for agriculture, tourism, renewable energy or industrial innovation can stimulate new local economies, generate employment opportunities and foster community resilience.

This manual presents examples of measures for the latter, repurposing former open-pit mines from around the world. Its aim is to provide an overview of potential applications and inspire new opportunities for mines. It is a part of the "Indonesia component" of the project "[Innovation Regions for a Just Energy Transition](https://doi.org/10.1111/rec.13771)".

### Further reading:



# Glossary in context: What is mine site repurposing?



Graphic by Young et al. (2022). With own additions on repurposing and offsetting.

# Glossary in context: What is mine site repurposing?

## Minimizing Impact

Ideally, ecological restoration and other forms of post-mining use begin before the ecosystem is degraded. This can be achieved by reducing the effects of degradation in the first place, for example by prioritising mining in areas that have already been converted.

## Remediation

Management actions aim to remove degradation, for example by detoxifying areas contaminated by excess pollutants in soil and water, in order to achieve safe, stable and non-polluting landscapes. This is a prerequisite for any form of post-mining use.

## Rehabilitation

These are management actions that aim to restore the productivity or functioning of degraded ecosystems. The objective is to provide stable long-term ecosystem services and other types of use, rather than to restore specific native ecosystems.

## Repurposing

The process of identifying a new use for a mine site that makes use of the site's characteristics to provide an economic or social activity, or another type of post-closure land use, after mine closure (e.g. light industry, recreation, or solar or wind farms).

## (+ Offsetting)

Offsetting involves taking measures to compensate for any losses of habitat, species or ecological functions that cannot be restored at the mining site. These measures apply to terrestrial, aquatic and marine habitats.

---

# Global Approaches to Repurposing Mine Sites

- *Turning degraded land into new opportunities*
- *Influencing factors for repurposing mines*
- *Common repurposing activities*

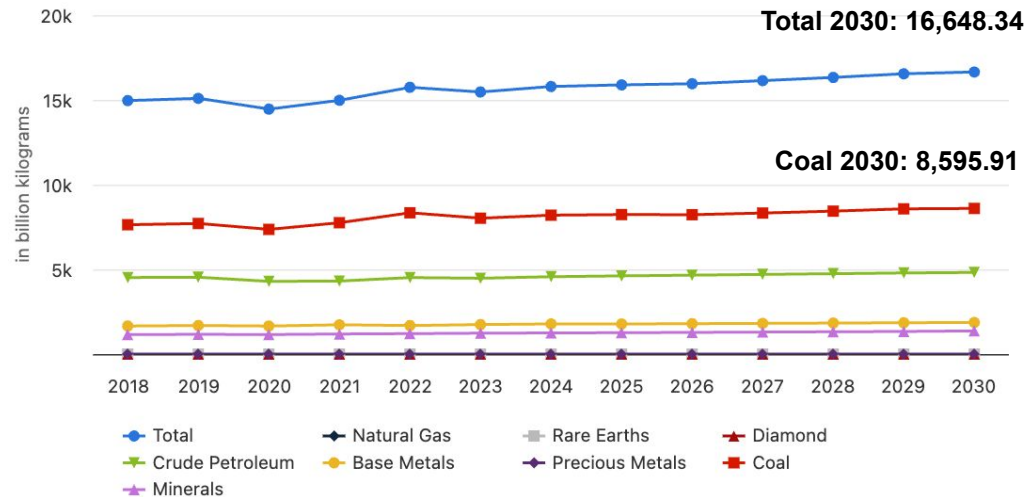
# Turning Degraded Land into New Opportunities

Mining has shaped  
— and will continue to shape —  
landscapes and economies  
around the world.

With global mining production expected to exceed 16.5 billion kilograms by 2030, the impact of extraction is far reaching. This raises essential questions:

*What happens once mining has finished? What sustainable and inclusive approaches can be taken in post-mining sites?*

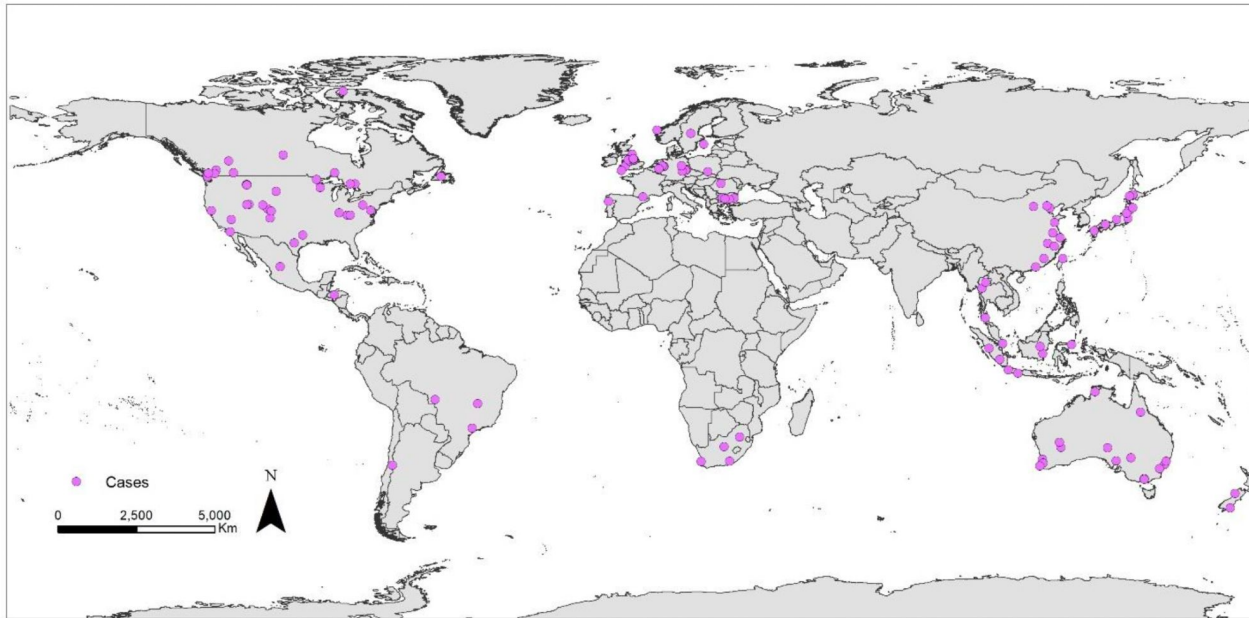
## Mining - Production



Source: Statista Market Insights

statista

# Global map of repurposing database cases

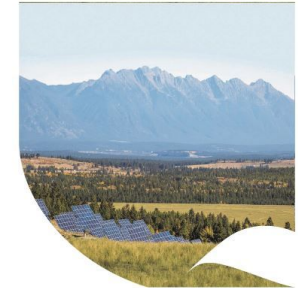


## Further reading:

Centre for Social Responsibility in Mining  
17 March 2020



### Mining as a temporary land use scoping project: transitions and repurposing



# Influencing Factors for Repurposing Mines

Repurposing mines depends on a mix of external and internal factors:

## External factors include:

- Location: Proximity to communities, infrastructure, ecological value, and land zoning.
- Economic viability: Successful repurposing often involves interconnected projects and must align with local supply and demand. Potential exists for companies to diversify into sectors like renewable energy or real estate.

## Internal factors include:

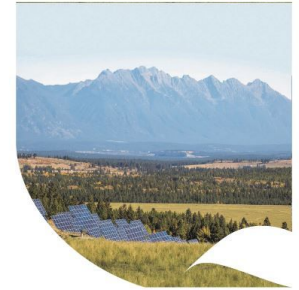
- Stakeholder and community engagement: Ongoing, inclusive engagement and a "beyond the gate" approach throughout the mine's life support smoother transitions.
- Company policies and standards: Clear closure plans, social performance roles, and internal leadership help build the business case for repurposing.
- Company continuity: Long-established or locally rooted companies tend to be more invested in sustainable post-mining land uses.

## Further reading:

Centre for Social Responsibility in Mining  
17 March 2020

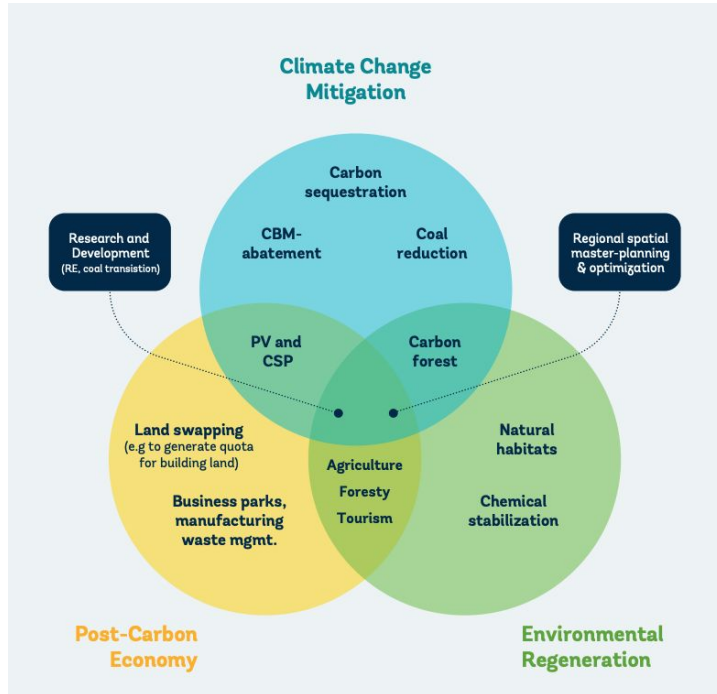
THE UNIVERSITY  
OF QUEENSLAND  
AUSTRALIA  
CREATE CHANGE

### Mining as a temporary land use scoping project: transitions and repurposing





# Common Repurposing Activities






Land repurposing offers a range of potential actions:

- Renewable energy generation (PV and CSP): Recultivated mining areas can be used to generate solar (photovoltaic, PV) and wind energy, and to store renewable energy (e.g. in pumped storage power plants or molten salt storage systems).
- Former mining areas can be converted into industrial and commercial parks suitable for various business and manufacturing purposes.
- Agriculture and forestry: Restoring land for agriculture and forestry can boost food production and the timber industry.
- Carbon sequestration and carbon forests: Carbon can be captured from the atmosphere by converting mining areas into forests or other natural habitats.
- Tourism and recreation: Repurposed land can be developed into tourist attractions or recreational areas, contributing to the local economy.

## Common Repurposing Activities

The table below groups some mine repurposing activities into three categories based on how frequently they occur. It captures the diversity of post-mining land uses — from nature restoration and cultural heritage to economic, energy, and industrial uses.

 Most Common	 Medium-Occurrence	 Rare & Niche Uses
Former mines often become nature, cultural and leisure assets.	Some sites are converted into centres for research, commerce and energy.	Some focus on specialised economic, agricultural or industrial roles.
<ul style="list-style-type: none"> <li>• Wildlife habitats</li> <li>• Museum or exhibition</li> <li>• Park &amp; open green space</li> <li>• Native woodlands</li> </ul>	<ul style="list-style-type: none"> <li>• Community events space</li> <li>• Research &amp; Education</li> <li>• Eco-tourism</li> <li>• Alternative energy</li> </ul>	<ul style="list-style-type: none"> <li>• Public/botanical garden</li> <li>• Aquaculture</li> <li>• Food production</li> <li>• Carbon offset</li> </ul>

---

# Energy Futures: From Mining to Clean Energy Production

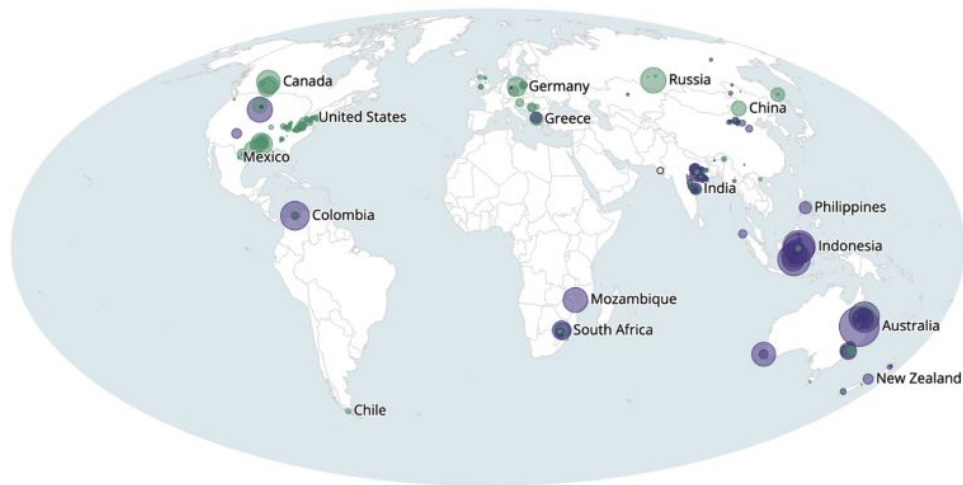
- *From mining to solar energy*
- *From mining to pumped hydro storage*
- *From mining to landfill and power generation*

## From Mining to Solar Energy

Global Energy Monitor (GEM) conducted a global survey of surface coal mines closed in the last five years (since 2020) and those that are forecasted to close over the next five (by the end of 2030). The analysis indicates that over 300 surface coal mines recently decommissioned have the potential to accommodate approximately 103 GW of photovoltaic (PV) solar capacity. Additionally, the closure of major operations in the near future could generate an additional 185 GW of solar power across 127 locations.

Coal mines closed, or expected to close, this decade, scaled by mine size (in sqkm)

■ Closed recently (since 2020) ■ Expected to close by 2030    Mine size: ○ 10 sqkm ○ 200 sqkm



Source: Global Coal Mine Tracker, Global Energy Monitor



# From Mining to Solar Energy

The majority of abandoned coal mines, as well as those due to close, are located close to existing grid infrastructure, including substations and transmission lines. The transition from coal to solar energy is well positioned to take place in both advanced and developing coal-producing economies, including Australia, Indonesia, the United States and India. Global Energy Monitor (2025) shows that coal-to-solar transitions are very promising.

Repurposing coal mines for solar can range from small (1–5 MW) community projects to massive (100+ MW) utility-scale builds.

- Small projects: Quick to deploy, connect to local grids, power schools/neighborhoods, costlier per MW, need creative financing, and often gain strong local support.
- Mid-sized projects (5–50 MW): Balance ambition and feasibility, attract corporate buyers, use existing grid without major upgrades.
- Large projects (100+ MW): Require new transmission, significant land prep, and long timelines but can transform coal communities into major clean energy hubs.

## Further reading:



### Bright side of the mine Solar's opportunity to reclaim coal's footprint

Coal was once hailed as the "fossil fuel" of a postwar boom. But the world has now entered an age of solar energy — a time when harnessing the sun has become more accessible, affordable, and environmentally sustainable than digging in for its fossil fuels. In 2024, the world reached a record-breaking 100,000,000 of solar capacity, and our only two sources that can deliver clean energy at scale are solar and wind. But that requires intelligent land use, and today's developers often struggle to secure prime locations that aren't already in use, or off limits.

What better ideal on a solar "map" can prove impactful on the ground. But vast tracts of current landscapes already sit idle in much of the world waiting for a second act — abandoned coal mines.

Global Energy Monitor (GEM) conducted a worldwide survey of solar-to-coal mines closed in the last five years (since 2020) and those forecasted to close over the next five (by the end of 2030). The first-time analysis shows that over 300 coal-to-solar mines recently out of commission could house around 700,000 of photovoltaic (PV) solar capacity, and opening clean energy operations could create an additional 100,000 of solar across 127 sites (see [data here](#)). These abandoned coal mines are positioned to reconnect with grid and adjacent and even go beyond as energy

# From Mining to Solar Energy

The following slides present a variety of approaches and projects for repurposing mining sites.



AI-generated visualisation

## Amynteo Solar Project, Greece

In Western Macedonia, Greece, the former Amynteo lignite mine is being transformed into a hub for renewable energy. Through their joint venture Meton Energy S.A., RWE and PPC Renewables have already built nearly 490 MWp of solar capacity (Clusters I & II) by the end of 2024, and are now completing Cluster III with another 450 MWp, due in 2025. Supported by EU funding and long-term power purchase agreements, the project shows how a coal mine can be successfully repurposed into large-scale green energy production.

## Datong Solar Revival, China

In Datong, Shanxi Province, a vast coal mining subsidence zone is being transformed into one of China's largest solar hubs. Built on land once considered unusable, the base combines solar power generation with ecological restoration by planting vegetation under the panels. By 2024, it had already produced over 12.6 billion kWh of clean electricity, showing how degraded coal landscapes can be revitalized into renewable energy and ecological recovery projects.

# From Mining to Solar Energy

## Floating solar power plant, Brazil

Installed on a decommissioned sand/gravel pit in São Paulo, the 1 MW floating solar plant turns post-mining land into a clean energy asset.

- In total, 1,852 photovoltaic panels generate 1 MW of electricity, which is enough to supply 1,500 homes.
- The panels occupy 8,000 m<sup>2</sup> of the water surface, while the exhausted pit covers 200,000 m<sup>2</sup>.
- It features on-float inverters and transformers to minimise cabling requirements and maximise energy efficiency.
- The unprecedented project, budgeted at R\$5 million, was implemented by F2B, a Brazilian company specialising in photovoltaic generation projects in water bodies.



AI-generated visualisation



## From Mining to Pumped Hydro Storage



A pumped hydro storage facility is an energy storage system comprising two water reservoirs at different elevations. Electricity is stored by pumping water uphill to the upper reservoir when demand is low, and released downhill through a turbine to generate power when demand is high. The necessary requirements are a natural or artificial gradient and sufficient water in the form of a lake to allow movement up and down. In most cases, the minimum head required for economic feasibility is 300 metres.

- The [ATLANTIS project](https://www.atlantis-project.eu/), coordinated by the GFZ German Research Centre for Geosciences, is one example of this approach. It aims to transform disused open-pit lignite mines in Europe into hybrid pumped-hydro energy storage facilities. The approach supports both the energy transition and structural change in former mining regions.



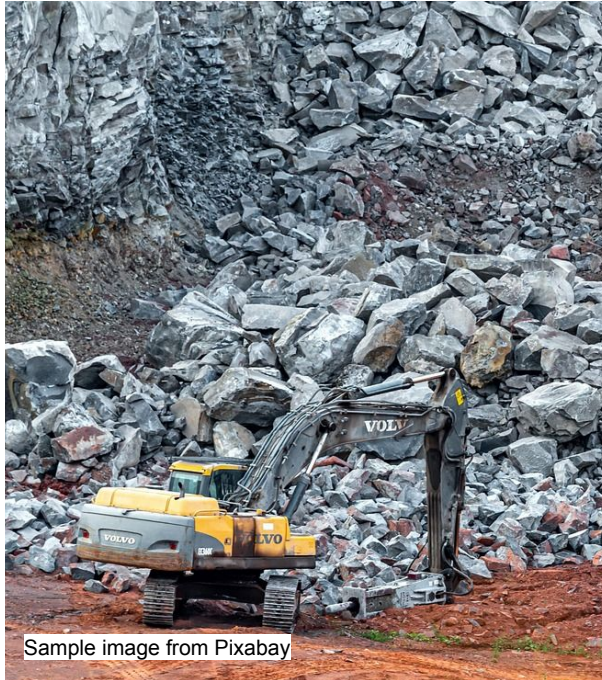
## From Mining to Pumped Hydro Storage

The [Kidston Clean Energy Hub](#) in Queensland, Australia: Once a gold mining town following the discovery of gold in 1907, mining ceased in 2001, leading to economic decline. The site has been transformed into Australia's first pumped hydro storage facility, complemented by wind and solar power.

- Construction of the 250 MW Kidston Pumped Storage Hydro Project (K2-Hydro) commenced in April 2021, and the project is on track to be operational in the second half of 2025.
- Once operational, the project will generate 250 MW of power for up to eight hours for North Queensland.
- It will be the third largest electricity storage device in Australia.



# From Mining to Landfill and Power Generation



Sample image from Pixabay

## Minas do Leão Landfill-to-Energy Project, Brazil

- In Minas do Leão, Rio Grande do Sul, a former open-pit coal mine has been converted into a sustainable landfill and energy facility. With capacity for 23 million tonnes of waste, the facility captures landfill biogas, reducing greenhouse gas emissions by around 170,000 tonnes of CO<sub>2</sub> each year.
- Since 2015, an on-site power plant has generated 8.5 MW of electricity from this biogas, providing around 100,000 people with energy.
- The site also integrates advanced wastewater treatment and constructed wetlands, supporting ecological restoration alongside energy production.

---

# Beyond Energy: From Mining to Agriculture, Industry and Community Uses

- *From mining to agriculture and palm oil*
- *From mining to eco-farmland and aquaculture*
- *From mining to industrial tourism*

## From Mining to Agriculture



Rhenish lignite mining region, Germany

The main purpose of agricultural re-cultivation is to promote soil fertility as a condition for sustainable productive land use.

In the Rhenish lignite mining region, agricultural recultivation focuses on transforming former open-pit mines into fertile farmland with yields comparable to the original highly productive soils. High-quality loess, carefully separated during mining, is used as the basis for new soils, supported by water-permeable layers to ensure proper drainage. Newly created fields are first planted with alfalfa to build humus, improve soil structure, and activate soil biology, followed by several years of interim cultivation with grains before transfer to local farmers. In addition to arable farming, recultivated areas are also used for orchards, pastures, and biodiversity measures such as flower strips, meadows, and habitats that support species diversity, creating multifunctional landscapes after mining.

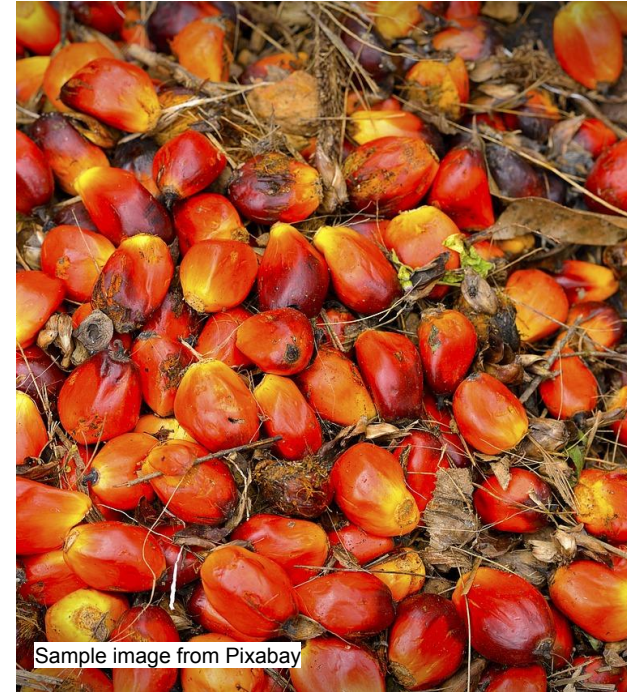


# From Mining to Palm Oil

## Palm Oil Cultivation on Reclaimed Mine Land, Indonesia

A case study in East Kalimantan, Indonesia, examines the conversion of an ex-coal open-pit mining area into oil palm plantations as part of mine reclamation. Starting in 2014, 300 hectares were planted with oil palm to provide a new economic base for surrounding communities while reducing the pressure to clear forests.

- Although soils in the mined area were degraded with low nitrogen and organic carbon, treatments such as manure, compost, and water management improved growth conditions.
- Yields and plant growth were initially lower than in commercial plantations but showed steady improvement, particularly after applying proper management like castration.
- Overall, the project demonstrates that palm oil plantations can repurpose former mining land into productive and sustainable agricultural use.



## From Mining to Eco-Farm Land



### Haerwusu Eco-Farm, China

- The [Haerwusu and Heidaigou coal mines](#) began reclamation in 2017, led by Shenhua Jungar Energy in collaboration with local partners, with the goal of supporting agriculture.
- Out of a total of 2,800 hectares reclaimed, 520 hectares were converted into farmland, including 105 hectares for crops, 144 hectares for forage, and 6.5 hectares for livestock, which now sustains more than 600 cattle.
- The initiative directly involves over 200 local farmers who participate in a profit-sharing model that raises household incomes by approximately €455–520 per year.

Gain more insights from China: [Identifying land reuse suitability and transformation strategies towards green development in a post-mining area: A case of Qijiang, Chongqing, China](#)

# From Mining to Aquaculture

## Fish Farming in Abandoned Mine Waters, India

- In Nandna village, Dumka, Jharkhand, an abandoned stone mining pit has been converted into a cage fish farming project managed by the self-help group Kaveri Cage Culture Samiti, comprising 24 members from local communities.
- The project uses floating cages in a 2-hectare deep-water pit to raise Pangasius and Monosex Tilapia, with support from the Jharkhand government.
- The initiative demonstrates how unused mining waters can be repurposed for aquaculture, providing an alternative livelihood, utilizing local water resources efficiently, and offering a model for rural development in similar contexts.



Sample image from Pixabay

# From Mining to Industrial Tourism



Some former coal mines have been turned into museums or industrial heritage sites. While this can provide income and jobs for local regions and help preserve cultural identity, industrial tourism is not a viable option for all coal regions. Tourist sites need to be accessible to visitors and ideally located near large cities or other attractions.

## Sawahlunto's Post-Mining Site, Indonesia

- After the closure of its coal mines in 2001, Sawahlunto faced economic decline, population loss and environmental damage. To address these issues, the former mining sites were converted into heritage tourism attractions, including three museums: The Goedang Ransoem Museum, the Hole Mine Site Museum Mbah Soero, and the Sawahlunto Railway Museum.
- These museums preserve mining artefacts, tunnels and historical equipment, telling the stories of miners to educate visitors about the city's past.



---

# Back to the Roots: From Mining to Ecosystem Restoration

- *From mining to carbon sequestration*
- *From mining to native ecosystems*
- *From mining to eco-tourism and botanical gardens*

## From Mining to Carbon Sequestration



The most common goal of mine closure is to rehabilitate mining areas to create stable, harmonious landscapes that resemble the conditions prior to mining. Post-mining rehabilitation projects aim to restore the original ecological environment by balancing ecological, economic and environmental values in order to improve the land's structure and increase its value.

One way to exploit synergies is through carbon sequestration and carbon forests. Converting mining areas into forests or other natural habitats enables carbon to be sequestered from the atmosphere. The most important factor for carbon storage is system stability, particularly the integrity of vegetation, soil and slopes.

# From Mining to Native Ecosystems

## Post-Mining Land Reclamation and Rehabilitation, Indonesia

- In Indonesia, PT Vale implements progressive reclamation as part of its mine closure strategy, restoring mined land in phases during active operations rather than waiting until extraction ends.
- The company prioritizes the planting of native and endemic species, such as ebony (*Diospyros celebica*) and dengen (*Dillenia serrata*), supported by an on-site nursery with the capacity to produce up to 700,000 seedlings each year.
- Restored areas undergo multi-year monitoring and maintenance, with biodiversity conservation integrated into rehabilitation through the systematic documentation and protection of local flora and fauna.

Gain more insights from Indonesia: [Flora and Fauna Monitoring in JBG Reclamation Area](#)



Sample image from Pixabay

## From Mining to Eco Tourism



### Aravalli Biodiversity Park, India

India has several biodiversity parks that have been established on former mining areas, transforming degraded landscapes into thriving ecosystems. The [Aravalli Biodiversity Park in Gurugram](#), Haryana, is a prime example.

- Native plants were reforested by citizens and social movements.
- Environmental memory of the local people combined with academic guidance was successful in establishing a much visited Biodiversity Park just outside of New Delhi.
- More than 50 PhD projects have been realised at this site showing the value of citizens and academia joining forces.

Gain more insights from India:

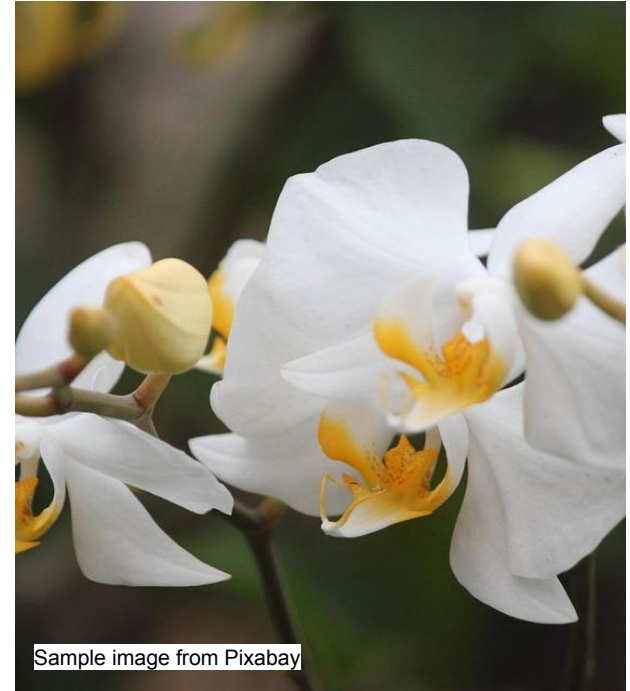
[Eco - Tourism in mining area | Ministry of Coal](#)

# From Mining to Botanical Garden

Tanjung Enim Tourism City Program, Indonesia

PT Bukit Asam Tbk (PTBA), together with the Muara Enim Regency Government, has been developing the [Tanjung Enim Tourism City Program](#) since 2016 to transform former coal mining land into a sustainable tourism destination. As part of this initiative, PTBA built a 17-hectare Botanical Garden on post-mining land, designed as both a tourist attraction and a center for education.

- The park includes various facilities such as educational buildings, cottages, camping areas, a food court, and will feature a replica of the Sriwijaya Ship as its landmark.
- The Botanical Garden applies a bioregion concept by showcasing endemic flora from different Indonesian islands, turning reclaimed mining land into a hub of biodiversity and recreation.



Sample image from Pixabay

### Turning Degraded Land into New Opportunities

As this manual demonstrates, repurposing land can create many opportunities for post-mining landscapes. Repurposed sites can continue to be used for energy production, for example to generate renewable energy sources such as solar power and pumped hydro storage, or to produce landfill biogas. Furthermore, former mining sites can be converted into agricultural areas, aquaculture sites, or industrial or tourist facilities, thereby creating new economic and social value. Finally, additional uses such as ecotourism and botanical gardens can support the restoration of local ecosystems and carbon sequestration.

These examples illustrate how former mining sites can be transformed into sustainable, multifunctional landscapes that benefit local communities, nature and the climate.



## Further readings

The repurposing of former mining sites is a broad field, with innovative approaches emerging worldwide. Beyond the examples highlighted in this manual, a growing body of international work is providing valuable insights, principles and practical guidance. The following selection showcases some of these publications, offering deeper insights.

### Toolkits & Guidelines

- ICMC (2025). [Integrated Mine Closure Good Practice Guide, 3rd Edition](#)
- European Commission (2022). [Environmental rehabilitation and repurposing toolkit - Platform for coal regions in transition](#)
- Young, R.E., Gann, G.D., Walder, B., Liu, J., Cui, W., Newton, V., Nelson, C.R., Tashe, N., Jasper, D., Silveira, F.A., Carrick, P.J., Häggglund, T., Carlsén, S. and Dixon, K. (2022), [International principles and standards for the ecological restoration and recovery of mine sites](#). Restor Ecol, 30: e13771. <https://doi.org/10.1111/rec.13771>
- World Bank (2021). [Mine Closure Standards and Improved Post-Closure Risk Management for Surface and Underground Coal Mines](#)
- Umweltbundesamt (2020). [Guideline on the rehabilitation of open-pit coal-mines in Mongolia \(GROM\)](#)
- World Bank (2020). [Repurposing Land and Assets for Western Macedonia](#)
- Holcombe, Sarah and Keenan, Julia. (2020). [Mining as a temporary land use scoping project: transitions and repurposing](#). Centre for Social Responsibility in Mining. The University of Queensland: Brisbane.
- LMBV (2020). [Preparing the ground for the future. Mine Recultivation](#)
- CCOP (2018). [Best Practices of Mine Rehabilitation and Decommissioning Programmes of Success Stories in East and Southeast Asia](#). Coordination Committee for Geoscience Programmes in East and Southeast Asia, Bangkok.

---

# Project Context

- *The IKI JET Project, 'Innovation Regions for a Just Energy Transition'*
- *A brief overview of the project and country-specific and global knowledge*
- *Acknowledgements and contact details*



# The IKI JET Project

## “Innovation Regions for a Just Energy Transition”

Supported by:



on the basis of a decision  
by the German Bundestag



<b>Commissioning Parties</b>	International Climate Initiative (IKI) of the Federal Ministry for Economic Affairs and Climate Action (BMWK) and jointly financed by the EU Commission – DG INTPA, Global Challenges Multiannual Indicative Programme 2021-27 for the <b>JET-CR Platform</b>
<b>Objective</b>	Support and accelerate just energy transitions (JET) away from coal to renewable energy and other sustainable economic activities in the Global South
<b>Countries</b>	Global approach with in-depth support to Indonesia and Colombia (tbc)

### Implementing organisations

Consortium composed of:

- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
- Climate Action Network International (CAN International)
- International Institute for Sustainable Development (IISD)
- International Labour Organisation (ILO)
- Wuppertal Institute for Climate, Environment and Energy

### Collaborating partner

Solidarity Center

**Project duration** December 2022 – July 2026

Implemented by



In collaboration with



100

Download publication

Download publication

[Download publication PDF](#)

- Visit our Knowledge Platform and sign up for our newsletter here:  
[Just Energy Transitions in Coal Regions | Empowering Sustainable Change \(jetknowledge.org\)](https://jetknowledge.org)
- You can also follow us on LinkedIn:  
[Just Energy Transition in Coal Regions Knowledge Hub: Overview | LinkedIn](#)

# Acknowledgements

## Just Energy Transition in Coal Regions

The project "Innovation Regions for a Just Energy Transition" is co-financed by the International Climate Initiative (IKI) of the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and by the Directorate-General for International Partnerships (DG INTPA) of the European Commission (DG INTPA) for the Interregional Platform for Just Energy Transition in Coal Regions (JET-CR).

Supported by:



Federal Ministry  
for Economic Affairs  
and Climate Action



Co-funded by  
the European Union

on the basis of a decision  
by the German Bundestag

## Just Energy Transition in Coal Regions

Any person who believes they may be harmed by an IKI project or who wishes to report corruption or the misuse of funds can lodge a complaint to the IKI Independent Complaint Mechanism at [IKI-complaints@z-u-g.org](mailto:IKI-complaints@z-u-g.org). The IKI Complaint Mechanism has a panel of independent experts who will investigate the complaint. In the course of the investigation, we will consult with the complainant so as to avoid unnecessary risks for the complainant.

More information can be found at:

<https://www.international-climate-initiative.com/en/aboutiki/values-responsibility/independent-complaint-mechanism/>

# Just Energy Transition in Coal Regions

## Contact

Wuppertal Institute for Climate, Environment and Energy

Jacqueline Klingen

[jacqueline.klingen@wupperinst.org](mailto:jacqueline.klingen@wupperinst.org)

Timon Wehnert

[timon.wehnert@wupperinst.org](mailto:timon.wehnert@wupperinst.org)

**This manual is written by:** Jacqueline Klingen, Linus Kurtenbach, Annisa Wallenta & Timon Wehnert.

**Please cite as:** Klingen, J., Kurtenbach, L., Wallenta, A., & Wehnert, T. (2025). Stories of revived lands, repurposing mine sites: Global examples from post-mining areas.