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Ministry of Coal, Government of India
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CLOSURE BEYOND COMPLIANCE
EMBRACING L.I.V.E.S. FOR A SUSTAINABLE FUTURE

INDEX

PREFACE
EMBRACING THE L.I.V.E.S. THROUGH MINE CLOSURE

Mine closure is one of the most critical stages in the life cycle of a coal mine, carrying significant environmental, social, and economic implications. Once mining operations cease, the challenge extends far beyond sealing shafts or filling voids it encompasses restoring degraded landscapes, stabilizing land, addressing water and air quality concerns, and ensuring long-term ecological balance. Equally important is the socio-economic dimension, as communities dependent on mining often face livelihood disruptions, reduced opportunities, and loss of social infrastructure. Without a structured and forward-looking approach, mine closures risk leaving behind abandoned lands, environmental hazards, and vulnerable populations.

Recognizing this need, Coal Controller Organization, under the Ministry of Coal, has developed the L.I.V.E.S. framework (Land and Technical Reclamation, Integrated Community Engagement & Empowerment, Viable Post-Closure Development, Ecosystem Rehabilitation, Regenerative Environmental Restoration, and Sustainability and Stewardship) that provides a comprehensive approach to this pressing challenge. LIVES is not just a collection of technical processes; it is a commitment to restoring the environment while uplifting the very communities that are integral to this restoration. At its core, LIVES integrates ecological restoration, community empowerment, and long-term sustainability, providing a clear and actionable pathway to repurpose lands, restore environments, rebuild ecosystems and strengthen communities.

This handbook aims to serve as a practical guide for practitioners, decision-makers, communities, and anyone dedicated to the restoration of mining-affected areas. It blends scientific principles with real-world applications, offering insights, strategies, and case studies from across the globe to demonstrate the transformative power of mine closures. It is built on the understanding that mine closure is a dynamic, collaborative process, one that involves a diverse set of stakeholders, ranging from local communities and governments to international organizations and businesses.

The chapters within this book are organized to provide a comprehensive understanding of the various aspects of the L.I.V.E.S. in Mine Closure, from technical reclamation to community-led empowerment. Each section not only presents practical methodologies but also emphasizes the importance of adaptability, innovative thinking, and inclusive collaboration.

LIVES Framework stands as a reminder that the earth is resilient, capable of regeneration when given the right conditions, support, and care. However, this resilience cannot be achieved in isolation. For true success, restoration efforts must be coupled with efforts to empower local communities to become active agents of change, and to build sustainable economic models that ensure the longevity of restoration projects.

As we embark on this journey, we will explore the key principles of embracing L.I.V.E.S. through mine closure, offering guidance on how to apply these concepts to specific challenges that arise during the closure processes. Whether you are involved in land reclamation, ecosystem rehabilitation, community-driven projects, or post-industrial site repurposing, the strategies outlined here will provide the foundational knowledge needed to create lasting, positive change.

The future depends upon us. Through collaborative action, restoration, and sustainable management, we have the power to revitalize the land and revive communities ensuring a thriving world for generations to come.

01.
INTRODUCTION

Traditionally, mine closure has been understood as the formal process of shutting down mining operations, decommissioning infrastructure, and implementing measures to restore land stability and environmental safety in compliance with legal and regulatory requirements. The focus has largely been on bringing the disturbed land back to its original or even improved condition, through measures such as reshaping the land, stabilizing slopes, covering waste, and planting vegetation. While these practices remain essential, they represent just one part of a much broader picture. Today, mine closure is increasingly recognized as a complex, multi-dimensional process that must also consider the long-term needs of communities, future land use, and environmental sustainability. Moving beyond technical and biological reclamation, modern closure planning calls for a more integrated and forward-looking approach; one that restores not just land, but also livelihoods, ecosystems, and hope for the future.

Modern mine closure is not just about "reclaiming the land"; it is about redefining the future of post-mining landscapes across social, economic, environmental, and cultural dimensions. This shift in perspective requires an integrated approach that goes beyond technical reclamation to embrace long-term land use, community livelihoods, stakeholder engagement, regulatory compliance, and resilience to climate change.

Recognizing this evolving landscape, the Ministry of Coal has been continuously driving efforts towards more responsible and sustainable mine closure practices. To further support this vision, the Coal Controller Organisation under the Ministry of Coal has developed the LI.V.E.S. Framework, a strategic and comprehensive approach to mine closure that goes beyond traditional practices. The LIVES Framework acknowledges that while technical and biological reclamation are still critical components, they alone are not sufficient to fully address the long-term social and economic potential of post-mining landscapes.

In this framework, the term "L.I.V.E.S." not only symbolizes the improvement of lives affected by mining, but also serves as an acronym representing five foundational pillars that guide responsible and regenerative closure:

L – Land and Technical Reclamation
I – Integrated Community Engagement & Empowerment
V – Viable Post-Closure Development (Repurposing)
E – Ecosystem Rehabilitation & Regenerative Environmental Restoration
S – Sustainability and Stewardship

Each component addresses a vital dimension of closure, ranging from restoring physical landscapes and ecosystems, to repurposing mine sites for future use, to ensuring inclusive engagement with local communities. It is based on the fundamental principle that "True Success" in mine closure is measured not only by the physical restoration of land but also by the lasting benefits to communities and ecosystems. It calls for a broader vision of closure; one that is holistic, forward-looking, and rooted in shared responsibility. It emphasizes that closure planning must begin at the zeroth stage of the project lifecycle, be embedded throughout operations, and reflect in the mine's entire lifespan.

By adopting this expanded perspective, practitioners, regulators, communities, mine owners and other related organizations can work together to ensure that mine closure is not a final act of repair, but a meaningful transition to lasting value; one that embodies the vision of embracing LIVES through mine closure.

VISION AND VALUES

LIVES Framework stands as a beacon of hope for landscapes and communities affected by industrial activities, resource extraction, and environmental degradation. At its core, the framework is about transformation: transforming contaminated, abandoned, or underutilized land into spaces of ecological, social, and economic vitality. The vision is clear: to leave behind Living, Integrated, Vibrant, and Empowered Spaces that not only heal but also thrive, for generations to come.

The values underlying this framework are centred on:

- Sustainability: Promoting long-term ecological balance through responsible management and restorative practices.
- Community Empowerment: Ensuring that the people most impacted by land degradation have a seat at the table, with opportunities for leadership and ownership.
- Collaboration: Recognizing that land reclamation and restoration cannot happen in isolation; it takes governments, businesses, NGOs, local communities, and technical experts working together toward shared goals.
- Innovation: Embracing new technologies and ideas to tackle the complex challenges of land reclamation, environmental restoration, and community renewal.

THE RATIONALE FOR AN INTEGRATED APPROACH

Historically, land reclamation efforts were approached in isolation: environmental restoration by one group, while community development was addressed separately. Community engagement was also minimal, which was often treated as a peripheral activity rather than an integral part of the closure process. Repurposing of mined-out land was not considered a core component, with no dedicated Repurposing Plan to guide long-term land use and community development. Detailed mapping of original landscapes and land contours, essential for effective restoration, was often lacking. This siloed and fragmented approach often led to disjointed projects that failed to fully address the complexities of the land and the people who depend on it.

The LIVESFramework proposes an integrated approach: one that sees the whole picture and addresses mine closure from multiple angles: technical reclamation, ecological restoration, community development, economic diversification, and long-term sustainability. By breaking down silos and embracing a holistic view, this framework ensures that land restoration becomes not just about "reclaiming" the land but about creating a vibrant, multi-faceted future for the land and its surrounding communities.

WHY INTEGRATION MATTERS:

- Environmental Interconnections: Ecosystems are complex. Soil, water, and air quality are interdependent, and ignoring these connections often results in ineffective solutions.
- Socio-Economic Needs: Communities living on or near degraded land often rely on the very resources that industrial activities have exhausted or polluted. Ignoring their needs creates a disconnect and can lead to the failure of reclamation projects.
- Long-Term Viability: Sustainability isn't a short-term fix; it's a long-term commitment. Without integrating social, environmental, and economic considerations, reclamation efforts are likely to falter after the initial efforts have been made.

STEP-BY STEP PRACTICAL APPROACH

Effective mine closure requires careful planning and integration. Adopting these four critical phases helps deliver closure that is effective, sustainable, and beneficial for both the environment and surrounding communities:

A.Planning

B.Identification & Implementation of Interventions

C.Monitoring

STEP 1: COMPREHENSIVE PLANNING

Comprehensive planning is the cornerstone of a successful and sustainable mine closure process. It requires a realistic understanding of local conditions, regulatory requirements, stakeholder expectations, and environmental factors. Effective planning is both strategic and adaptive, preparing for known challenges while remaining flexible for unforeseen issues.

The preparation of a Mine Closure Plan (MCP) must begin at the zeroth stage of the project lifecycle and be developed along with a Repurposing Plan. Delaying closure and repurposing planning until later stages often leads to significant environmental, social, and regulatory challenges. A proactive and systematic MCP ensures that closure objectives are embedded from the outset, guiding operational decisions and enabling smoother transition post-mining. The plan should be grounded in comprehensive baseline data, including land use patterns, ecological and topographical features, biodiversity, and the socio-economic and occupational landscape of the area. This information must be closely aligned with findings from the Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) to ensure consistency and relevance. Crucially, the planning process must involve continuous engagement and meaningful consultation with local communities, self-help groups (SHGs), and other stakeholders to develop a post-mining vision that restores the environment, supports alternative livelihoods, and delivers long-term value to the region. To translate this vision into actionable outcomes, it is essential to:

1.1 DEFINE CLEAR AND ACHIEVABLE CLOSURE OBJECTIVES

- Set SMART Goals: Establish Specific, Measurable, Achievable, Relevant, and Time-bound objectives that reflect technical, social, and environmental priorities.
- Contextualize Objectives: Consider the socio-economic profile of the local area, existing infrastructure, cultural values, and potential future land uses.
- Balance Stakeholder Needs: Ensure objectives incorporate community aspirations, ecological integrity, and economic viability, avoiding unrealistic targets that compromise any one aspect.

1.2 CONDUCT COMPREHENSIVE BASELINE ASSESSMENTS

- Detailed Baseline Studies: Conduct detailed baseline studies on Land Use Patterns (pre-mining and current), Topography, Ecology, Biodiversity Inventory, Socio-Economic and Occupational Patterns
- Document Current Social Conditions: Gather data on community livelihoods, demographics, health indicators, and infrastructure access to understand social vulnerabilities.

- Multi-Source Data Collection: Use satellite imagery, drone surveys, on-site sampling, and historical records to build a detailed baseline of soil quality, water resources, biodiversity, and land contours.
- Identify Critical Data Gaps: Prioritize filling gaps that affect restoration success, such as groundwater flow or endemic species presence, planning phased studies if needed.
- Local Knowledge Integration: Actively involve local residents and Indigenous communities to capture traditional knowledge, historical land use, and cultural sites that may not be documented formally.
- Mapping with EIA and SIA: Map data and information gathered with the Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) reports for cross-verification, planning alignment, monitoring progress and measuring outcomes.

1.3 DEVELOP STAKEHOLDER ENGAGEMENT STRATEGY

- Comprehensive Stakeholder Mapping: Identify all relevant groups including local residents, Indigenous peoples, government agencies, NGOs, and mine employees.
- Inclusive Communication Methods: Use culturally appropriate channels, such as community meetings, local language materials, visual aids, and social media, to reach diverse audiences effectively.
- Early and Continuous Engagement: Involve stakeholders at every stage, from planning to monitoring, to build trust and ensure their input shapes decisions.
- Conflict Prevention: Establish grievance mechanisms and open dialogue forums early to address concerns before they escalate.

1.4 DEVELOP COMMUNITY ENGAGEMENT AND DEVELOPMENT PLAN

- Early and Continuous Consultation: Engage local residents, Self-Help Groups (SHGs), NGOs, and local government bodies. Conduct regular meetings and workshops to incorporate community inputs.
- Co-Creation of Sustainable Solutions: Encourage community participation in decision-making. Identify community needs and expectations for post-mining land use. Promote indigenous and cultural practices in repurposing initiatives.
- Fostering Long-Term Community Benefits: Ensure local employment opportunities in post-mining projects. Establish community-managed enterprises for asset maintenance (e.g., eco-tourism, solar farms). Provide ongoing support and training.

1.5 DEVELOP REPURPOSING PLAN

·Land Repurposing: Convert mined land into agricultural zones, solar power plants, Data center, eco-tourism sites, or community forests. Utilize former mine pits for water storage, irrigation, and fish farming. Develop industrial or commercial hubs based on regional demand.
·Infrastructure Repurposing: Convert mine infrastructure (offices, warehouses, roads) into schools, clinics, training centers, or community halls. Supply residual electricity from mining infrastructure for community use.
·Fostering Long-Term Community Benefits: Ensure local employment opportunities in post-mining projects. Establish community-managed enterprises for asset maintenance (e.g., eco-tourism, solar farms). Provide ongoing support and training.

1.6 ALIGN WITH LEGAL AND REGULATORY FRAMEWORKS

- Regulatory Landscape Analysis: Thoroughly review national, regional, and local regulations related to mine closure, environmental protection, and community rights.
- Maintain Compliance Registers: Track all relevant permits, licenses, and closure requirements, and update plans as regulations evolve.
- Engage Regulators Proactively: Develop working relationships with regulatory bodies to clarify expectations, seek guidance, and facilitate timely approvals.
- Prepare for Audits and Reporting: Maintain clear documentation of all compliance activities to support transparency and accountability.

1.7 RESOURCE AND BUDGET PLANNING

• Detailed Cost Estimation: Include all anticipated expenses, such as technical reclamation, community programs, monitoring, and capacity building.
• Contingency Funds: Allocate 10-20% of the budget for unexpected challenges, such as environmental incidents or social unrest.
• Leverage Partnerships: Explore collaboration opportunities with government agencies, NGOs, academic institutions, and local businesses to pool expertise and resources.
• Capacity Building Investments: Budget for training local workers and community members in closure-related skills, fostering local ownership and future employment.
• Phased Resource Allocation: Align budgeting with project phases to ensure resources are available as needed and prevent funding gaps.

1.8 ESTABLISH GOVERNANCE AND ACCOUNTABILITY MECHANISMS

- Clear Roles and Responsibilities: Define who is accountable for each aspect of planning and closure activities to avoid overlaps or gaps.
- Create Closure Steering Committees: Form multi-stakeholder groups including community representatives to oversee planning and implementation.
- Set Decision-Making Protocols: Ensure transparent processes for resolving disputes and making adjustments to plans as conditions change.
- Regular Review and Adaptive Management: Schedule periodic reviews of the closure plan to incorporate lessons learned, new data, and stakeholder feedback.

TIPS FOR PRACTITIONERS

- Start planning well before mining begins to incorporate closure into overall mine lifecycle management.
- Use participatory mapping and community workshops to complement technical surveys and enrich baseline data.
- Ensure communication materials are accessible and translated into local languages where needed.
- Build flexibility into plans to accommodate changing environmental conditions or community priorities.
- Document all decisions and data carefully to build a clear audit trail.

Example: Use baseline data and stakeholder inputs to create an integrated closure roadmap that addresses landforms, community needs, and compliance.

Tip: Involve cross-functional teams from the start to build shared ownership of closure goals.

TIPS FOR PRACTITIONERS

■ Do's	✕ Don'ts
Set SMART goals (Specific, Measurable, Achievable, Relevant, Time-bound)	Set vague or unrealistic objectives
Align closure goals with technical, environmental, and social priorities	Focus solely on technical or regulatory compliance
Base objectives on local socio-economic and ecological context	Ignore local needs, culture, or existing infrastructure
Involve stakeholders early in defining closure objectives	Exclude community input or delay engagement
Revisit and revise objectives throughout the mine lifecycle	Treat closure goals as fixed or one-time tasks
Ensure end-use plans are practical and locally beneficial	Assume generic or unsuitable post-mining land uses

- This detailed, step-by-step planning approach grounded in practical realities prepares for a smoother, more effective mine closure aligned with the L.I.V.E.S. Framework's holistic vision.

STEP 2: IDENTIFICATION & IMPLEMENTATION OF INTERVENTIONS IN MINE CLOSURE

In this step, targeted interventions are identified and implemented to ensure effective mine closure, that is, technically sound, ecologically sustainable, socially beneficial, and economically viable. These interventions serve as a practical bridge between planning and long-term post-mining sustainability. The process of identification and implementation of interventions embraces the LIVES.

The term "L.I.V.E.S." here not only signifies the lives affected by mining, but also serves as an acronym representing five foundational pillars of interventions that guide responsible and regenerative closure, namely:

- L – Land and Technical Reclamation: Reclamation of mined-out areas.
- I – Integrated Community Engagement & Empowerment: Ensuring participation, livelihood support, and stakeholder involvement.
- V – Viable Post-Closure Development (Repurposing): Transforming reclaimed land into productive or community-use areas.
- E – Ecosystem Rehabilitation & Regenerative Environmental Restoration: Restoring biodiversity, water bodies, and ecological balance.
- S – Sustainability and Stewardship: Long-term monitoring, maintenance, and responsible management of reclaimed mined-out areas.

Each component of the LIVES framework is explained in detail in later sections of this handbook.

STEP 3: MONITORING

Monitoring plays a crucial role in ensuring compliance, efficiency, and sustainability in various operations. It involves establishing structured mechanisms to track progress, assess performance, and identify areas for improvement. A well-defined monitoring framework, supported by key performance indicators (KPIs) and expert oversight, helps organizations maintain accountability and transparency. Regular reviews, technological integration, and stakeholder collaboration further enhance the effectiveness of monitoring systems. By adopting a systematic approach, organizations can drive continuous improvement, mitigate risks, and achieve long-term sustainability goals. Below are the key steps that can be included for seamless monitoring:

Establish an Institutional Mechanism

- Develop a structured approach to monitoring by setting up a dedicated task force at multiple levels.
- Ensure a hierarchical monitoring framework from Mine → Area → Company
- Strengthen accountability and streamline reporting mechanisms across different organizational levels.

Constitute a Task Group for Monitoring

- Form a specialized team responsible for overseeing monitoring activities at each level.
- Define roles and responsibilities for effective supervision and coordination.
- Encourage interdepartmental collaboration to enhance efficiency and compliance.

Develop Key Performance Indicators (KPIs)

- Establish measurable KPIs to assess sustainability, safety, and operational performance.
- Set benchmarks for evaluating environmental and social impact.
- Use data-driven insights to improve decision-making and ensure continuous progress.

Ensure Relevant Expertise in Monitoring Teams

- Train and equip team members with the necessary technical and managerial skills.
- Foster capacity building through workshops and knowledge-sharing initiatives.
- Encourage periodic evaluations to ensure teams remain updated on best practices.

Implement a Systematic Review Process

- Conduct regular audits and assessments to track progress.
- Implement feedback loops for continuous improvement in monitoring mechanisms.
- Integrate digital tools and technologies for real-time data collection and analysis.

LAND AND TECHNICAL RECLAMATION:

1.1
Understanding the Land and Technical Reclamation

Land reclamation is the first step in rehabilitating landscapes affected by industrial or resource extraction activities. The process involves restoring or stabilizing land to prevent erosion, reduce contaminants, and make it safe for future use. But technical reclamation goes beyond just 'filling in the hole'. It requires a deep understanding of the land's physical, chemical, and biological characteristics, with the goal of restoring the land back to its original condition, to the maximum extent possible, in terms of contour, topography, cropping pattern, biodiversity, and water bodies. Accordingly, reclamation is undertaken through a series of integrated stages, as discussed below, with each complementing the other to ensure long-term ecological balance and sustainable land use:

1. **Technical Reclamation** – engineering and physical restoration of mined-out areas.
2. **Biological Reclamation** – ecological restoration through vegetation and soil rehabilitation.
3. **Hydro Reclamation** - abandoned mine pits/voids filled with water are scientifically reclaimed and converted into productive ecosystems or community resources

Together, these stages ensure the safe, productive, and sustainable post-mining use of land.

1.2
Approach for Ecosystem Rehabilitation & Regenerative Environmental Restoration

Technical reclamation is the first stage of land restoration after mining, focusing on the engineering and physical stabilization of mined-out areas. The objective is to create a landform that is safe, erosion-resistant, and suitable for future ecological restoration or productive use.

The objective is to create a landform that is safe, erosion-resistant, and suitable for future ecological restoration or productive use. This stage is a cornerstone of sustainable mining, as it directly influences environmental safety, ecological stability, and community well-being. When carried out properly, it ensures that disturbed land is returned to a stable, productive, and environmentally sound state, thereby reducing long-term hazards and fostering socio-environmental harmony.

Technical reclamation involves practical measures, such as backfilling mined voids with overburden (OB), Grading and slope stabilization to prevent erosion and landslides, Topsoil preservation and management to support vegetation, drainage systems (garland drains, sedimentation ponds, turfing) to control runoff and soil loss, discussed as follows:

Topsoil Excavation and Preservation

The most critical step is the careful stripping / removal and preservation of topsoil prior to drilling, blasting, or excavation in mining. Topsoil acts as the primary growth medium for vegetation and has a biological shelf life of approximately two to three years. It must be stored separately in regulated dumps not exceeding 3 meters in height, with stable slope

angles (<28°), turfing, and proper drainage arrangements. As per best practice, the preserved topsoil should be utilized at the earliest opportunity for backfilled areas, land leveling, or plantation to maintain its fertility. If necessary proper treatment can be done to maintain its properties.

Key Elements to Consider:

- Stripping / removal of topsoil using dozers, scrapers, or excavators separately before mining (drilling, blasting, or excavation) begins.
- Segregation of top soil from subsoil and overburden
- Preservation of top soil by stockpiling in in regulated dumps (upto 3 m height, slope <28°) with turfing and drainage (bunds, contour drains, coir or jute matting etc) to prevent erosion and maintain anaerobic condition.
- Mulching or covering (with vegetation/straws etc) for preventing top soil from drying.
- Utilizing preserved topsoil promptly (within 2–3 years) (preferably mixing with organic matters over backfilled areas for plantations.ope grading, and vegetation cover.

Minimization of External OB Dumps

In line with the latest MoEF&CC and MoC provisions, creation of external OB dumps is to be avoided to the maximum extent possible. Overburden generated during mining should be directly backfilled into de-coaled voids through internal dumping. This reduces the need for large external waste dumps, minimizes need for extra land, and ensures progressive reclamation alongside mining operations. If external dumps are temporarily unavoidable, they must be scientifically designed, stabilized, and eventually re-handled into internal voids before final closure. In case backfilling is not feasible due to dump height or slope stability issue, then it shall be Technically & Biologically reclaimed in the best possible manner.

Key Elements to Consider:

- Direct dumping of OB into de-coaled voids (internal dumping).
- Restricting external dumps to temporary use only, with eventual re-handling into internal voids.
- Stabilizing any temporary OB dump with terracing, slope grading, and vegetation cover.

Concurrent Backfilling and Grading

Backfilling operations should commence as early as possible, ideally concurrent with ongoing mining activities. Sequential backfilling of de-coaled voids ensures that landforms are restored progressively rather than waiting until the end of mine life. The backfilled material is compacted in layers, and graded to achieve stable slopes, safe angles of repose, and positive drainage. This minimizes risks of erosion, landslides, and waterlogging, while also accelerating land availability for reclamation.

Key Elements to Consider:

- Initiating backfilling as soon as voids are available during mining operations.
- Compacting OB in layers to create stable ground.
- Shaping landforms to safe slope gradients and ensuring positive surface drainage.

Final Landform and Topsoil Application

Once backfilling and grading are completed; the preserved topsoil is re-spread over the stabilized surface. This provides the essential nutrient base for vegetation and prepares the ground for biological reclamation. The final landform should be integrated with the surrounding terrain, avoiding sharp contrasts, and designed with adequate drainage systems such as contour drains, toe drains, and sedimentation ponds. In cases where post-mining voids are retained as water bodies, they must be proportional to pre-mining conditions and equipped with fencing, slope stabilization, and safe access.

Key Elements to Consider:

- Grading the landform to blend with surrounding terrain and reduce erosion risks.
- Constructing proper drainage systems (toe drains, contour drains, sedimentation ponds).
- Re-spreading preserved topsoil over backfilled areas to enable vegetation growth.
- Converting residual voids into safe, proportionate water bodies with fencing, stable batters, and access control.

As per Guidelines dated 31st January 2025, issued by the Ministry of Coal, external overburden (OB) dumps should be minimized by prioritizing internal dumping and concurrent backfilling into de-coaled voids. The focus must be on creating stable landforms, reducing the extent of mine voids, and preserving topsoil to support progressive closure. Topsoil must be stored in regulated dumps and safeguarded against erosion through measures such as turfing, garland drains, and sedimentation ponds, ensuring its availability for effective reclamation.

1.3 Approach for Ecosystem Rehabilitation & Regenerative Environmental Restoration

Biological reclamation, is the process of restoring the ecological and biological functions of mined land by re-establishing vegetation, improving soil fertility, and enhancing biodiversity. It complements technical reclamation by creating a self-sustaining ecosystem on land that has been physically stabilized through engineering measures.

Bio-reclamation ensures that reclaimed land regains its productive and ecological value, contributing to environmental sustainability and community welfare. It improves soil structure, enhances water retention, reduces erosion, supports native flora and fauna, and fosters long-term resilience of post-mining landscapes.

In compliance with MoEF&CC norms, a minimum of 33% of the total leasehold area must be biologically reclaimed. This involves a planned plantation program specifying native species, sapling numbers, and phased greening schedules. The spread of preserved topsoil provides fertile ground for grass, shrubs, and trees, thereby accelerating soil stabilization and biodiversity recovery.

Biological reclamation not only enhances aesthetics but also improves air quality, reduces erosion, and supports livelihoods of surrounding communities.
While technical measures provide stability and restore the physical environment, biological measures bring back ecological balance and long-term productivity. Both processes are integral to achieving the fundamental goal of mine closure ensuring a safe environment, minimizing post-mining hazards, and supporting sustainable community development around mining regions.

Plantation
(Local species and native species)

Key Elements to Consider:

- Selection of Plant Species: Grasses, legumes, hardy shrubs to stabilize soil, native species adapted to local climate and soil conditions, nitrogen-fixing plants to improve soil fertility.
- Planting fast-growing, hardy, and multi-purpose tree species with mixed planation with community participation.
- Microbial inoculation, organic matter addition, moisture management (mulching, contour trenching, rainwater harvesting structures, drip irrigation etc.) and soil/erosion control.
- Reclamation of land using water-based methods → hydroseeding, hydro mulching, rainwater harvesting, irrigation support, wetland creation, and water-driven slope stabilization.
- Succession management through assisting ecological succession, stable vegetation and promoting biodiversity restoration.
- Monitoring & Maintenance for survival of plant and Protection from grazing, fire, and invasive species

1.4
Approaches for Hydro-reclamation:

Hydro-reclamation of abandoned mine or mine voids is a specialized part of mine closure and post-mining land use requiring technical, ecological, and socio-economic dimensions. This involved planning for stabilizing the pit, storage of water in the mine void to minimize the degradation of quality of water stored in the mine void along with improving water quality, take measures to protect the quality of surface water for safe community use (like fisheries, irrigation, biodiversity parks, renewable energy, recreation) and also recharge the ground water.

Key Elements to Consider:

- Assessment of Void Characteristics like Hydrogeology & Hydrology, its Water Quality, Slope Stability () and risk related to safety.
- Water quality management: sediment control, bioremediation, moisture & catchment management, land water interface management, treatment of acid mine drainage (AMD) if any.
- Engineering & Structural Measures : Slope stabilisation viz., benching, terracing pitching etc. of side walls of the water body including grading of steep slopes (pit walls to <30–35°), bioengineering to prevent erosion, Fencing, guard rails, controlled access zones and signage for safety.
- Community use along with socio-economic & ecological integration
- Ecological succession & biodiversity enhancement through stepwise naturalization, wildlife attraction, aquatic biodiversity, habitat connectivity etc.
- Regular monitoring of water parameters (pH, DO, metals, TDS), plankton, nekton, benthos, and microorganisms' survival checks along with adaptive closure planning.

1.5
Monitoring and Adaptive Management

Monitoring and adaptive management are critical to ensure that reclamation measures achieve their intended outcomes. By tracking progress and adjusting strategies when necessary, mine closure can meet both environmental and community objectives effectively.

Key Monitoring Practices

- **Slope Stability Monitoring**: Regular inspection of reclaimed dumps and backfilled areas to detect erosion, settlement, or slope failures.
- **Vegetation Survival Assessment**: Tracking plantation survival rates, canopy cover, and biodiversity progression through field surveys and remote sensing.
- **Water Quality and Hydrology Monitoring**: Testing runoff and water bodies for sediment load, pH, and pollutants to ensure safe post-mining water conditions.
- **Remote Sensing and GIS Tools**: Using satellite imagery and drones for land use/land cover (LULC) change detection and to verify reclamation progress.

Key Adaptive Management Practices

- **Corrective Measures for Erosion**: Installing additional drains, turfing, or bio-engineering methods when erosion is detected.
- **Replantation and Gap Filling**: Replacing dead saplings, diversifying with native species, and enhancing soil fertility to improve vegetation success.
- **Water Body Stabilization**: Reinforcing shorelines, improving slope gradients, and enhancing fencing or signage if safety risks emerge.
- **Community Feedback Integration**: Incorporating local community observations and needs into reclamation improvements to ensure long-term usability.

1.6 Summary: Tips for Practitioners

Successful mine land reclamation requires not only compliance with laws and guidelines but also practical wisdom in execution. The following tips can help practitioners ensure effective technical and biological reclamation outcomes.

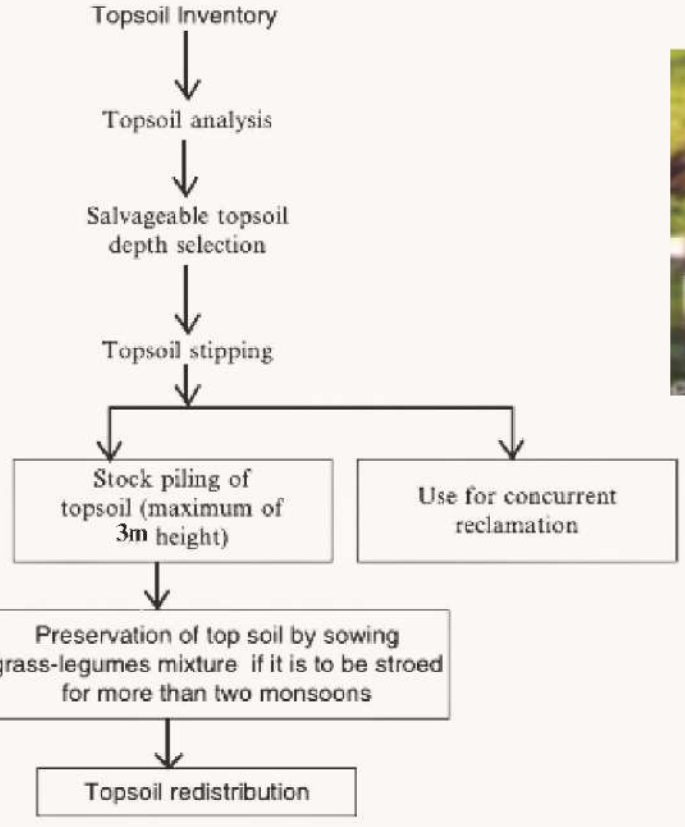
A. Planning & Integration

- Design reclamation as part of the Mining Plan / Mine Closure Plan (MCP), not as a post-mining activity.
- Sequence mining and backfilling so that progressive reclamation begins from the initial years of operation.
- Prepare material balance (OB generation vs. backfilling capacity) to avoid excessive external dumping.
- Ensure that reclamation planning reflects the pre-land use pattern, so that the post-mining land use matches the original as far as possible (e.g., agricultural land restored for farming, forest land rehabilitated with native plantation).
- Follow applicable laws, rules, and regulations to strictly minimize external OB dumps (MoEF&CC provisions).
- Prefer internal dumping and concurrent backfilling into de-coaled voids for progressive reclamation.

- Where external dumps are unavoidable, keep them temporary, stabilize with vegetation, and re-handle OB later.
- Take up reclamation progressively during the life of the mine to avoid large-scale backlog at closure stage.
- Planned land use and community safety measures to ensure sustainable post-mining benefits.

B. Topsoil Management

- Strip and store topsoil separately before excavation, as per Environment Clearance (EC) and MCP conditions.
- Store topsoil at earmarked places and protect it with turfing, grass bedding, or leguminous vegetation to check erosion and preserve fertility.
- Restrict the height of topsoil dumps to not more than 3 metres to prevent compaction.
- Early preservation and prompt reutilization of topsoil (within 2–3 years) to maintain biological fertility and biological potential.
- Apply topsoil evenly on backfilled and graded land before initiating plantation.
- Prepare a Topsoil Management Plan under the MCP, maintaining inventory and utilization records.
- Monitor soil parameters (pH, organic carbon, NPK, etc.) and apply corrective measures if fertility decline is noticed.
- Keep protective buffer strips around topsoil dumps to prevent silt run-off into natural water courses.
- Use stored topsoil exclusively for biological reclamation and plantation as per EC.



C. Overburden (OB) Dump & Void Management

- Maintain dump heights and slope angles as per EC and DGMS guidelines.
- Scientific grading and slope stabilization to ensure geotechnical safety.
- Develop terraces/benches on external OB dumps to check erosion and ensure slope stability.
- Provide integrated drainage and erosion control measures (garland drains, contour drains, settling ponds, toe walls) to prevent land degradation and control runoff.
- Compact and grade reclaimed surfaces to reduce surface disturbance, improve stability, and avoid subsidence.
- Secure water-filled voids with fencing; where practicable, convert them into safe reservoirs for fisheries, irrigation, or other community uses, after confirming water quality.
- Ensure that the final landform merges with the surrounding natural topography to minimize long-term erosion.
- Carry out stability assessments of dumps and highwalls periodically, especially during monsoons, as per DGMS/MCP guidelines.
- Level, grade, and landscape areas where OB dumps or structures are removed to avoid waterlogging.

D. Biological Reclamation

- Spread topsoil uniformly on technically reclaimed land before plantation.
- Enrich soil with compost, manure, and bio-fertilizers to restore fertility and microbial activity.
- Undertake plantation with a suitable mix of native grasses, legumes, shrubs, and trees to enhance biodiversity and ecological resilience.
- Begin with grasses and legumes for quick stabilization, then expand to shrubs and trees.
- Ensure at least 33% of the lease area or surface right area (In case of UG Mine) is brought under green cover at closure, as per MoEF&CC norms.
- Develop green belts along mine boundaries and on dumps to act as dust barriers.
- Encourage eco-restoration of degraded patches through assisted natural regeneration wherever feasible.
- Promote agroforestry, grazing plots, medicinal plants, fruit-bearing plants, minor forest produce (MFP) and non-timber forest produce (NTFP) species, and community plantations in consultation with local stakeholders.
- Maintain plantations for at least five years (or until self-sustaining) with watering, gap filling, and protection measures.
- Monitor plantation survival and growth every year to evaluate reclamation success.

E. Hydro Reclamation (Water Body Reclamation)

- Select voids for water body development only after confirming long-term slope stability and geotechnical safety.
- Assess water quality (pH, heavy metals, TDS, sulphates, hardness) before designating voids as reservoirs.
- Treat acidic or polluted water through liming, aeration, or biological treatment before use.
- Provide safe access, fencing, and signage around water bodies to prevent accidents.
- Develop designated zones for fisheries, irrigation, recreation, or groundwater recharge, in consultation with stakeholders.
- Ensure water depth and shoreline stability are suitable for intended end use (e.g., gentle slopes for irrigation/fisheries).
- Construct peripheral drains and silt traps to prevent contamination from runoff.
- Maintain ecological value by promoting aquatic vegetation and creating habitat for birds and aquatic fauna.
- Carry out periodic monitoring of water quality and stability during post-closure phase.
- Encourage community-based management of water bodies to ensure long-term sustainability and economic benefits.
- Integrate hydro reclamation as a livelihood and revenue opportunity (fisheries, eco-tourism, irrigation support).

F. Safety & Post-Mining Measures

- Remove mine infrastructure (buildings, conveyors, CHP, workshops, substations) unless repurposed for community use.
- Secure underground openings (ventilation shafts, inclines, adits) by sealing/filling.
- Fence reclaimed voids/water bodies to prevent accidents.
- Install warning signs and boundary markers at reclaimed voids, water bodies, and highwalls.
- Follow DGMS guidelines for final slope stability & dump removal.
- Carry out safety audits of reclaimed sites before handing over for community use.
- Hand over repurposed infrastructure (schools, health centers, community halls) to local authorities or community groups.
- Dismantle and safely dispose of hazardous materials (oils, fuels, chemicals) as per Hazardous Waste Rules.

G. Monitoring, Reporting & Community Participation

- Use remote sensing, drones, and field surveys to monitor land use change, vegetation survival, and slope stability.

- Adjust reclamation measures based on site-specific feedback (e.g., replantation where mortality is high, additional drains where erosion persists).
- Continue post-closure monitoring for 3–5 years as per MCP requirements.
- Consult local communities in repurposing reclaimed land (agriculture, forestry, grazing, fisheries, or water reservoirs).
- Use mine closure funds for alternative livelihoods like agroforestry, skill training, and fishery development.
- Maintain transparency in reporting reclamation progress to regulatory bodies and stakeholders.

H. Legal & Regulatory Compliance

- Prepare & follow Progressive Mine Closure Plan (PMCP) and Final Mine Closure Plan (FMCP) as per Mine Closure Guidelines.
- Comply with:
  - **MMDR Act, 1957** – scientific mining & closure obligations.
  - **Mines Act, 1952 & DGMS guidelines** – scientific mining & safety in coal mining and reclamation.
  - **Environment (Protection) Act, 1986 & EIA Notification, 2006** – reclamation as per EC conditions.
  - **Forest (Conservation) Act, 1980** – compensatory afforestation for diverted forest land.
  - **Water (Prevention & Control of Pollution) Act, 1974** – pollution control during operation, closure, and post-closure.
  - **Air (Prevention & Control of Pollution) Act, 1981** – pollution control during operation, closure, and post-closure.
  - **Coal Bearing Areas (Acquisition & Development) Act, 1957** – policy guidelines for land acquired, land use change and repurposing.
  - Work strictly as per **approved mining plan and mine closure pla**n in line with **applicable guidelines**.

DO's	DON'Ts
Do remove mine infrastructure (buildings, conveyors, CHP, workshops, substations) unless repurposed.	Do not abandon mines without implementing an approved Mine Closure Plan.
Do secure underground openings (ventilation shafts, inclines, adits) by sealing/filling.	Do not leave topsoil unprotected or unused and it must not be mixed with overburden.
Do fence reclaimed voids/water bodies to prevent accidents.	Do not exceed dump heights & slope angles as per Environment Clearance (EC) and DGMS guidelines to avoid risk of failure/landslides.
Do follow DGMS guidelines & other related laws for final slope stability & dump removal.	Do not leave steep highwalls or open voids without backfilling or fencing.
Do dismantle and dispose of hazardous materials (oils, fuels, chemicals) safely as per Hazardous Waste Rules.	Do not leave abandoned mine structures, remove or rehabilitate them.
Do level, grade, and landscape areas where structures are removed to avoid waterlogging.	Do not discharge untreated mine water into natural streams.
Do hand over repurposed infrastructure (schools, health centers, community halls) to local authorities or community groups, as per applicable laws and guidelines.	Do not use exotic monoculture in reclamation to avoid reduction in biodiversity & water table.
Do maintain records of dismantling, sealing, and fencing works for compliance reporting.	Do not neglect progressive reclamation activities as end-of-life reclamation alone is risky and costly.
Do install warning signs and boundary markers at reclaimed voids, water bodies, and highwalls.	Do not leave reclaimed areas without maintenance, vegetation must be protected for 3–5 years as per Mine Closure Plan.

Field Checklist

This field checklist is designed to guide practitioners on the ground, ensuring that every step of mine closure and reclamation is carried out safely, scientifically, and in alignment with regulatory requirements and community expectations.

1. Planning & Integration

- Reclamation designed as part of Mining Plan / Mine Closure Plan (MCP).
- Progressive reclamation initiated from early years of mining.
- Material balance prepared (OB generation vs. backfilling capacity).
- Post-mining land use aligned with pre-mining land use (agriculture, forest, etc.).
- Internal backfilling advancing as per plan; no new external dumps.
- Temporary external dumps stabilized with vegetation & later re-handled.
- Reclamation taken up progressively during mine life, not left for closure stage.

2. Topsoil Management

- Topsoil stripped and stored separately at earmarked sites (EC/MCP compliance).
- Topsoil dump height <=3 m to prevent compaction.
- Topsoil protected with grass/legumes to prevent erosion.
- Stored topsoil used within 2–3 years to preserve fertility.
- Topsoil re-spread and amended before plantation.
- Slopes protected with turfing or mulching.
- Topsoil Management Plan prepared with inventory & utilization records.
- Soil fertility (pH, NPK, organic C) monitored and corrected.
- Buffer strips maintained around topsoil dumps to check silt run-off.

3. Overburden (OB) Dump & Void Management

- Dump height & slope within EC/DGMS limits (<28° overall slope).
- Dumps provided with terraces/benches to check erosion.
- Grading complete with positive drainage.
- Drainage systems installed (garland drains, contour drains, toe walls, settling ponds).
- Drains functional and desilted regularly.
- Erosion controls in place; no active gullies.
- Reclaimed surfaces compacted & graded to avoid subsidence.
- Residual voids minimized.
- Water-filled voids fenced and provided with safe access & signage.
- Water quality tested before using voids as reservoirs (fishery, irrigation, community use).
- Final landform designed to merge with surrounding topography.
- Stability assessment of dumps & highwalls done periodically (esp. monsoons).

4. Biological Reclamation

- Topsoil applied uniformly over reclaimed surfaces.
- Soil enriched with compost/manure/bio-fertilizers.
- Native species planted (mix of grasses, legumes, shrubs, trees).
- Grasses/legumes introduced first, followed by shrubs & trees.
- At least 33% lease area/ surface right area brought under green cover (MoEF&CC norm).
- Green belts developed along mine boundary & dumps (dust barrier).

- Eco-restoration promoted through assisted natural regeneration.
- Agroforestry, grazing plots, medicinal plants, community plantations promoted.
- Plantation done in current window; survival > target; replacements scheduled.
- Plantations maintained for minimum 3–5 years (watering, gap filling, protection).
- Plantation survival & growth monitored annually.

5. Safety & Post-Mining Measures

- Mine infrastructure removed unless repurposed for community use.
- Underground openings sealed/filled (shafts, adits, inclines).
- Reclaimed voids & water bodies fenced and signposted.
- Warning signs/boundary markers installed at dumps & unstable zones.
- Final slope stability ensured (DGMS guidelines).
- Safety audit conducted before handover for community use.
- Repurposed buildings (schools, health centers, halls) handed to local authorities.
- Hazardous materials (fuels, oils, chemicals) disposed as per rules.

6. Monitoring, Reporting & Community Participation

- Remote sensing/drones/field surveys used to track reclamation progress.
- Monitoring data current for slope stability, water quality & vegetation survival.
- Corrective measures taken for high plant mortality or erosion.
- Post-closure monitoring continued for 3–5 years.
- Local communities consulted for repurposed land use (agriculture, forestry, fisheries, etc.).
- Mine closure funds utilized for livelihood activities (agroforestry, skill training, fisheries).
- Reclamation progress transparently reported to regulators & stakeholders.
- Progressive & Final Mine Closure Plans (PMCP/FMCP) prepared, approved & implemented.

1.7 Conclusion:

Scientific mine closure and reclamation are not end-of-mine formalities, but an integral part of sustainable mining. By planning reclamation concurrently with operations through proper topsoil management, controlled overburden handling, progressive backfilling, biological restoration, and hydro reclamation, mines can be transformed into safe, productive, and environmentally resilient landscapes.

Remember – Effective reclamation is about doing the basics right, consistently, and at the right time.

INTEGRATED COMMUNITY ENGAGEMENT AND DEVELOPMENT

2.1
Understanding the Community Engagement and Development

Land reclamation isn't just about the land. It's about the people who live on it, work with it, and rely on it. For mine closure to be truly sustainable, you need to engage the community at every step. Why? Because successful reclamation is not just fixing the environment; it's about building long-term relationships that empower communities to take control of their future.

Community development means investing in the long-term well-being of the people, through livelihoods, education, healthcare, infrastructure, and self-governance. It's about understanding what the community needs now, what they aspire to, and helping build the foundations for those futures.

Let's make it clear: No community, no success. From the moment you step into the mine closure, think of the local population as your key collaborators, not just beneficiaries. Engaging with them transforms your project from a top-down intervention to a shared journey that benefits everyone involved.

2.2
Core Principles of Integrated Community Engagement and Development

1. Start Early: Don't Wait for the Land to Heal First: Engagement must start before any shovel hits the ground. Begin with building trust and understanding. This early phase is all about listening, not just telling people what you're going to do. Community engagement starts by asking: "What do you need?" and "How can we work together to create something better?"

2. Speak the Language of Local Communities: Incorporating local knowledge is crucial. Communities may have deep historical knowledge about the land; knowledge that's irreplaceable and can guide reclamation decisions. This could include traditional agricultural practices, water management systems, and even local plants and animals that thrive in the area. Respecting and valuing this knowledge is key to creating trust.

3. Build Real, Hands-On Skills Through Capacity Building, Skill Development and Vocational Training Programs: Sustainable mine closure isn't just about fixing the land; it's about giving local people the knowledge, resources and skills they need to thrive in a post-mining economy. It's about creating long-term, sustainable livelihoods that don't rely on the mine but are instead built on new opportunities, like horticulture, agriculture, tourism, pisciculture or renewable energy. It involves fostering community resilience and ensuring that the workforce has access to education and skill development for the future. Investing in capacity-building programs, training local people to be environmental stewards is a win-win for both the project and the community. Education doesn't just mean formal training; it's about making people aware of the value of their natural resources and teaching them how to make decisions that support sustainability.




4. Co-Design Solutions: Bring the Community to the Table

Reclamation is not a one-size-fits-all solution. Every land has a unique set of challenges, and so does every community. This is where co-design comes in. It's not enough to ask for feedback; it's about creating the repurposing plan together with the community.

Co-designing means local people aren't just consulted; they're decision-makers. When they have a voice in shaping the project, it enhances the chances of long-term success. Plus, it leads to solutions that are rooted in local needs and values.

5. Inclusivity: Engaging All Voices

When engaging communities, it's crucial to ensure that everyone, especially marginalized groups, has a voice. This includes women, youth, indigenous communities, and other underrepresented groups. True engagement means considering the diverse perspectives and needs within a community.

6. Building Trust Through Transparency and Accountability

Engagement is not just about listening to the community but also being open and transparent about the goals, challenges, and progress of the project. When people understand the why and how of a project, they are more likely to feel empowered and trust the process.

Tip for Practitioners:

- Always conduct baseline community surveys to understand local pain points, needs, perspectives, priorities and aspirations. These conversations should be happening from Day 1. Use open-ended questions and avoid making assumptions about what the community values most.

- Collaborate with local knowledge holders. Engage with elders, local farmers, and community leaders. They may have solutions to problems that you wouldn't even think to ask about. Their input will make the mine closure more culturally relevant and environmentally effective.
- Host community workshops and planning sessions early in the project. Get input on things like plant selection, water management, and long-term land use. Design with, not for the community.
- Focus on practical training that meets the immediate needs of the community. Workshops, demonstration farms, and peer-to-peer education are great ways to teach community members how to implement sustainable practices.
- Make sure your community engagement strategy includes a focus on underrepresented groups. Organize focus groups, hold consultation meetings, and create safe spaces where everyone feels comfortable sharing their ideas and concerns.
- Use tools like regular community updates, public consultations, and visual progress reports to keep everyone informed. Transparency creates accountability, which fosters trust and long-term cooperation.

2.3
Step-by Step Practical Approach

Successful mine closure is not just about shutting down operations; it's about building sustainable futures for communities. Based on field experiences, the following priority areas have emerged as effective and practical interventions:

1. Identification of Projects to Co-Envision and Co-Create Sustainable Solutions

- Identify projects that reflect community aspirations and local context.
- Conduct visioning workshops where communities articulate their desired post-mining future.
- Involve local governance (e.g. Panchayats), women's groups, and youth clubs in co-design sessions.
- Prioritize projects with long-term relevance like water harvesting, public spaces, community halls, or agro-processing units.

2. Develop Alternative Livelihoods

- Promote context-specific livelihoods such as:
  - Agriculture and allied activities (e.g. vermicomposting, floriculture)
  - Food processing (e.g. papad-making, pickles)
  - Traditional crafts and handicrafts
- Ensure that new livelihoods are market-linked and build on existing skills and preferences.

- Integrate these activities with ongoing government.

3. Capacity Building, Skill Development, and Vocational Training

- Collaborate with SHGs, NGOs, government skilling missions and other related organization to:
  - Train, local communities, youth and women in entrepreneurial skills & trades relevant to regional economies.
  - Include modules on entrepreneurship, financial literacy, and digital tools.
- Prioritize skills with both local application and migration-readiness, allowing flexibility in livelihood pathways.

4. Promote Sustainable Practices

- Shift maintenance responsibilities of community assets (parks, water tanks, streetlights) to trained local groups.
- Encourage Operation & Maintenance outsourcing models where community-based organizations manage public infrastructure.
- Foster a culture of community stewardship through awareness drives and hands-on involvement.

5. Support Community-Driven Initiatives

- Set aside flexible funds or grants to support innovative local proposals.
- Facilitate platforms where communities pitch their ideas (e.g. micro-entrepreneurship, social enterprises).
- Create mentorship linkages with nearby CSR teams, cooperatives, and local entrepreneurs.
- Track progress jointly with communities using visual progress charts and monthly review circles.

These five action areas, that is, co-creation, livelihood development, skilling, sustainability, and community ownership, are most impactful when treated not as standalone interventions, but as an integrated community engagement and development approach. Practitioners are encouraged to adapt and layer them based on the unique needs of each site.

Tips for Practitioners:

In many mining-affected villages, women's groups led the revival of traditional papad-making and turned it into a viable home-based business. This worked not because it was new, but because it was locally rooted, familiar, and needed little capital. The key was linking it to a buyer.

2.4
Approaches for Community Engagement and Development

1. Start with Information: Notify Communities, SHGs, and NGOs About Mine Closure

Timely and transparent communication is the first step toward trust. Many mine closures fail to gain community support because people feel blindsided or excluded. Sharing closure timelines and intentions early allows communities, Self-Help Groups (SHGs), and local NGOs to mentally prepare, organize, and engage meaningfully.

2. Participatory Planning: A Shared Vision for the Future

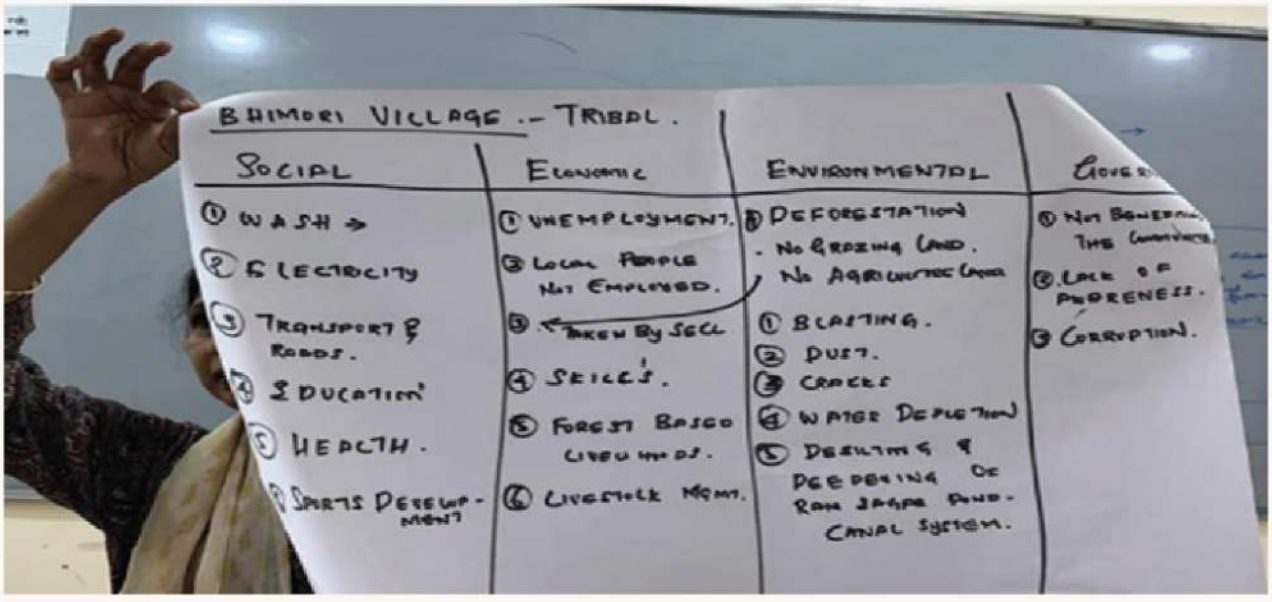
Participatory planning ensures that community members are not just consulted but are active co-creators of the planning process. This approach involves gathering input from all sectors of the community, analyzing shared goals, and working together to design solutions that fit local needs.

3. Participatory Mapping: Visualize the Past, Present, and Future

Use participatory mapping as a tool for engagement. It's a powerful way for communities to visualize the land's transformation and offer insights based on historical context and local needs. People can mark places that are culturally significant, identify areas prone to flooding, or suggest places for sustainable agricultural activities.

4. Livelihood and Community Development Integration: Linking Community Needs with Closure Goals

Sustainable mine closure projects are most successful when they prioritize and support the economic needs of the local community. Linking environmental goals with livelihood improvement is crucial for long-term success. When people see tangible benefits, such as increased income, job opportunities, or access to new markets they are more likely to invest in the project.



5. Conflict Resolution: Navigating Differences for Collective Action

In any community, there are likely to be conflicting interests; whether between landowners, farmers, government bodies, or indigenous groups. Conflict is natural, but conflict resolution strategies can help mediate differences and bring people together to focus on common goals.

6. Regular Feedback Loops: Keep the Conversation Going

Engagement is not a one-off event. It's an ongoing conversation. Establish feedback loops where the community can share progress concerns, challenges, and ideas throughout the process. regularly. This can be through community surveys, informal interviews, or ongoing consultation meetings. By staying in touch with community members and being responsive to their needs, you can make adjustments to your engagement strategy in real-time.

7. Empower Through Technology: Use Digital Tools to Keep the Community Informed

Technology can be an amazing tool for keeping people engaged, especially in remote areas. Consider creating community apps or using social media to share project updates, answer questions, and get immediate feedback.

8. Collaborations with communities/ NGOS/ SHGs for Implementation

Strong collaboration with community-based organizations, SHGs, and local NGOs can significantly improve the relevance and success of mine closure initiatives. These local actors understand the cultural, social, and economic landscape better than anyone, and they're trusted voices in the community.

9. Co-Creating pool of Ideas for Sustainable development

Communities are rich in ideas, but they're often untapped. Creating a space where everyone contributes to a shared pool of ideas ensures that development solutions are relevant, inclusive, and rooted in real needs. This collective brainstorming also builds community pride and ownership.




10. Outcomes Assessment with the Communities

Evaluation is most effective when it's done with the people, not just for the people. Communities bring context to outcomes that data alone can't reveal. When they're involved in assessing impact, they are more likely to trust the process and hold themselves accountable for sustaining progress.

Tip for Practitioners:

- Organize formal and informal information sessions to notify communities, SHGs, and NGOs about the upcoming closure. Use local language, visual aids, and multiple formats (e.g. wall posters, village meetings, WhatsApp messages). Ensure that the message reaches everyone, not just leaders. Make space for questions, emotions, and initial feedback, it builds the foundation for collaborative planning ahead.
- Involve community members early in the process, whether through community meetings, surveys, or focus groups. Use participatory tools like mapping exercises, visioning workshops, and local knowledge assessments to create a collective vision for the project.
- Hold mapping sessions where community members can draw, mark, and discuss the land's history and its future. These maps become tools for decision-making and planning.
- Identify ways to integrate livelihood development into your environmental projects. Explore opportunities in eco-tourism, sustainable agriculture, natural resource management, and green jobs that directly benefit the local community.
- Develop a simple mobile app or social media platform where people can easily check on project updates, track land progress, and share their input in real-time. It's an easy, low-cost way to keep everyone involved and informed.
- Identify active local NGOs and community groups early in the process. Bring them in as co-implementers, not just outreach partners. Share responsibilities for planning, execution, and monitoring. This enhances ownership and ensures that solutions are locally adapted, sustainable, and more resilient in the long run.
- Host community idea-sharing sessions, suggestion drives, or "visioning days" where locals share what they want to see post-mining; whether it's eco-tourism, agroforestry, or small businesses. Use open walls, flipcharts, or even drawings to collect ideas from all age groups and social segments. Then cluster these ideas and co-prioritize them with the community to form the basis of your development plans.
- Set up regular community check-ins, either in-person or online, depending on access. Use these sessions to share progress, gather feedback, and make adjustments
- Use facilitators trained in conflict mediation and negotiation techniques to navigate difficult conversations. Creating safe spaces for dialogue and focusing on shared goals can help build trust and resolve disputes effectively.

- Use simple, visual tools like community scorecards, mapping exercises, and feedback circles to jointly review progress. Ask: Is this working for you? What's missing? What needs to change? Make sure the process captures both quantitative results and lived experiences. This builds trust, transparency, and shared responsibility.

2.5
Framework for Community Engagement and Development

- Use simple, visual tools like community scorecards, mapping exercises, and feedback circles to jointly review progress. Ask: Is this working for you? What's missing? What needs to change? Make sure the process captures both quantitative results and lived experiences. This builds trust, transparency, and shared responsibility.

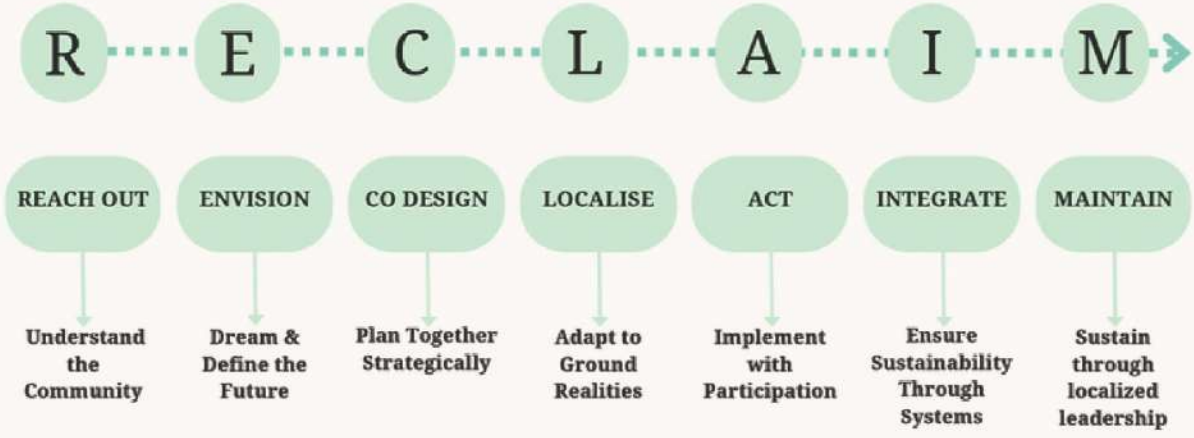
The Coal Controller Organisation, under the Ministry of Coal, in partnership with the Heartfulness Institute, has developed a comprehensive Community Engagement and Development Framework designed specifically for mine closures. Recognizing that mine closures significantly impact both landscapes and local livelihoods, this framework was launched on 04th July, 2025 by the Ministry of Coal, as a key step toward ensuring a just and sustainable transition for communities that have developed alongside mining operations over decades. The framework, referred to as the RECLAIM, serves as a structured guide for inclusive community engagement and development throughout the mine closure and post-closure phases. Standing for Reach Out, Envision, Co-design, Localise, Act, Integrate, and Maintain, RECLAIM provides a clear pathway for engaging communities and aligning development with ground realities. Communities and institutions co-design closure and development plans that reflect local needs and capabilities, which are then localised to ground realities, ensuring cultural, ecological, and economic relevance.

It offers a practical, step-by-step approach to institutionalizing community participation in the transition process. The framework is supported by a suite of actionable tools, templates, and field-tested methodologies tailored to the Indian context. Special emphasis is placed on gender inclusivity, the representation of vulnerable groups, and alignment with Panchayati Raj Institutions, ensuring that the transition is equitable and locally relevant.

You can use **RECLAIM** to:

- Engage communities early and build trust through dialogue.
- Co-create closure and post-closure plans that reflect local aspirations and needs.
- Ensure inclusivity, with a focus on women, vulnerable groups, and local governance structures like Panchayati Raj Institutions.

- Localise plans to suit the specific ecological and economic context of the area.
- Implement and monitor actions with community participation for long-term resilience.



RECLAIM emphasizes that sustainable mine closure isn't just a technical process; it's a social one. By centering people in the transition, the framework helps practitioners create outcomes that are not only environmentally sound but also economically viable and socially just.

2.6
Framework for Community Engagement and Development

It's essential to measure how well the community is integrated into the reclamation process and whether the project has genuinely empowered them. Here are some ways to assess success:

- **Increased Local Employment:** Are community members gaining new skills or jobs?
- **Active Participation:** Are locals attending meetings, providing feedback, and leading initiatives?
- **Ownership of the Project:** Are the local communities taking on roles in the management and maintenance of the restored land?
- **Improved Livelihoods:** Are local people seeing economic benefits from the reclamation efforts?

2.7
Summary: Tips for Practitioners

- Engage communities early; don't wait for the closure phase to begin.
- Maintain a regular presence in the community to build trust over time.
- Communicate in local languages using culturally familiar terms and visuals.
- Identify and engage all stakeholder groups, including women, youth, informal workers, and vulnerable groups.
- Collaborate with Panchayati Raj Institutions and local governance bodies from the start.
- Facilitate co-creation of closure and development plans instead of imposing external solutions.
- Focus on livelihood systems, not just individual job replacements.
- Design targeted programs for youth engagement, skills training, and entrepreneurship.
- Create two-way feedback mechanisms to adapt plans based on community input.
- Use disaggregated data to ensure inclusion of marginalized groups.
- Use visual tools (e.g., community maps, timelines) to show progress and build shared ownership.
- Document and incorporate local knowledge related to land, resources, and livelihoods.
- Expect and respect resistance; Use dialogue, not persuasion, to address concerns.
- Link with existing government schemes and development programs to ensure long-term support.
- Build local leadership and institutional capacity to sustain development after project closure.

Do's	Don'ts
Approach community engagement as a long-term relationship	Don't treat it as a one-time project deliverable
Be transparent about what can and cannot be done	Don't raise unrealistic expectations
Spend time understanding local dynamics before designing	Don't assume one model fits all contexts
Allow space for community members to lead discussions and decisions	Don't dominate meetings or push expert-driven agendas
Coordinate with other departments and agencies working in the region	Don't work in isolation or duplicate existing efforts
Adapt your approach based on real-time feedback and changing	Don't rigidly follow a pre-set plan if ground realities shift
Keep records of all interactions and decisions made with the community	Don't rely on memory or informal tracking alone
Involve frontline field workers and local facilitators in decision-making	Don't leave field teams out of strategic discussions
Make space for informal interactions (tea, home visits, festivals)	Don't limit engagement to formal, structured meetings
Regularly update the community on progress, delays, or changes	Don't go silent once plans are approved
Encourage local innovations and solutions from the community itself	Don't undervalue community ideas or dismiss non-technical suggestions
Include exit and handover strategies in your planning from the start	Don't assume sustainability will happen automatically after closure
Practice active listening without interruption or judgment	Don't rush conversations or dismiss differing views
Recognize and address social power imbalances in meetings	Don't assume all voices in the room carry equal weight
Stay patient and flexible; it's a process, not a checklist	Don't expect quick fixes or linear progress

2.8
Field Checklist: Integrated Community Engagement & Development

A. Before Engagement Begins

- Conduct baseline mapping of communities, stakeholders, and livelihoods
- Identify key local institutions (Panchayati Raj Institutions, Self-Help Groups, youth clubs, Community-based Organizations)
- Understand local power dynamics and social hierarchies
- Review relevant government schemes and development programs in the area
- Establish contact with local leaders and gatekeepers
- Recruit and brief local facilitators or field teams

B. During Community Engagement

- Use local language and culturally appropriate communication
- Ensure participation from women, youth, and vulnerable groups
- Hold meetings at times and locations convenient to the community
- Use visual tools (maps, charts, drawings) to explain concepts
- Allow time for open discussion and community-led input
- Record community concerns, suggestions, and expectations clearly
- Set clear expectations about what can and cannot be promised
- Provide mechanisms for feedback and grievance redressal

C. During Planning and Co-Design

- Facilitate inclusive co-design workshops with diverse community representation
- Align proposed activities with community priorities and local knowledge
- Incorporate traditional livelihoods, skills, and environmental practices
- Cross-check that plans align with Panchayati Raj Institutions and government schemes
- Assess risks and feasibility of each proposed intervention with community input
- Finalize plans with community sign-off or endorsement

D. During Implementation

- Keep community updated on progress and timelines
- Ensure local labour and services are engaged wherever possible
- Monitor inclusion: check participation data by gender, caste, and age
- Facilitate ongoing training and capacity-building for local institutions
- Document outcomes, lessons, and challenges in real time
- Regularly revisit and revise plans based on community feedback

E. Post-Closure / Exit Planning

- Develop a clear exit strategy with roles handed over to local institutions
- Support formation or strengthening of local monitoring committees
- Ensure long-term livelihood support systems are in place
- Link ongoing development to government programs and funding streams
- Plan follow-up visits or light-touch monitoring after exit
- Share learnings with the community and across other project areas

2.9
Conclusion: The Heartbeat of Mine Closure

Community engagement and development isn't just a step in the process; it's the heartbeat of a successful mine closure. The closer the collaboration between the technical teams and the local people, the more likely it is that the land and its people will thrive. By making the community an active partner in every step, from planning and design to execution and monitoring, you ensure that the benefits of reclamation are felt long after the project concludes.

Remember: Mine Closure is about people, not just landscapes.

VIABLE POST-CLOSURE DEVELOPMENT (REPURPOSING)

3.1
Understanding the Viable Post-Closure Development

Viable Post-closure development is about repurposing not only the land but also the associated assets, infrastructure, and resources in ways that benefit both the community and the environment. Repurposing is the process of transforming a mine site for sustainable post-mining uses that benefit the environment, economy, and community. This includes transforming the land for new uses (such as agriculture, tourism, or green energy) as well as reusing existing infrastructure (roads, buildings, utilities) and other assets (e.g., water bodies, reclaimed lands) for sustainable purposes. The key here is to avoid leaving behind a barren, unusable landscape, infrastructure, and associated assets. Instead, transform it into something that provides lasting value.

The challenge is creating a sustainable future for the land and the local community by finding innovative ways to repurpose it. It's not just about mitigating environmental impacts; it's about creating new opportunities for people, for ecosystems, and for local economies. A critical part of this process involves shifting from a mono-economy, often dependent solely on mining or industrial activities, to a multi-dimensional economy that includes diverse sectors such as agriculture, renewable energy, tourism, and small-scale industries.

3.2
Pillars of Post-Closure Repurposing

Viable Post-Closure Development (Repurposing) goes beyond land restoration, focusing on creating new infrastructure based on community needs, and reusing old mine infrastructure for public purposes. Repurposing also emphasizes re-skilling of local communities to enable a shift from a mono-economy dependent on mining to a diversified, multi-dimensional economy.

The key pillars of repurposing include:

- **Land Transformation:** Focuses on converting degraded and mined-out land into safe, stable, and productive landscapes. This includes restoring land for agriculture, forestry, renewable energy projects (like solar parks), industrial use, or community spaces such as parks and sports grounds. The goal is to bring long-term value to the land, making it usable for future generations;
- **Environmental Rehabilitation:** Aims to restore the natural ecosystem that was impacted during mining operations. This involves soil stabilization, afforestation, treatment of polluted water bodies, and the recovery of flora and fauna. It ensures ecological balance, prevents hazards like erosion, and contributes to carbon sequestration and climate resilience in the region;
- **Economic Diversification:** Helps communities shift from a mono-economy dependent solely on mining to a more balanced, multi-dimensional economy. This includes promoting small-scale industries, agro-based enterprises, tourism, skill development, and start-ups. By introducing new sources of income, it helps create job opportunities, strengthens the local economy, and promote livelihoods; and
- **Community Development:** It is community-centric approach, which include participatory planning with local stakeholders, and reusing mining infrastructure for community benefit (e.g., turning buildings into training centers or clinics). Empowering communities ensures social stability, enhances quality of life, and builds resilience against economic disruption.

3.3
Core Strategies for Effective Post-Closure Repurposing

1. Understanding the Community's Needs First

Before deciding what to repurpose the land for, it's essential to understand the community's needs, values, and aspirations. This is where community engagement intersects with post-closure development. Repurposing should focus on meeting local needs and not just creating new land uses that benefit a few stakeholders.

2. Embrace Multi-Use Repurposing

Rather than thinking about one-use solutions, consider creating multi-functional spaces. These spaces can serve a range of purposes: agriculture, recreation, housing, and even renewable energy production. By thinking broadly, you ensure that the land continues to generate benefits over time.

3. Evaluate Environmental Considerations Early

Repurposing doesn't just mean transforming the land into a different human-centric space; it's also about ensuring the land is ecologically healthy and resilient. Assess the soil quality, water availability, biodiversity, and pollution levels before moving

forward with any repurposing plan. Environmental assessments will help inform how you can transition the land into new uses without causing more harm.

4. Prioritize Sustainable Economic Opportunities
Post-closure development should be about creating sustainable livelihoods. Whether it's through green energy production, eco-tourism, or agricultural initiatives, you want to ensure that the land repurposing creates long-term jobs and opportunities for the community. Repurposing can be a way to drive economic growth while also promoting sustainability.

5. Transition from mono-economy to multi-dimensional economy
The overarching goal of repurposing is to transition from a mono-economy, where the community depends on a single industry, that is, mining, to a multi-dimensional economy that draws on multiple sectors. This diversification not only builds economic resilience but also opens up broader opportunities for inclusive growth, innovation, and long-term sustainability.

3.4
Practical Steps for Viable Post-Closure Development

1. Develop a Repurposing Plan/ Just Transformation Plan
Creating a Repurposing Plan/ Just Transformation Plan for the site is a critical first step. This plan should include clear timelines, budgets, and phased development to ensure that each aspect of the repurposing process happens in a structured way. Be sure to integrate environmental restoration techniques into the master plan as well.

2. Phased Implementation: Small Wins Lead to Big Wins
Start with small, tangible projects that can bring immediate benefits. Whether it's a community garden or a small-scale renewable energy installation, these initiatives can build momentum and demonstrate that repurposing the land will create tangible, real-world results. As these projects progress, you can then expand into larger projects like greenhouses, solar farms, or recreational spaces.

3. Consider Long-Term Monitoring and Management
Post-closure development doesn't end when the land is repurposed. You need a long-term management plan to ensure that the repurposed land continues to meet its environmental and economic goals. Establish regular monitoring of soil health, water quality, biodiversity, and community impacts.

3.5
Measuring Success in Post-Closure Repurposing

Here are some key indicators to measure how well your post-closure repurposing is doing:

- **Ecological Restoration:** Is the land showing signs of healthy recovery (soil fertility, plant diversity, clean water)?
- **Community Benefits:** Are local people benefiting from new jobs, economic opportunities, and recreational spaces?
- **Sustainable Use:** Is the repurposed land contributing to long-term sustainability, like renewable energy generation or sustainable agriculture?
- **Biodiversity Support:** Is the repurposed site providing habitats for wildlife and supporting biodiversity?

3.6
Summary: Tips for Practitioners

- Start early by integrating repurposing discussions into mine planning well before closure to align community, regulatory, and company expectations.
- Explore ways to utilize unmined land in the early years of mining projects. During mining, not all parts of a land are excavated at once. Certain areas may remain unmined for several years before operations actually begin. These idle lands/ unmined areas may be effectively used to create livelihood opportunities, generating revenue and economic benefits for local communities and mine owners, before mining starts in such areas.
- Engage communities continuously through meaningful, participatory and culturally sensitive consultations to identify needs, aspirations, and preferred land uses.
- Map local socio-economic and environmental conditions through baseline studies to understand existing livelihoods, ecological conditions, and infrastructure gaps.
- Choose a theme for repurposing that adds new purpose and value for people, such as agriculture, tourism, or green energy projects. Ensure the theme aligns with local needs and offers tangible benefits for the community.
- Before selecting a theme, assess current land use, environmental factors, and any local challenges. Choose themes that are not only feasible in the short term but also sustainable in the long run.
- Involve local stakeholders from the outset to ensure the chosen theme meets their needs and expectations. Foster a sense of ownership by engaging residents, businesses, and other relevant groups throughout the planning and execution phases.

- When planning mine closure or repurposing initiatives, ensure the model is designed with the flexibility to be applied across different scales and locations, while recognizing that adaptation may not always be necessary and can depend on the specific context of each community.
- When developing the project, build in flexibility to accommodate future changes in local conditions, needs, or resources. Aim to create a project that can evolve and scale, allowing for adjustments as new opportunities or challenges arise.
- Prioritize livelihood linkages so repurposed sites generate sustainable income opportunities (fisheries, renewable energy, eco-tourism, agro-forestry).
- Respect local traditions, religious sites, and tribal practices by embedding them into closure and repurposing strategies to build community ownership and avoid resistance.
- Leverage natural assets of post-mined landscapes, such as water bodies, reclaimed lands, and ecological corridors, for environmental restoration and productive reuse.
- Balance ecology and economy by blending ecological restoration with economic repurposing, avoiding over-commercialization.
- Ensure regulatory compliance with Mine Closure Plans, Just Transformation Plan, MoEFCC guidelines, DGMS rules, and other statutory requirements.
- Align mine closure and repurposing with national and international standards. Begin working towards nationally and internationally recognized certification and awards.
- Align your mine closure and repurposing efforts with an Environmental, Social, and Governance (ESG) strategy. Focus on measurable environmental improvements, social responsibility, and good governance.
- Develop ESG Framework and regularly report on ESG performance to stakeholders. Transparency in environmental and social impacts will build trust with investors, local communities, and regulatory bodies.
- Keep your ESG framework dynamic and adaptable, incorporating new insights from global best practices and regulatory changes.
- Align mine closure and repurposing with relevant Sustainable Development Goals (SDGs). Regularly assess and report on how your efforts contribute to achieving SDGs.
- Develop high-impact, scalable, and replicable project that can serve as a model for others. A flagship project, whether it's a major environmental restoration, sustainable livelihood initiative, or renewable energy integration, generate a positive and lasting value for all stakeholders concerned.
- Design the flagship project in a way that the success of this project should not only be limited to one site but should be adaptable and applicable to other regions or sectors, creating a ripple effect of leadership.
- To measure impact, develop performance indicators around environmental restoration, community benefits, and economic outcomes.

- Identify individuals within the community or organization who are passionate about sustainability. Provide them with the tools, knowledge, and platform to lead the repurposing efforts. Training and mentorship are key to developing their skills.
- Publicly acknowledge the contributions of local champions and project leaders through awards, certificates, or community celebrations. Recognizing success helps maintain motivation and fosters a sense of ownership among the stakeholders.
- Encourage local champions and leaders to share their successes and lessons learned from the flagship project. This can be done through workshops, webinars, or conferences. These platforms serve to inspire others and facilitate the spread of best practices.
- Build a community or network of leaders who are working on similar sustainability projects. This network can offer ongoing support, mentorship, and guidance to emerging leaders and champions in the field of mine closure and land repurposing.
- Build institutional and individual capacity by forming dedicated teams to manage closure and repurposing. Invest in education and skill development of local workers in environmental management, resource efficiency, and sustainable livelihoods, such as solar technicians, eco-tourism guides, or aquaculture experts.
- Collaborate with government agencies, technical institutes, research organizations, NGOs, local authorities and private enterprises for innovative, scalable and viable models.
- Leverage existing government schemes such as MGNREGA (employment), Jal Shakti Abhiyan (water reuse), or PM-KUSUM (solar energy) to maximize resource efficiency and scale impact. Combine efforts across different sectors (e.g., water, energy, livelihood) to create a holistic, sustainable solution.
- Investigate the potential for carbon credit generation/ sequestration through your mine repurposing activities, especially if you're involved in reforestation or restoring wetlands.
- Explore both domestic and global financing opportunities.
- Pursue prestigious national and international certifications and awards to build project credibility and stakeholder confidence.
- Define long-term operation and maintenance responsibilities for assets like community infrastructure, water bodies, plantations, and livelihood centers to ensure sustained outcomes.
- Monitor performance using measurable indicators related to environmental recovery, social well-being, and economic upliftment to demonstrate impact and enable continuous improvement.
- Share success stories and lessons learned through case studies, awards, publications, and participation in national/international forums to build reputation and shape future practices.

- Be flexible and adaptive since ground realities often differ from plans, requiring course corrections. Integrate community feedback, evolving policies, and new technologies into ongoing plans.

Do's	Don'ts
Do keep closure and repurposing plans realistic, based on ground conditions and available resources.	Don't design projects that look good on paper but are unviable on the ground.
Do involve local governance institutions (Panchayats, District Administration) for legitimacy and smoother approvals.	Don't bypass local authorities or ignore their role in long-term ownership.
Do create diversified livelihood options to reduce overdependence on a single activity.	Don't assume one repurposing model (like tourism or aquaculture) fits all locations.
Do factor in climate resilience and disaster preparedness in post-closure land use.	Don't ignore risks of flooding, erosion, or water contamination.
Do prioritize safety, stabilize slopes, secure shafts, and ensure hazard-free sites before handover.	Don't leave behind unsafe pits, highwalls, or contaminated zones.
Do ensure transparent communication on timelines, budgets, and responsibilities.	Don't raise unrealistic expectations in the community about scale or speed of benefits.
Do plan for phased repurposing to allow learning and mid-course correction.	Don't attempt large-scale repurposing in one go without pilot testing.
Do encourage women's participation and youth engagement in livelihood activities.	Don't restrict benefits to a narrow group or dominating group.

3.7
Field Checklist for Viable Post-Closure Development (Repurposing)

- Early Integration and Planning
  - Has repurposing been integrated into the mine closure plan from the outset?
  - Is there a clear phased implementation plan with pilot projects and scaling options?

- **Community Engagement and Stakeholder Involvement**
  - Have community consultations been conducted at all stages, ensuring meaningful and culturally sensitive participation?
  - Are local livelihood needs, skills, and aspirations mapped and incorporated into planning?
  - Have gender, youth, and vulnerable groups been actively included in consultations and decision-making?
- **Socio-Economic and Environmental Assessment**
  - Have socio-economic and environmental baselines been documented, including local livelihoods, ecological conditions, and infrastructure gaps?
  - Have cultural, tribal, and religious sensitivities been factored into land-use planning?
  - Have natural assets (land, water bodies, biodiversity) been mapped for productive use and ecological restoration?
- **Sustainable Livelihood and Economic Opportunities**
  - Have potential livelihood options been identified (e.g., agriculture, aquaculture, renewable energy, tourism, forestry)?
  - Is there a clear livelihood transition and skill development plan for workers, including training programs?
  - Have skill gaps been assessed, and capacity-building initiatives been designed?
- **Ecological Restoration and Economic Repurposing**
  - Is there a balance between ecological restoration and economic repurposing ?
  - Has green cover and biodiversity restoration been initiated and is it monitored regularly?
  - Has climate resilience and disaster preparedness been integrated into planning?
- **Regulatory Compliance and Risk Management**
  - Are all regulatory and statutory requirements (DGMS, MoEFCC, State Govt.) being complied with?
  - Have safety risks (e.g., slope stability, shaft closure, contamination control) been assessed and addressed?
  - Is land stability and water quality tested before handover to ensure long-term safety?
- **Partnerships and Resource Mobilization**
  - Have collaboration been established with government agencies, NGOs, technical institutes, and local stakeholders?
  - Has a sustainable funding mechanism been secured ?
  - Have government schemes been leveraged for maximum impact?
- Long-Term Operations and Maintenance

Have long-term ownership and maintenance responsibilities for assets (e.g., community infrastructure, water bodies, plantations) been clearly defined?

- Is there a plan for the reuse of existing infrastructure (roads, buildings, utilities) for post-mining activities?

- **Monitoring and Evaluation**
  - Is a monitoring and evaluation system in place with measurable indicators related to environmental recovery, social well-being, and economic upliftment?
  - Are lessons being documented, shared, and applied for replication and scaling?

- **Project Impact and Communication**
  - Is transparent communication maintained with stakeholders regarding timelines, budgets, and responsibilities?
  - Have success stories and lessons learned been shared through case studies, publications, or participation in forums to build reputation and influence future practices?
  - Have local champions and leaders been acknowledged and celebrated to inspire further engagement?
- **Sustainability and Adaptability**
  - Is the mine closure and repurposing model flexible and adaptable to different scales and locations, with a focus on local context?
  - Is the project designed to evolve and accommodate future changes in local conditions, needs, or resources?
- **ESG Strategy and Reporting**
  - Is the mine closure and repurposing aligned with a robust Environmental, Social, and Governance (ESG) strategy?
  - Are there regular reports on ESG performance, focusing on environmental improvements, social responsibility, and good governance?
  - Is the ESG framework dynamic and adaptable, incorporating global best practices and evolving regulatory requirements?
- **Alignment with Sustainable Development Goals (SDGs)**
  - Does the project align with relevant SDGs?
  - Are the contributions to SDGs regularly assessed and reported to stakeholders?
- **Flagship Project Design and Impact**
  - Has the project been designed as a high-impact, scalable, and replicable model to serve as a flagship for others?
  - Does the flagship project focus on generating lasting value for all stakeholders, such as through environmental restoration, sustainable livelihoods, or renewable energy integration?
  - Is the project designed to be adaptable and applicable to other regions or sectors to create a ripple effect of leadership?

- **Certifications and Awards**
  - Has the project pursued prestigious national and international certifications and awards to enhance credibility and stakeholder confidence?
  - Is there a strategy in place to work toward globally recognized certifications?
  - Are national and international awards being pursued to showcase the project's achievements and build its reputation?
- **Exit Strategy and Handover**
  - Has an exit strategy and community handover plan been finalized to ensure sustained outcomes after project completion?
  - Are long-term operations and asset maintenance strategies in place for community infrastructure, water bodies, and livelihoods?

This comprehensive checklist ensures that the mine closure and repurposing process is holistic, adaptable, and impactful, focusing on sustainability, stakeholder involvement, regulatory compliance, and measurable outcomes.

3.8
Mine Repurposing Options: A Practical Guide for Mine Operators

To support mine operators in identifying suitable options for post-mining utilization, this section presents a curated list of 35 mine repurposing projects. Each project is described with key details such as concept description, indicative feasibility conditions, approximate capital expenditure (CAPEX), and illustrative examples. The details provided are indicative in nature, intended to serve as a reference, enabling stakeholders to compare alternatives and assess their applicability in the context of local conditions.

Having a clear or limited set of repurposing options in mind from the beginning of mine closure planning not only enhances efficiency but also makes the process more economical. The selection of a suitable project should be guided by multiple factors, including the geographical characteristics of the site, mining legacies, social and economic contexts, as well as regulatory guidelines. By aligning these parameters, mine operators can identify the most feasible and sustainable repurposing pathways that serve both community aspirations and long-term regional development.

The Mine Repurposing Options for post - Mining Utilization

01.

SOLAR PV FARMS

Description

In India, solar photovoltaic (PV) farms on post-closure coal mines offer a strategic pathway for a just transition by repurposing environmentally degraded lands into renewable energy assets. With over 500 square kilometers of former mine land identified across states like Telangana, Odisha, and Madhya Pradesh, India has a significant potential to install over 27 GW of solar capacity [1].

This initiative leverages existing infrastructure, such as power transmission lines, and generates new employment opportunities in construction and operations for communities that previously depended on the coal industry. However, successful implementation requires addressing significant challenges, including clarifying land ownership, addressing regulatory hurdles, and ensuring environmental stability through proper reclamation to prevent issues like land subsidence and water contamination.

01.

SOLAR PV FARMS

Prerequisite Conditions

- Stable land area ≥ 20 ha [6,11]
- Slope ≤ 10% [11]
- Geotechnical stability FoS > 1.5 [11,12]
- Solar insolation ≥ 4.5 kWh/m^2/day [1,4,9]
- Grid proximity ≤ 15 km; available capacity [3]
- Clear land tenure;
- ES risk manageable [8]

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Stable land area (ha)	>50	20-50	<20
Slope (%)	0-5	5 to 10	>10
Geotechnical stability (FoS)	>1.5	1.2-1.5	<1.2
Solar insolation (kWh/m²/day)	>5.5	4.5-5.5	<4.5
Grid proximity (km)	<5	5 to 15	>15
Grid capacity (MW)	>50	10-50	<10
Road access	<5 km from national/state highway	5-15 km from national/state highway	>15 km from national/state highway
Water access (kL/day)	>100	50-100	<50
Land tenure	Clear and unencumbered	Pending legal review	Disputed or unclear
Environmental & Social (ES) risk	Low	Medium	High

CAPEX

- Utility (50 MW): ₹30,000,000 - ₹36,000,000 per MW [4, 1, 14].
- Medium (10 MW): ₹34,000,000 - ₹48,000,000 per MW [4, 14].
- Community (1 MW): ₹45,000,000 - ₹85,000,000 per MW [4, 16].

02.

FLOATING SOLAR

Description

Floating solar farms can be developed on pit lakes with adequate area and volume, transforming these water bodies into productive energy assets. A report prepared under the Indo-German Technical Cooperation on Innovative Solar (IN Solar) shows that India's inland water bodies have the technical potential to host over 206 GW of floating solar capacity [2].

This option reduces land use, minimizes water evaporation, and offers higher efficiency due to the cooling effect of the water on the solar panels.

Prerequisite Conditions

- Pit lake area ≥ 5 ha; volume adequate [20]
- Lake depth 5–40 m; safe banks [11,20]
- Solar insolation ≥ 4.5 kWh/m^2/day [1,4,9]
- Grid proximity ≤ 15 km [3]
- Water quality within limits for corrosion/fouling [7]
- Land and water rights clear [8]

02.

FLOATING SOLAR

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Pit lake area (ha)	>20	5–20	<5
Average depth (m)	10–30	5–10 or 30–40	<5 or >40
Lake volume (MCM)	>20	5–20	<5
Solar insolation (kWh/m²/day)	>5.5	4.5–5.5	<4.5
Grid proximity (km)	<5	5–15	>15
Road access	<2 km	2–10 km	>10 km
Water quality (TDS/pH)	Within materials spec	Treatable	Aggressive/corrosive
CAPEX	Low	Medium	High

CAPEX

- Large (10 MW): ₹45,000,000 - ₹75,000,000 per MW [12, 2].
- Medium (2 MW): ₹55,000,000 - ₹95,000,000 per MW [12, 2].

Example

- Project Name : Huainan & Panji floating PV (former coal mining subsidence areas)
- Country: China

03.

WIND FARMS

Description

Repurposing mine sites for wind farms requires specific topography and wind speeds. A case study on a 2 MW project in Maharashtra cited a total installed capital cost of ₹106.92 million [3]. Wind farms can be a valuable addition to the energy mix at mine sites, especially on high-altitude plateaus or ridges created during the mining process, offering a complementary power source to solar energy.

Prerequisite Conditions

- Mean wind speed ≥ 6 m/s at hub height [1,4,9]
- Topography suitable (ridge/plateau) [11]
- Foundation capacity adequate [11]
- Grid proximity ≤ 20 km [3]
- Aviation clearance (AAI/DGCA) [14,15]

03.

WIND FARMS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Wind speed (m/s)	>7	6–7	<6
Topography	Ridge/plateau	Open plains	Irregular valleys
Geotechnical stability (FoS)	>1.5	1.2–1.5	<1.2
Grid proximity (km)	<10	10–20	>20
NH proximity (km)	<5	5–15	>15
Aviation clearance	Secured	Partial	Restricted

CAPEX

- Utility (50 MW): ₹75,000,000 - ₹110,000,000 per MW [3, 13].
- Small (5 MW): ₹90,000,000 - ₹140,000,000 per MW [3, 13].

Example

- Project Name : Königshovener Höhe Wind Farm (Garzweiler lignite mine)
- Country: Germany

04.

PUMPED HYDRO STORAGE (PHS)

Description

Pumped Hydro Storage (PHS) requires a suitable landscape for the creation of two reservoirs, which can be formed using existing mine voids. The Government of India has released a set of guidelines to promote PHS projects [4]. PHS is the dominant form of energy storage globally, providing a reliable and large-scale solution to manage the intermittency of renewable energy sources like solar and wind [4].

Prerequisite Conditions

- Two reservoirs (upper/lower) feasible [20]
- Vertical head ≥ 100 m [3,4]
- Sustainable water balance [20]
- Grid proximity ≤ 20 km [3]
- Environmental and safety clearances [2,12]

04.

PUMPED HYDRO STORAGE (PHS)

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Two feasible reservoirs	Existing pits/reservoirs	Requires new construction	Not possible
Vertical head (m)	>200	100–200	<100
Reservoir area (ha)	>50	20–50	<20
Water balance	Surplus	Neutral	Deficit
Grid proximity (km)	<10	10–20	>20
Geotechnical stability	High	Moderate	Low

CAPEX

- Any Scale: Site-specific; ₹3,000,000,000+ per GW [4, 14].

Example

- Project Name : Kidston Pumped Storage Hydro Project (Genex)
- Country: Australia

05.

BATTERY ENERGY STORAGE (BESS)

Description

BESS facilities require proximity to existing electrical infrastructure. The Indian government has approved a Viability Gap Funding scheme to encourage the establishment of 4,000 MWh of BESS projects, which will help reduce the cost of electricity from these systems [7]. BESS can be a critical component in repurposing mine sites, as it allows for the storage of excess renewable energy generated from solar or wind farms on-site, providing a stable power supply and increasing the value of the energy generated.

Prerequisite Conditions

- Substation proximity < 10 km [3]
- Ambient temperature 10–35°C [9]
- Fiber optic proximity < 5 km [13]
- Security and ES compliance [2,8]

05.

BATTERY ENERGY STORAGE (BESS)

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Grid proximity (km)	<2	2–10	>10
Ambient temperature (°C)	15–30	10–15 or 30–35	<10 or >35
Fiber optic proximity (km)	<2	2–5	>5
Power reliability	>95% uptime	80–95%	<80%

CAPEX

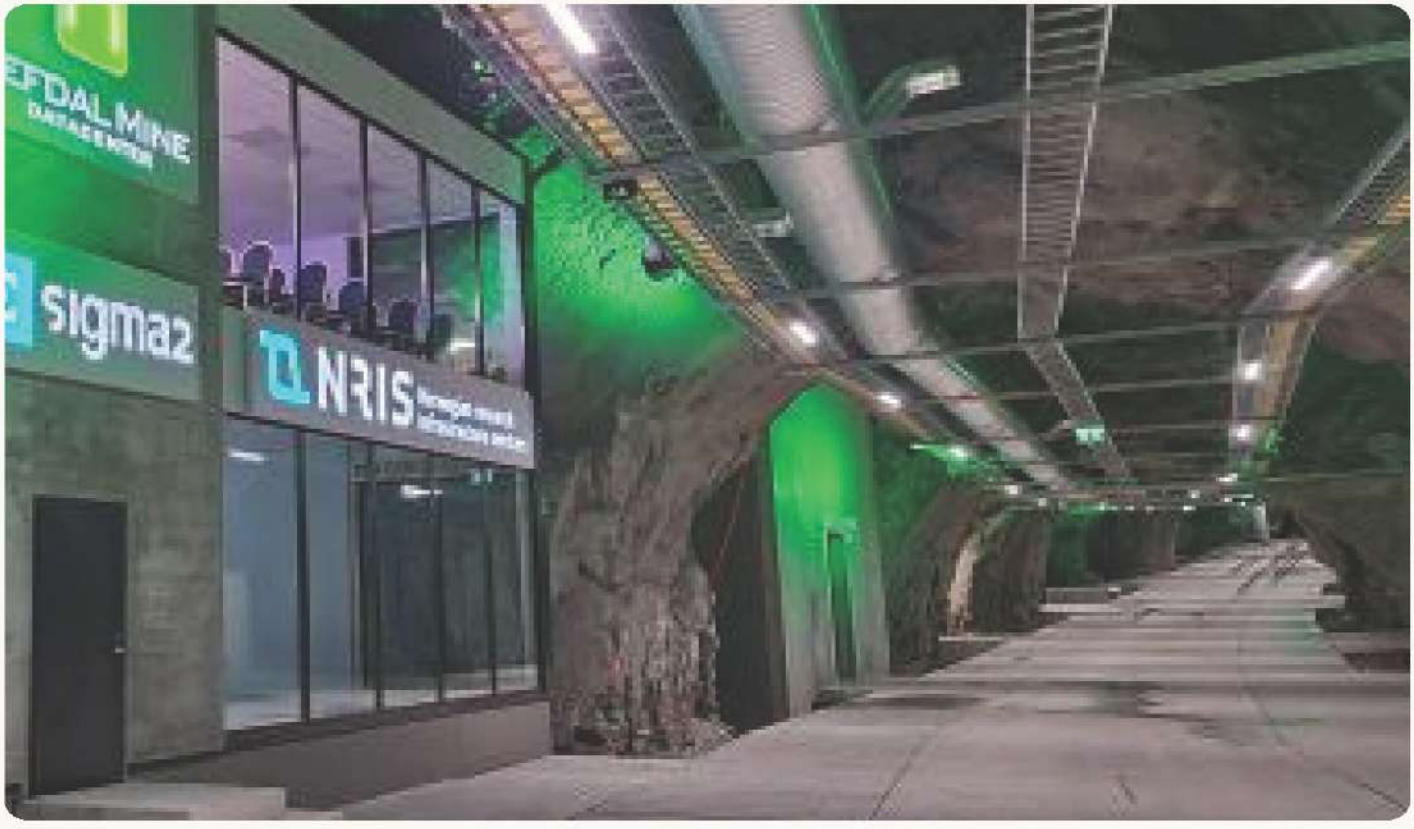
- Grid-Scale (>100MWh): ₹9,000 - ₹16,000 per kWh [4, 14].
- Local-Scale (<10MWh): ₹12,000 - ₹25,000 per kWh [4, 14].

Example

- Project Name : Pyhäsalmi Mine
- Country: Finland

06.

DATA CENTERS



Description

Data centers require a stable power supply and connectivity. The cost of setting up a greenfield data center in India is estimated to be approximately ₹400-₹450 million per MW [8]. Repurposing mine sites for data centers can take advantage of the vast, secure land available and the potential for a dedicated, reliable power supply from co-located renewable energy sources, such as solar or wind farms.

Prerequisite Conditions

- Reliable grid power + redundancy [3]
- Water supply assured [20]
- Fiber backhaul < 2 km [13]
- Ambient temp 15–30°C; AQI < 100 [7,9]
- Land tenure clear [8]

06.

DATA CENTERS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Power reliability	>99% uptime	90–99%	<90%
Grid capacity (MW)	>100	50–100	<50
Water supply	Reliable	Seasonal	Unreliable
Fiber optic proximity (km)	<2	2–5	>5
Air quality (AQI)	<50	50–100	>100
Avg. temperature (°C)	15–25	10–15 / 25–30	<10 or >30
Urban center proximity (km)	<20	20–50	>50
CAPEX	Low	Medium	High

CAPEX

- Hyperscale: ₹180,000,000 - ₹400,000,000 per MW [6, 15].
- Edge/Local: ₹60,000,000 - ₹160,000,000 per MW [6, 15].

Example

- Project Name : Lefdal Mine Datacenter (former olivine mine)
- Country: Norway

07.

AGROFORESTRY

Description

Agroforestry requires soil conditions to be suitable for vegetation growth and can be used to rehabilitate mined lands by planting a mix of trees, shrubs, and crops. India's National Agroforestry Policy, 2014, recommends an initial corpus to support the sector [9]. This practice can restore soil fertility, prevent erosion, and create a sustainable source of income for local communities, contributing to both ecological restoration and economic development.

Prerequisite Conditions

- Reconstructed soil depth ≥ 0.5 m [6,5]
- Topsoil availability ≥ 50% area [5]
- Soil pH 6.0–7.5; EC < 2 dS/m [5]
- Water access for establishment [20]
- Community acceptance high [6]

07.

AGROFORESTRY

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Soil depth (m)	>1.0	0.5–1.0	<0.5
Topsoil availability (%)	>70	50–70	<50
pH	6.0–7.5	5.5–6.0 / 7.5–8.0	<5.5 or >8.0
EC (dS/m)	<1.5	1.5–2.0	>2.0
Water access	Reliable	Seasonal	Unreliable
CAPEX	Low	Medium	High

CAPEX

- Commercial: Site-specific; a more specific estimate is not available but varies widely depending on the type of agroforestry [4].
- Community: Site-specific; a more specific estimate is not available but varies widely depending on the type of agroforestry [4].

Example

- Project Name : Guqiao Coal Mine subsidence
- Country: China

08.

GREENHOUSES

Description

Greenhouses can be a viable option for agriculture on repurposed mine sites if power and water are available. The cost to set up a naturally ventilated greenhouse in India ranges from ₹400,000 to ₹480,000 per acre [10]. This method allows for controlled, high-yield cultivation of crops, minimizing the impact of poor soil conditions and external weather, and creating high-value produce for local markets.

Prerequisite Conditions

- Stable land area ≥ 5 ha [6]
- Water supply and drainage [20]
- Power availability for climate control [3]
- Ambient temp profile suitable [9]

08.

GREENHOUSES

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Stable land area (ha)	>10	10 to 5	<5
Water supply & drainage	Assured & adequate	Seasonal/requires infrastructure	Inadequate
Power availability	Reliable grid access	Requires backup generation	Not present
Ambient temperature profile	Within optimal range for crops	Requires climate control	Not suitable for crops

CAPEX

- Large Commercial: ₹7,000 - ₹15,000 per m^2 [7, 2].
- Polyhouse: ₹1,200 - ₹6,000 per m^2 [7, 2].

Example

- Project Name : Mine-I, NLC India Ltd
- Country: India

09.
AQUACULTURE

Description

Aquaculture is suitable for mine pit lakes with specific water quality parameters. The Pradhan Mantri Matsya Sampada Yojana (PMMSY) is an initiative by the Indian government to boost the fisheries sector with an investment of ₹20,050 crore for five years [11]. The use of mine pit lakes for aquaculture can transform unproductive voids into a source of food and income for local communities, contributing to food security and economic diversification.

Prerequisite Conditions

- Pit lake area/volume adequate [20]
- Water pH 6.5–8.5; TDS < 1500 ppm [7]
- Heavy metals within CPCB limits [7]

09.
AQUACULTURE

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Lake area (ha)	>20	5–20	<5
Water pH	6.8–8.2	6.5–6.8 / 8.2–8.5	<6.5 or >8.5
TDS (ppm)	<1000	1000–1500	>1500
Heavy metals	Within limits	Treatable	Above limits
Water renewal	Surplus	Balanced	Deficit

CAPEX

- Commercial Farm: ₹50,000 - ₹500,000 per ha [8, 9, 16].
- Fishery: ₹30,000 - ₹200,000 per ha [8, 16].

Example

- Project Name : CCL Kerketta OCP Mine Void Pisciculture
- Country: India

10.
MUSHROOM FARM

Description

Mushroom farms require controlled environments and market access. The Khadi and Village Industries Commission (KVIC) provides project profiles with estimated costs, with some projects costing around ₹2.5 million [12]. The controlled environment needed for mushroom cultivation makes it a suitable option for repurposed mine sites, as it can be housed in existing structures or purpose-built facilities, providing a high-value agricultural product with minimal land use.

Prerequisite Conditions

- Ambient temperature/humidity controllable [9]
- Power availability for HVAC [3]
- Market linkage/demand [10]

10.

MUSHROOM FARM

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

- Any Scale: ₹50,000 - ₹1,200,000 per project [10].

Example

- Project Name : Les Carrières (Montesson)
- Country: France

11.

APICULTURE / BEE KEEPING

Description

Apiculture is a low-impact option that benefits from floral diversity and good air quality. A project profile for 50 beehives estimates a non-recurring cost of ₹27,500 [13]. Beekeeping can be integrated with other land use options, such as agroforestry, to promote biodiversity, improve crop pollination, and provide a sustainable source of income through honey and other bee products.

Prerequisite Conditions

- Floral diversity and pesticide-safe zone [2,5]
- Air quality acceptable (AQI < 100) [7]
- Water availability nearby [20]

11.

APICULTURE / BEE KEEPING

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

- Any Scale: ₹50,000 - ₹1,200,000 per project [10].

Example

- Project Name : Benguet
- Country: Philippines

12.

LIVESTOCK FARMING

Description

Livestock farming requires a land area and a plan for fodder and waste management. The Animal Husbandry Infrastructure Development Fund (AHIDF) facilitates investments for various livestock projects [14]. This repurposing option can utilize reclaimed land and provide food and a livelihood for communities, contributing to the rural economy.

Prerequisite Conditions

- Grazing/fodder plan and land area [5]
- Water supply and waste management [20,7]
- Biosecurity and ES compliance [2,8]

12.

LIVESTOCK FARMING

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
CAPEX	Low	Medium	High

CAPEX

- Ranch (500+ head): ₹150,000 - ₹1,000,000 per head [18].
- Community (50 head): ₹60,000 - ₹200,000 per head [18].

Example

- Project Name : Navajo Mine GMP
- Country: New Mexico

13.
DAIRY

Description

Dairy operations need reliable water and power, as well as proximity to markets. . Dairy farming can be a stable and profitable enterprise on reclaimed mine land, offering a sustainable source of income and contributing to the local food supply.

Prerequisite Conditions

- Water supply reliability [20]
- Power for chilling/processing [3]
- Wastewater management as per CPCB [7]
- Market proximity [10]

13.

DAIRY

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

- Commercial: ₹1,500,000 - ₹6,000,000 per head [2].
- Cooperative: ₹400,000 - ₹2,000,000 per head [2].

Example

- Project Name : Black Thunder Mine
- Country: Wyoming, USA

14.

REWILDING

Description

Rewilding focuses on restoring the land to a natural state. It is gaining traction in India as a method for conservation and ecological restoration [16]. This option can be used to re-establish native ecosystems, enhance biodiversity, and create natural habitats for wildlife, offering long-term ecological benefits.

Prerequisite Conditions

- Biodiversity enhancement potential [2]
- Soil remediation status acceptable [7]
- Long-term land security [8]
- Water positivity opportunities [20]

14.
REWILDING

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

- ₹2,30,000 – ₹3,45,000 / ha [38]

Example

- Project Name : Asola Bhatti Wildlife Sanctuary (former stone/sand mines)
- Country: India

15.

WETLANDS

Description

Wetlands are a repurposing option that focuses on restoring hydrology. The Indian government has made budgetary allocations to declare and revive wetlands [17]. Creating wetlands can transform mine pit lakes into a valuable ecosystem, providing flood control, water purification, and a habitat for a diverse range of flora and fauna.

Prerequisite Conditions

- Hydrology suitable; water balance neutral/surplus [20]
- Water quality within thresholds [7]
- Landscape connectivity for fauna [2]

15.

WETLANDS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

- ₹5,00,000 – ₹7,00,000 / ha [39]

Example

- Project Name : Wigan Flashes National Nature Reserve (former coal subsidence)
- Country: United Kingdom

16.

POLLINATOR / WILDLIFE CORRIDORS

Description

Pollinator/Wildlife corridors are a series of habitats that provide resources for pollinators and support biodiversity.

Prerequisite Conditions

- Native flora establishment potential [2,5]
- Low pesticide drift risk [2]
- Air quality suitable [7]

16.

POLLINATOR / WILDLIFE CORRIDORS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Floral diversity	High	Medium	Low
Pesticide-safe zone	High	Medium	Low
Air Quality Index (AQI)	<50	50-100	>100
Water availability	Year-round source	Seasonal source	Not present

CAPEX

- ₹1,30,000 – ₹2,00,000 / km [40]

Example

- Project Name : Coal Country Beeworks
- Country: Kentucky, USA

17.

ECO PARKS

Description

Eco-parks are recreational areas that also focus on ecological restoration and conservation.

Prerequisite Conditions

- Scenic value and visitor safety [12,19]
- Access via NH/arterials [17]
- Community acceptance and ES compliance [2,6,8]

Ecological restoration

17.
ECO PARKS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Biodiversity enhancement potential	High	Medium	Low
Soil remediation status	Low contamination	Medium contamination	High contamination
Long-term land security	Unencumbered	Government land with long-term lease	Disputed or short-term lease
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2

CAPEX

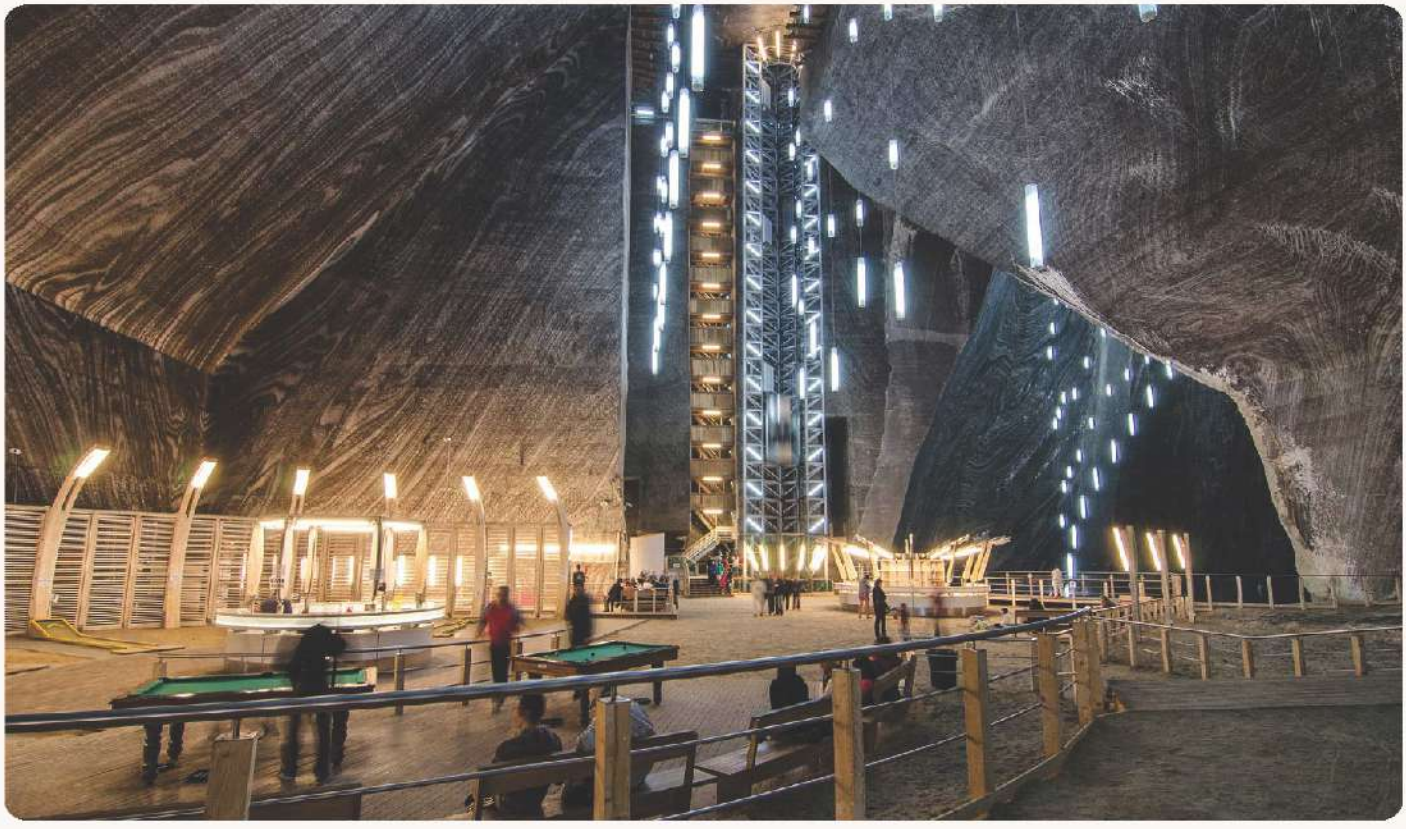
- ₹2,00,00,000 – ₹20,00,00,000

Example

- Project Name : Chandra Shekhar Azad Eco-Park
- Country: India

18.

UG PARKS



Description

Underground parks repurpose underground mine voids for recreational and educational use.

Prerequisite Conditions

- UG access safety clearance [12]
- Ventilation and egress provisions [12]
- Visitor risk management per tourism guidelines [19]
- Structural stability verified [11]

18.

UG PARKS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Geotechnical stability (RMR)	>70	50-70	<50
UG Access (Shaft/Decline)	Yes	Requires modification	Not present
Rock Mass Rating (RMR)	>70	50-70	<50
Ventilation	Natural or simple assisted	Requires extensive mechanical	Not possible
Land/Water area	Large	Moderate	Small

CAPEX

- Any Scale: ₹1,000,000 - ₹8,000,000 per ha [23].

Example

- Project Name : Salina Turda
- Country: Romania

19.

HERITAGE MUSEUM

Description

Heritage museums can be developed to preserve the history of mining in the region.

Prerequisite Conditions

- Heritage/industrial archaeology value [18]
- ES compliance [2]
- Visitor access and amenities [17,19]

19.

HERITAGE MUSEUM

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Existing structures	Suitable for repurposing	Requires significant retrofitting	Not present
Accessibility	Close to major roads/tourism hubs	Requires new road infrastructure	Remote
Land tenure	Clear and unencumbered	Pending legal review	Disputed or unclear

CAPEX

Example

- Project Name : Zollverein Coal Mine Industrial Complex (UNESCO)
- Country: Germany

20.
ADVENTURE TOURISM

Description

Adventure tourism can be developed by leveraging the varied topography and features of the mine site.

Prerequisite Conditions

- Terrain/topography suitability [11]
- Safety standards and trained staff [19]
- Emergency access and communications [17,13]

20.

ADVENTURE TOURISM

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Topography	Hilly/varied with unique features	Hilly terrain	Flat plain
Environmental & Social (ES) risk	Low	Medium	High
Accessibility	Close to major roads	Requires new road infrastructure	Remote
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10

CAPEX

- Major Destination: ₹15,000,000 - ₹150,000,000 [25].
- Local Attraction: ₹1,000,000 - ₹10,000,000 [25].

Example

- Project Name : Zip World Penrhyn Quarry
- Country: United Kingdome (Wales)

21.

AMPHITHEATERS

Description

Amphitheaters can be constructed in the natural depressions of the mine site.

Prerequisite Conditions

- Noise management plan [7]
- Road and parking access [17]
- Population catchment/market [10]

21.

AMPHITHEATERS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Topography	Hilly/varied with natural bowl shape	Varied terrain	Flat plain
Soil stability	High	Medium	Low
Accessibility	Close to major roads/pop. centers	Requires new road infrastructure	Remote

CAPEX

- Large (5000+ seat): ₹8,000 - ₹40,000 per seat [26].
- Community (500 seat): ₹12,000 - ₹60,000 per seat [26].

Example

- Project Name : UCSC Quarry Amphitheater
- Country: USA (California)

22.

BOTANICAL GARDENS

Description

Botanical gardens can be a part of the ecological restoration process and a recreational space

Prerequisite Conditions

- Soil and water suitability [5,20]
- Biodiversity conservation alignment [2]
- Visitor access [17,19]

22.

BOTANICAL GARDENS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Reconstructed soil depth (m)	>1.0	0.5-1.0	<0.5
Topsoil availability	>75% of area	50-75% of area	<50% of area
Water access	Reliable	Seasonal	Not present

CAPEX

- National Level: ₹5,000,000 - ₹50,000,000 per project [27].
- Local Park: ₹500,000 - ₹5,000,000 per ha [27].

Example

- Project Name : Gold Mine–Botanical Garden
- Country: Minahasa, Indonesias

23.

SPORTS COMPLEXES

Description

Sports complexes can be built on reclaimed flat land, providing a new community asset, nurturing the Local Talent.

Prerequisite Conditions

- Large contiguous area [10]
- Road/NH proximity [17]
- Safety and crowd management [19]

23.

SPORTS COMPLEXES

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Stable land area (ha)	>10	10 to 5	<5
Soil stability	High	Medium	Low
Accessibility	Close to major roads/pop. centers	Requires new road infrastructure	Remote

CAPEX

- Regional Stadium: ₹60,000 - ₹200,000 per seat [28].
- Local Field: ₹500,000 - ₹5,000,000 total [28].

Example

- Project Name : Oasis Sports Park
- Country: Marion, Illinois, USA

24.

ART & CULTURAL CENTRE

Description

Cultural centers can be developed to provide community spaces and promote local arts and crafts.

Prerequisite Conditions

- Urban proximity and market demand [10]
- Noise and traffic management [7,17]
- ES compliance [2]

24.

ART & CULTURAL CENTRE

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Stable land area (ha)	>1	0.5-1	<0.5
Accessibility	Close to community centers	Requires new road infrastructure	Remote
Land tenure	Clear and unencumbered	Pending legal review	Disputed or unclear

CAPEX

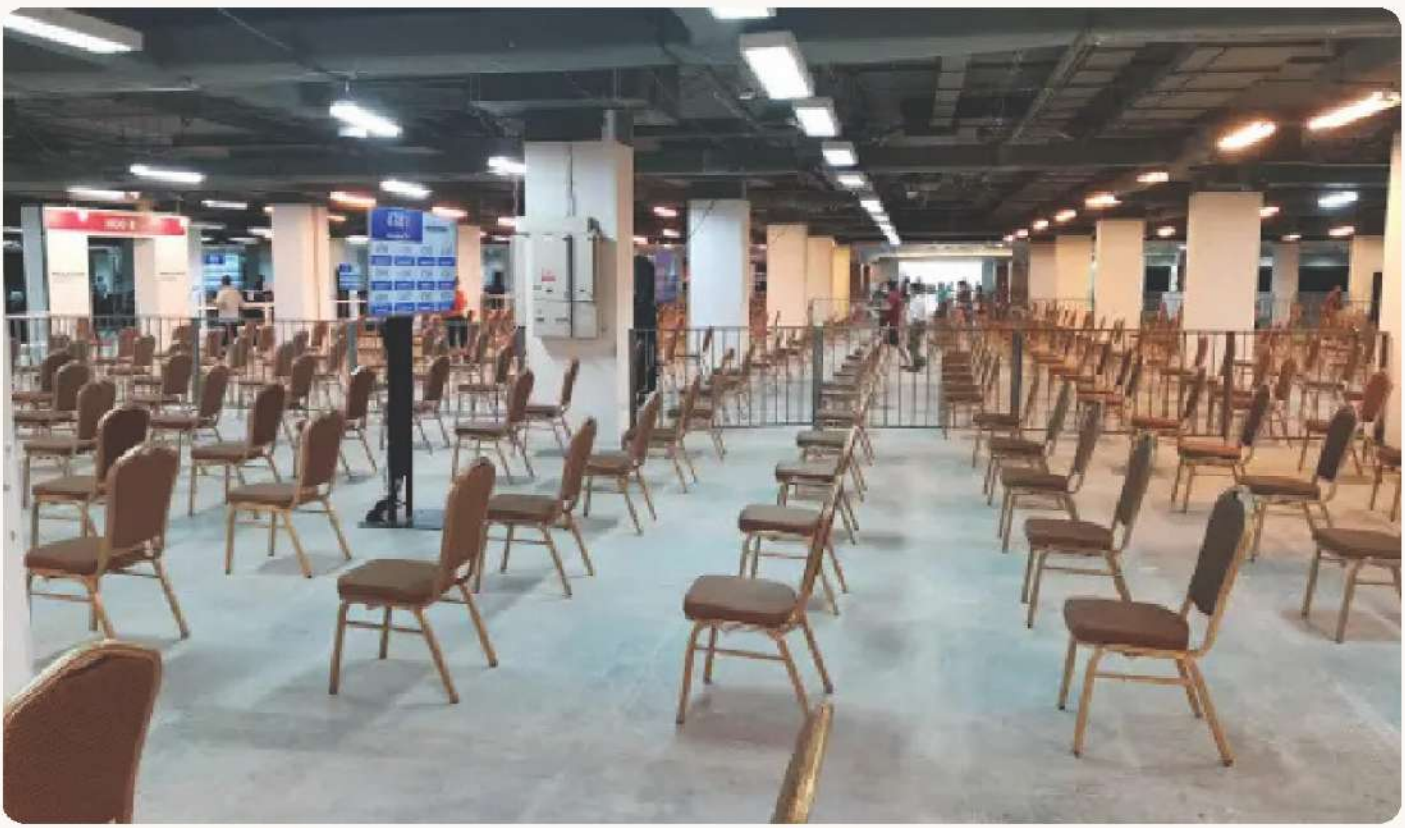
- National Centre: ₹30,000 - ₹150,000 per m^2 [27].
- Community Hall: ₹10,000 - ₹40,000 per m^2 [27].

Example

- Project Name : Samtan Art Mine
- Country: South Korea

25.

CONVENTION CENTRE



Description

Convention centers can be developed to provide community spaces and conducting local events.

Prerequisite Conditions

- Reliable power and HVAC [3]
- Airport access/clearance [14,15]
- High-capacity data connectivity [13]

25.

CONVENTION CENTRE

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Stable land area (ha)	>5	5 to 1	<1
Accessibility	Close to major roads/pop. centers	Requires new road infrastructure	Remote
Grid Power	Reliable redundant supply	Single grid connection	Unreliable connection

CAPEX

- Large (5000+ pax): ₹20,000 - ₹150,000 per m^2 [26].
- Local (500 pax): ₹12,000 - ₹60,000 per m^2 [26].

Example

- Project Name : International Congress Centre (Katowice) on former coal mine site
- Country: Poland

26.
INDUSTRIAL HUB

Description

Repurposing mine lands as industrial hubs enables the productive use of previously disturbed areas while minimizing fresh land diversion. With development costs in the range of ₹10,000 – ₹200,000 per m^2 for warehouses, logistics facilities, and R&D campuses, such hubs can attract diverse industries. This approach fosters regional economic growth, employment generation, and sustainable industrial development.

Prerequisite Conditions

- Grid capacity and reliability [3]
- Road (NH)/rail siding access [17,16]
- Water availability [20]
- Policy alignment and land tenure [10,8]

26.

INDUSTRIAL HUB

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Stable land area (ha)	>50	20-50	<20
Grid Power	Reliable redundant supply	Single grid connection	Unreliable connection
Road access	<5 km from national/state highway	5-15 km from national/state highway	>15 km from national/state highway

CAPEX

- Large Park: ₹5,000,000 - ₹30,000,000 per ha [29].
- MSME Cluster: ₹1,000,000 - ₹6,000,000 per ha [29].

Example

- Project Name : Ruhr Valley
- Country: Germany

27.
LOGISTICS PARKS

Description

Logistics parks can be a hub for transportation and storage, leveraging existing road and rail infrastructure.

Prerequisite Conditions

- NH proximity and access control [17]
- Rail siding connectivity [16]
- Urban/industrial hub proximity [10]

27.

LOGISTICS PARKS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Stable land area (ha)	>10	10 to 5	<5
Road access	<5 km from national/state highway	5-15 km from national/state highway	>15 km from national/state highway
Grid Power	Reliable redundant supply	Single grid connection	Unreliable connection
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

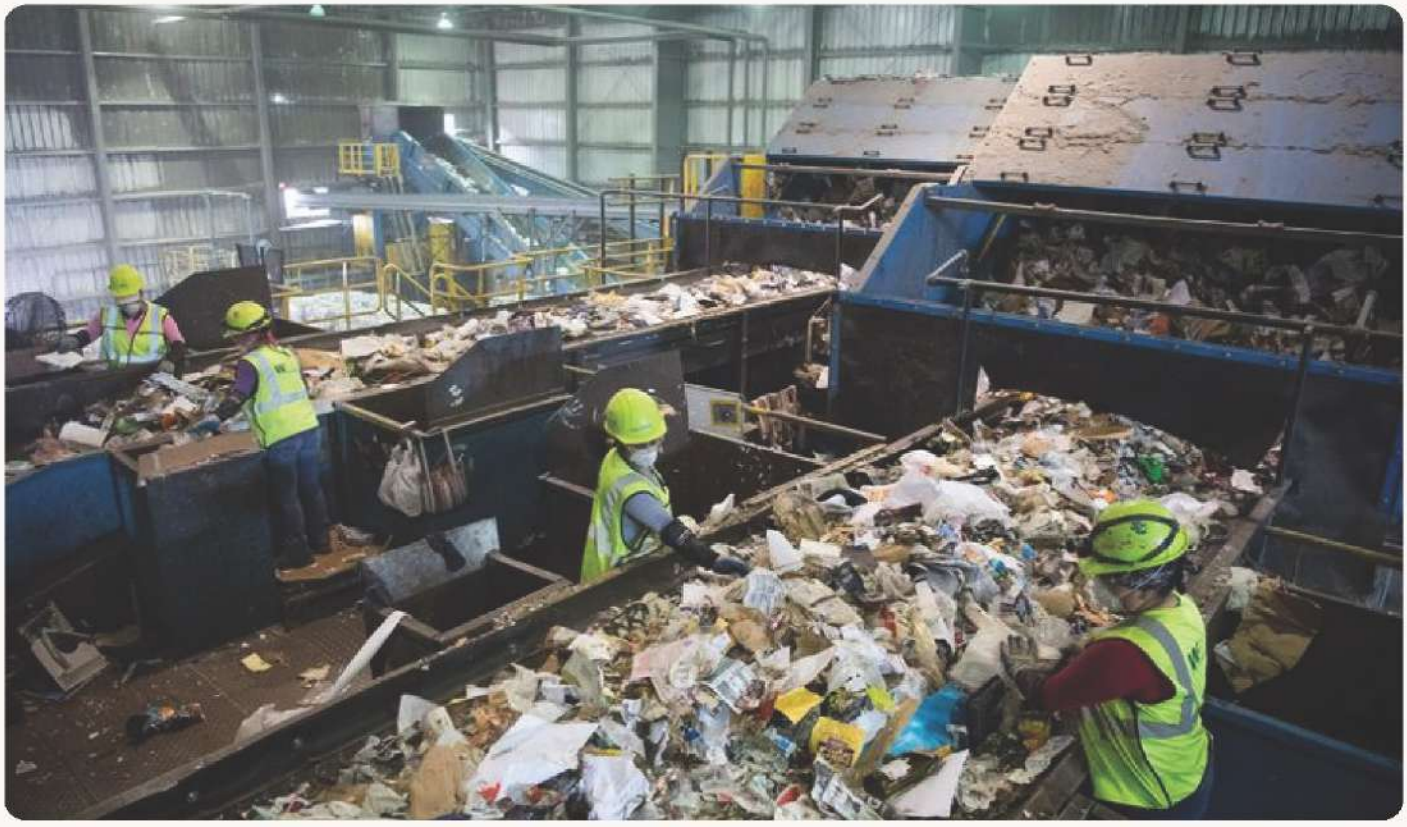
- Large Plant: ₹30,000,000 - ₹300,000,000 [31].
- Local Segregation: ₹500,000 - ₹5,000,000 [31].

Example

- Project Name : iPort Doncaster (former Rossington Colliery area)
- Country: United Kingdom

28.

WASTE RECYCLING CENTER



Description

Waste recycling facilities can be set up to process waste and create a circular economy.

Prerequisite Conditions

- CPCB authorization and siting criteria [7]
- Grid power and water [3,20]
- Community acceptance [6]

28.

WASTE RECYCLING CENTER

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Stable land area (ha)	>5	5 to 1	<1
Water access	Reliable	Seasonal	Not present
Road access	<5 km from national/state highway	5-15 km from national/state highway	>15 km from national/state highway
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

- Large Plant: ₹30,000,000 - ₹300,000,000 [31].
- Local Segregation: ₹500,000 - ₹5,000,000 [31].

Example

- Project Name : Appalachia
- Country: USA

29.
CONCRETE PLANTS

Description

Concrete plants can be established to use the fly ash and other materials from the mine site.

Prerequisite Conditions

- Proximity to raw materials (aggregate/cement) [10]
- NH/arterial access for trucks [17]
- Power availability [3]
- Dust/noise mitigation [7]

29.

CONCRETE PLANTS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Stable land area (ha)	>2	2 to 1	<1
Water access	Reliable	Seasonal	Not present
Road access	<5 km from national/state highway	5-15 km from national/state highway	>15 km from national/state highway

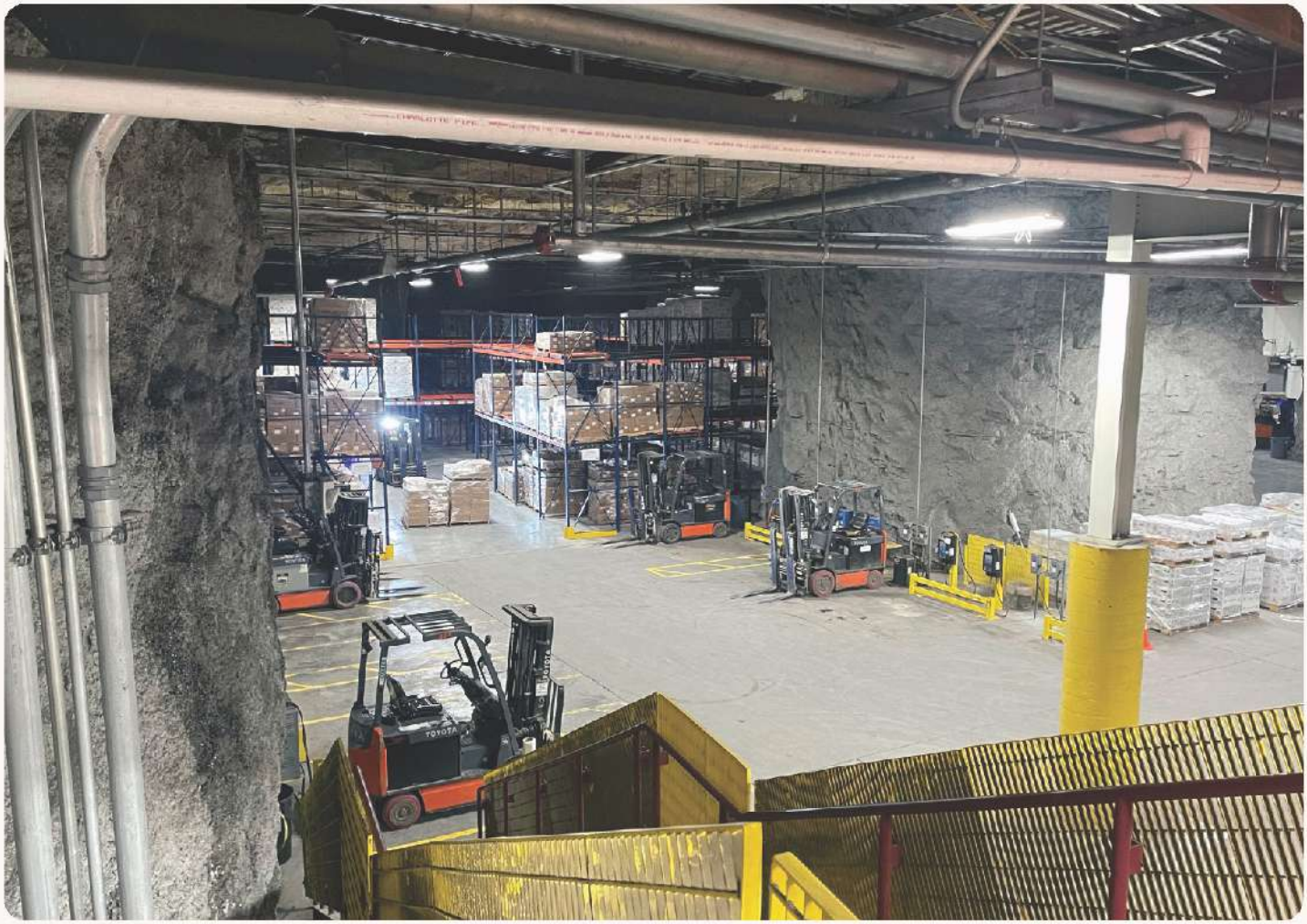
CAPEX

- Any Scale: ₹10,000,000 - ₹80,000,000 total [32].

Example

- Project Name : Ready Mix Concrete Plants
- Country: India

30.
PRESERVATION CENTRE



Description

Preservation centers can be used for cold storage of food or as seed banks.

Prerequisite Conditions

- Cold-chain power reliability [3]
- Ambient control requirements [9]
- Food/seed standards compliance [5]

30.

PRESERVATION CENTRE

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Grid Power	Reliable redundant supply	Single grid connection	Unreliable connection
Water access	Reliable	Seasonal	Not present
Stable land area (ha)	>1	0.5-1	<0.5

CAPEX

- Large Cold Store: ₹8,000 - ₹30,000 per tonne [33].
- Community Seed Bank: ₹500,000 - ₹3,000,000 total [18].

Example

- Project Name : Mo i Rana
- Country: Norway

31.

MINING DRIVING SCHOOL

Description

Driving schools which are exclusively for hehavy machinery like dump trucks etc can help in giving further employment to unskiller workers in the locality by utilizing the extensive road network of a mine site.

Prerequisite Conditions

- Practice track land and safety [12,17]
- Population catchment [10]
- Access roads and signage [17]

31.

MINING DRIVING SCHOOL

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
Stable land area (ha)	>1	0.5-1	<0.5
Road network	Existing paved roads	Requires some new road construction	No existing roads
Land tenure	Clear and unencumbered	Pending legal review	Disputed or unclear

CAPEX

- National Institute: ₹50,000,000 - ₹300,000,000 [34].
- Local Centre: ₹2,000,000 - ₹12,000,000 [34].

Example

- Project Name : Truck and HEMM operator training schools
- Country: Mindanao, Philippines

32.

LIVELIHOOD CENTER

Description

Livelihood centers can be developed to provide skills training and employment opportunities.

Prerequisite Conditions

- Community acceptance and participation [6]
- Urban proximity [10]
- Access to utilities [3,20]

32.
LIVELIHOOD CENTER

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Stable land area (ha)	>1	0.5-1	<0.5
Water access	Reliable	Seasonal	Not present
Grid Power	Reliable	Unreliable	Not present
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

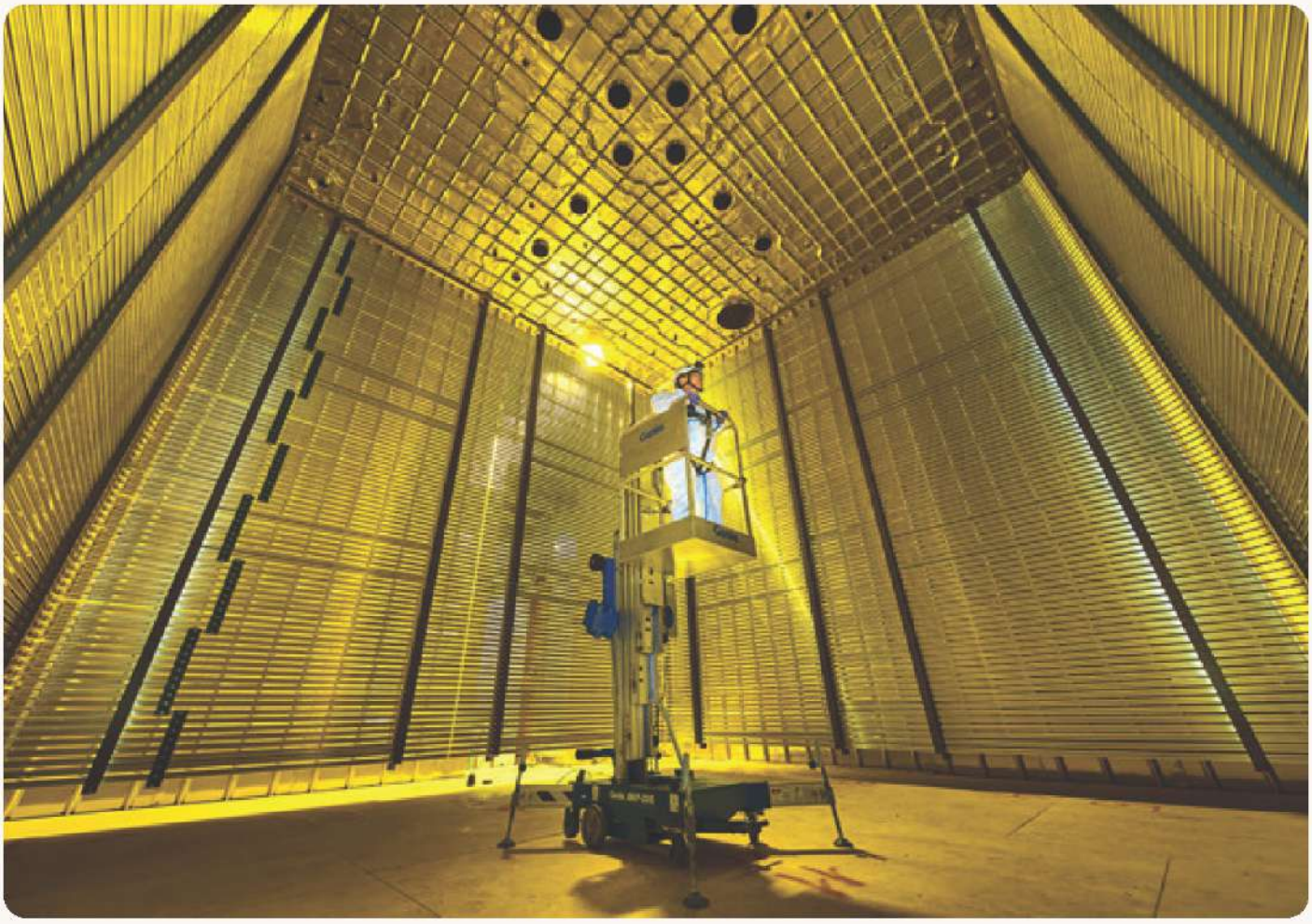
- Large Campus: ₹10,000,000 - ₹100,000,000 [35].
- Community Hall: ₹1,000,000 - ₹5,000,000 [35].

Example

- Project Name : Sewing Machine Program (BCCL)
- Country: Jharkhand, India

33.

PHYSICS LABS



Description

Physics labs can be established in underground mine voids to conduct specialized research.

Prerequisite Conditions

- Stable power and backup [3]
- Low vibration/noise environment [7]
- High-speed data connectivity [13]
- Building stability per BIS [11]

33.

PHYSICS LABS

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
UG Access (Shaft/Decline)	Yes	Requires modification	Not present
Geotechnical stability (RMR)	>70	50-70	<50
Grid Power	Reliable redundant supply	Single grid connection	Unreliable connection
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

- Any Scale: ₹50,000,000 - ₹500,000,000 [36].

Example

- Project Name : SNOLAB (Creighton Mine)
- Country: Canada

34.

GEO REPOSITORIES

Description

Geo repositories can be used for the long-term storage of geological samples and CORE data.

Prerequisite Conditions

- Long-term stability and controlled environment [11]
- UG access/handling safety [12]
- ES compliance [2]

34.

GEO REPOSITORIES

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low
UG Access (Shaft/Decline)	Yes	Requires modification	Not present
Geotechnical stability (RMR)	>70	50-70	<50
Water control	Excellent	Requires active pumping	Not possible

CAPEX

- Any Scale: ₹20,000,000 - ₹200,000,000 [37].

Example

- Project Name : Ruhr Region Mines
- Country: Germany

35.

R&D SITES

Description

R&D sites can be developed for research into new technologies, such as carbon capture or renewable energy.

Prerequisite Conditions

- Utilities (power, water, telecom) [3,20,13]
- Policy alignment and land tenure [10,8]
- Access and logistics [17,16]

35.

R&D SITES

Feasibility Ranges

Factor	Highly Feasible	Moderately Feasible	Non-Feasible
Stable land area (ha)	>5	5 to 1	<1
Water access	Reliable	Seasonal	Not present
Grid Power	Reliable redundant supply	Single grid connection	Unreliable connection
Land/Water area	Large	Moderate	Small
Slope (%)	0–5	5–10	>10
Stability (FoS)	>1.5	1.2–1.5	<1.2
Proximity (km)	<10	10–20	>20
Community acceptance	High	Medium	Low

CAPEX

- Case Specific

Example

- Project Name : Sanford Underground Research Facility (SURF)
- Country: South Dakota, USA

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3.9
Conclusion: Reclaiming Possibilities

Repurposing post-closure land is about transforming something once deemed unusable into a resource that provides value for people, the environment, and the economy. Post-closure development is a powerful tool for turning challenges into opportunities. With thoughtful planning and interventions, active community engagement, innovative solutions and the right sustainable practices, you can create new opportunities that benefit all stakeholders concerned, foster long-term sustainability and create lasting value in communities.

Remember, the land has potential—it's up to you to unlock it.

ECOSYSTEM REHABILITATION & REGENERATIVE ENVIRONMENTAL RESTORATION

4.1
Understanding Ecosystem Rehabilitation & Regeneration

When we talk about ecosystem rehabilitation and regenerative environmental restoration, we are focusing on healing and re-creating a functioning ecosystem that can support native and local plants, animals, and natural processes once again. It's more than just fixing environmental damage; it's about building resilience, restoring biodiversity, and creating a system that can continue to regenerate on its own.

Ecosystem Rehabilitation & Regenerative Environmental Restoration refers to the process of restoring ecosystems that have been degraded, damaged, or destroyed. It involves improving the health of ecosystems to ensure that they can once again perform their ecological functions. While restoration often focuses on bringing ecosystems back to their pre-disturbed state, regenerative restoration goes a step further, aiming not only to restore but to improve the resilience, diversity, and functionality of ecosystems.

The idea is to shift from traditional "restoration" practices, which often aim to simply "bring back" what was there before, to a more holistic, regenerative approach that nurtures the land, making it self-sustaining and resilient to future challenges.

4.2
Principles of Ecosystem Rehabilitation & Regenerative Environmental Restoration

1. Understanding the Ecosystem's Ecological Functions

Before beginning any restoration effort, it's crucial to understand the natural processes and functions of the ecosystem you're working to restore. This includes studying the soil types, water cycles, flora, and fauna that define the ecosystem's health and stability.

Key Elements to Consider:

- **Soil health and fertility:** Assessing the condition of the soil, its composition, organic matter content, and ability to retain water.
- **Water management:** Understanding how water moves through the ecosystem, which is critical for maintaining both plant and animal life.
- **Biodiversity:** Identifying native and local species that are key to the ecosystem's functioning.

2. Focusing on Resilience, Not Just Restoration

In traditional restoration, the goal is often to return an ecosystem to its original state. However, with modern challenges such as climate change, it's becoming clear that ecosystems must be resilient and able to adapt to changing conditions. Therefore, regenerative restoration goes beyond simple restoration to focus on making ecosystems stronger and more resilient to future disturbances.

Key Considerations for Building Resilience:

- **Diversity:** Ensuring a variety of species (plants, animals, microorganisms) to support ecosystem stability.
- **Connectivity:** Creating corridors that allow species to move and adapt as needed.
- **Adaptability:** Using species that can withstand climate shifts or changes in land use.

3. Involving Stakeholders: A Collaborative Approach

Ecosystem rehabilitation and restoration are not just scientific and technical tasks; they are social processes too. For restoration to be sustainable, local communities, indigenous knowledge, government bodies, and other stakeholders must be actively involved. This helps ensure that the restoration efforts align with local needs and traditional ecological knowledge, which can be pivotal for success.

4.3
Approach for Ecosystem Rehabilitation & Regenerative Environmental Restoration

1. Soil Restoration

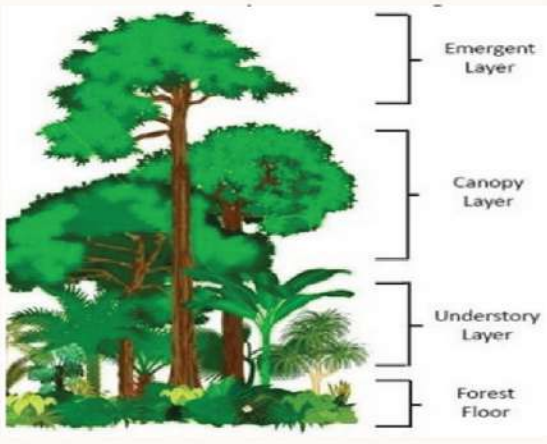
Soil is the foundation of any ecosystem, and its health is critical to successful restoration. When soil is degraded, techniques like composting, biochar addition, and revegetation with native species can help restore its fertility and improve water retention.

Key Soil Restoration Techniques:

- Composting and mulching to add organic matter back to the soil.
- Biochar to enhance soil fertility and water retention.
- Cover crops to prevent soil erosion and enhance microbial activity.

2. Reforestation and Afforestation: Rebuilding Ecosystem Canopies

Forests play a crucial role in maintaining ecosystem health by regulating water cycles, storing carbon, and supporting biodiversity. Reforestation (restoring forests in previously forested areas) and afforestation (creating new forests in non-forested areas) are key methods for ecosystem rehabilitation. However, it's not just about planting trees; it's about planting the right trees. Selecting species that are native and suited to local conditions is essential for long-term success.



3. Water Management: Restoring Hydrological Functions

Water is the lifeblood of ecosystems. Restoring the hydrological function of an area by improving water infiltration, enhancing flood resilience, and reintroducing natural water courses, is essential in many restoration projects. This can be done by constructing wetlands, swales, or rain gardens that restore natural water flow.

4. Biodiversity

A diverse mix of plant, animal, and microbial life supports essential ecological functions such as pollination, seed dispersal, pest control, and nutrient cycling. Restoration efforts should prioritize re-establishing a balanced community of native and locally adapted species that interact to form a stable, self-sustaining system. This includes using a variety of vegetation types (trees, shrubs, groundcovers), creating wildlife corridors to connect fragmented habitats, protecting keystone and culturally significant species, and controlling invasive species that threaten native ecosystems. Enhancing biodiversity not only improves ecological resilience but also increases the long-term success and sustainability of restoration projects.

Dendrocalamus strictus
(Bamboo)

Ficus benghalensis
(Banyan/ Marri)

Ficus religiosa
(Bodhi tree/ravi)

Acasia nilotica
(Babul)

Azadirachta indica (Neem)

4.4
Monitoring and Adaptive Management

Restoration is not a one-time effort. It's an ongoing process that requires continuous monitoring to assess its success and make adjustments. Adaptive management involves regularly reviewing the project's progress, learning from experience, and adapting strategies as needed.

Key Monitoring Techniques:

- Ecological surveys to track species populations and habitat health.
- Water and soil testing to monitor improvements in quality.
- Remote sensing technologies to observe changes in vegetation cover and land use.

Tips for Practitioners

- Conduct a comprehensive baseline & site assessment, including soil tests & quality, hydrology, biodiversity, water movement, water quality monitoring, and surveys of flora and fauna to guide species selection and restoration interventions.
- Understand local hydrology by studying water movement, infiltration, and surface runoff to guide water management practices such as contour planting and swales.
- Design water management systems (e.g., swales, rain gardens) that mimic natural hydrological cycles, improving water retention and supporting vegetation growth.
- Identify and remove invasive species which hinder the establishment of native plants.

- Conduct pilot planting trials to identify resilient, well-adapted species and allow for adjustments before full implementation, reducing the risk of large-scale failure.
- Enhance soil fertility and microbial activity by incorporating organic matter such as compost, biochar, or green manure to improve soil quality.
- Prioritize soil health by reintroducing organic matter, addressing compaction, and enhancing microbial diversity.
- Focus on soil stabilization and erosion control techniques like mulching, fast-growing grasses, and the construction of check dams or retaining walls.
- Implement a three-tier plantation system with native species: lower tier grasses for soil stabilization, middle tier shrubs/bushes for biodiversity, and upper tier trees for carbon sequestration and habitat.
- Incorporate Miyawaki plantations and permaculture principles to design restoration projects, optimizing land use for sustainability.
- Use natural fertilizers and organic materials rather than chemical treatments, which can harm long-term soil health and biodiversity.
- Work with natural processes by allowing ecosystems to regenerate through techniques that enhance natural succession and restore ecological functions.
- Integrate natural succession by supporting pioneer species that prepare the environment for more complex plant communities.
- Integrate the regeneration and sustainable harvesting of Minor Forest Produce (MFP), Tree-Borne MFP (TMFP), medicinal plants, fruit-bearing trees, etc., which support both biodiversity and local livelihoods.
- Focus on creating functional habitats for wildlife, such as adding water features (ponds, wetlands), shelters, or specific plant species to support particular species.
- Strengthen ecological connectivity by developing links between the site and surrounding forested areas, enabling wildlife movement and genetic flow between habitats.
- Promote ecosystem connectivity by creating wildlife corridors and green spaces to link smaller restoration projects to larger conservation areas for improved landscape-level resilience.
- Build climate resilience by selecting species that can tolerate extreme weather conditions and consider future climate shifts in your restoration strategy.
- Incorporate a variety of restoration techniques, such as direct seeding, plant propagation, and natural regeneration, to suit the specific needs of the ecosystem you are restoring.
- Incorporate traditional and local knowledge by involving local communities in the restoration process and leveraging their understanding of the land and ecological practices.
- Involve local communities in the planning and implementation stages, ensuring restoration activities meet both ecological and socio-economic needs.

- Ensure that restoration projects bring tangible socio-economic benefits to the community, such as through community forests, sustainable agriculture, or ecotourism.
- Foster a continuous learning approach, allowing practitioners to adapt and improve their methods based on successes and challenges encountered in restoration projects.
- Build partnerships and collaborate with academic institutions, research bodies, government agencies, and environmental organizations to integrate scientific research, share expertise, and strengthen restoration efforts.
- Leverage technology such as drones, remote sensing, ecological modelling software (species distribution models, habitat suitability models, dynamic vegetation models), and GIS mapping to enhance data collection, track land recovery, and monitor ecological changes over time.
- Establish clear monitoring indicators such as vegetation growth, soil quality, and species diversity, and regularly evaluate progress using both traditional and modern technologies.
- Continuously monitor the restored area, tracking plant survival, biodiversity recovery, and other ecological indicators to guide adaptive management.
- Regularly review the success of your restoration efforts through ecological surveys, analyzing changes in species composition and ecosystem functions.
- Plan for long-term sustainability by including regular monitoring, weed control, and replanting, with community involvement in maintenance efforts.
- Engage with stakeholders and local communities to secure resources and support for ongoing maintenance and stewardship.
- Be patient and set realistic expectations, understanding that ecosystem restoration is a long-term process that requires ongoing adaptive management.

Do's	Don'ts
Conduct thorough baseline assessments before starting.	Don't ignore or skip initial site assessments.
Start with small, manageable restoration projects to build momentum.	Don't tackle the entire project at once without prioritization.
Prioritize enhancing soil health with organic methods.	Don't rely on chemical fertilizers or synthetic inputs.
Involve local communities and integrate their knowledge.	Don't disregard local cultural practices or stakeholder needs.
Monitor and track ecological progress throughout the project.	Don't assume that the project is progressing without regular checks.
Select native species that are adapted to the local environment.	Don't introduce invasive species or non-native plants.
Focus on restoring natural water cycles and improving water infiltration.	Don't overlook water management or assume natural processes will self-correct.
Establish wildlife corridors and create diverse habitats.	Don't create isolated, disconnected habitats.
Build resilience by considering climate change and future environmental shifts.	Don't plan without considering future environmental changes.
Use adaptive management practices to refine your approach as you go.	Don't stick rigidly to a plan if it's not working.
Plan for the long-term sustainability and maintenance of the restoration site.	Don't abandon the site after initial efforts.
Work with interdisciplinary teams and collaborate with experts.	Don't work in isolation or neglect the need for expert advice.
Factor in the social and economic impacts of restoration efforts on local populations.	Don't ignore the human impact of environmental restoration.
Implement erosion control measures early in the restoration process.	Don't wait until erosion becomes a significant issue.
Align your restoration efforts with broader conservation goals and policies.	Don't operate without understanding broader environmental frameworks.
Set clear, incremental goals with realistic timelines.	Don't set vague or overly ambitious goals that aren't achievable.

4.5
Field Checklist: Ecosystem Rehabilitation & Regenerative Restoration

Pre-Project Preparation

- **Conduct a Baseline Assessment:**
  - Soil quality tests (pH, texture, organic matter, fertility)
  - Water quality and hydrology study (water sources, flow patterns, infiltration)
  - Flora and fauna survey (species identification, biodiversity count)
  - Site topography and mapping (elevation, slope, erosion risk)

- **Engage Stakeholders:**
  - Meet with local communities and indigenous groups
  - Align goals with community needs and concerns
  - Collect traditional ecological knowledge, if relevant

- **Develop Restoration Plan:**
  - Define project scope, goals, and timeline
  - Identify high-priority areas for intervention
  - Set clear, measurable success indicators (e.g., biodiversity increase, soil fertility)

Site Preparation

- **Clear Area for Restoration:**
  - Remove invasive species, if applicable
  - Clear debris or non-native vegetation
  - Avoid over-disturbing soil or ecosystem

- **Assess Erosion Control Needs:**
  - Install erosion barriers (e.g., silt fences, check dams, mulching)
  - Plan for water diversion or runoff management

- **Set Up Water Management Systems:**
  - Dig swales, rain gardens, or ponds as needed for water infiltration Improve or restore natural water courses and hydrological features

Restoration Actions

- **Soil Restoration:**
  - Apply compost, mulch, or biochar where necessary
  - Use cover crops to prevent erosion and improve soil fertility
  - Implement soil de-compaction techniques if needed (e.g., deep-tilling or aeration)

- **Planting:**
  - Select and plant native species suitable for local conditions (trees, shrubs, ground cover)
  - Ensure proper spacing and planting depths
  - Include a variety of species to promote biodiversity (e.g., nitrogen-fixing plants, food sources for wildlife)

- **Reintroduce Wildlife Habitat:**
  - Install birdhouses, bat boxes, or insect hotels for pollinators
  - Create or restore wildlife corridors for species movement
  - Add water features, like small ponds or wetlands, to support biodiversity

Ongoing Monitoring

- **Ecological Monitoring:**
  - Conduct regular plant survival and growth assessments (monthly, quarterly)
  - Track species diversity (flora and fauna) and ecosystem health indicators
  - Measure soil health (organic matter levels, erosion rate, nutrient cycles)

- **Water Quality & Hydrology Monitoring:**
  - Test water quality periodically (pH, turbidity, contaminants)
  - Monitor water flow patterns to ensure natural hydrological functions are restored

- **Evaluate Erosion & Sedimentation Control:**
  - Inspect erosion-prone areas (slopes, riverbanks) for stability
  - Check erosion control measures regularly for effectiveness
  - Repair or replace damaged barriers and drainage systems as needed

Post-Restoration Actions

- **Evaluate Ecosystem Recovery:**
  - Conduct a comprehensive post-restoration assessment (compare to baseline data)
  - Identify areas requiring further intervention or long-term management

- **Stakeholder Feedback & Involvement:**
  - Engage the community to assess their satisfaction with the restoration results
  - Collect feedback and suggestions for future efforts or ongoing care

- **Establish Long-Term Maintenance Plan:**
  - Schedule regular maintenance (e.g., weeding, invasive species control)
  - Plan for continued community involvement and stewardship
  - Ensure continued monitoring and adaptive management based on progress

Documentation & Reporting

- **Maintain Detailed Records:**
  - Document all activities, inputs, and observations (planting dates, soil amendments, species used)
  - Record changes in ecosystem health (biodiversity surveys, water quality, soil tests)

- **Report Findings to Stakeholders:**
  - Provide progress reports to community members, funders, or government agencies
  - Share lessons learned and best practices for future restoration projects

This field checklist provides a structured approach to help ensure the key steps of ecosystem rehabilitation and restoration are effectively planned, executed, and monitored, leading to successful and sustainable outcomes.

4.6
Conclusion: A Regenerative Future

Ecosystem rehabilitation and regenerative environmental restoration are not just about repairing damaged landscapes but about revitalizing ecosystems so they can thrive and regenerate on their own. By focusing on understanding ecological functions, building resilience, and working collaboratively with stakeholders, we can restore ecosystems to a state that supports biodiversity, improves soil and water quality, and adapts to future challenges. This regenerative approach offers a pathway to a more sustainable and ecologically balanced future.

SUSTAINABILITY AND STEWARDSHIP

5.1
Introduction to Sustainability and Stewardship

In the context of mine closure, sustainability is not just about completing a project; it's about ensuring that the restored ecosystems, communities, and processes remain viable long after the initial efforts have been completed. Similarly, stewardship refers to the responsible management and care of resources, landscapes, and ecosystems, ensuring they are protected, enhanced, and sustained for future generations.

As practitioners, we must not only focus on immediate restoration but also design systems that are resilient and adaptable over time. This involves creating sustainable systems, managing resources efficiently, and ensuring that both ecological and community outcomes can be maintained long term.

This chapter will provide foundational concepts and practical strategies for integrating sustainability and stewardship into responsible mine closure efforts.

5.2
Principles of Sustainability

1. Ecological Sustainability: Maintaining Ecosystem Integrity

Ecological sustainability refers to maintaining or restoring the integrity and functionality of ecosystems. This involves protecting the biodiversity, water quality, and soil health that allow ecosystems to thrive in the long term. Ecosystem services, ranging from cultural and recreational benefits to regulating and supporting functions, must be preserved to ensure continued ecological balance.




Key Practices for Ecological Sustainability:

- **Promoting biodiversity:** Restoring a variety of native species and creating habitat corridors for wildlife movement.
- **Ensuring ecosystem resilience:** Designing restoration projects that are adaptive and able to withstand future stresses, like climate change.
- **Soil and water conservation:** Implementing methods like no-till farming, wetland restoration, and water-efficient agriculture.


Tip for Practitioners:

- Work with, Not Against, Natural Processes.
- Always prioritize local species restoration and resilience-building techniques.
- Restoring ecological balance is about more than reintroducing plants and animals; it's about ensuring they can thrive in an ever-changing world.
- Assess the broader ecosystem like watersheds, wildlife corridors, and land-use patterns, to ensure that restoration fits into the regional ecological context.
- Map degraded vs. intact zones, invasive species hotspots, and natural regeneration areas before interventions.
- Support natural regeneration where possible instead of relying solely on artificial planting.

- Maintain and encourage processes like seed dispersal, pollination, succession, and soil regeneration.
- Use locally adapted, indigenous species in restoration to promote ecological resilience.
- Avoid fast-growing exotics that may become invasive or alter soil and hydrological conditions.
- Minimize soil disturbance during interventions. Use mulching, cover crops, or erosion control structures to protect topsoil.
- Monitor for compaction, erosion, or nutrient depletion, especially in areas previously logged or farmed.
- Incorporate varied plant heights, layers (canopy, understory, ground cover), and microhabitats to support a wide range of fauna.
- Leave deadwood, rocks, and logs on-site to provide essential habitats for decomposers and ground-dwelling species.
- Protect and restore wetlands, riparian buffers, and natural drainage systems.
- Avoid altering water flows with hard infrastructure unless absolutely necessary; use nature-based solutions instead.
- Hiring locally builds stewardship and ensures that restoration methods are culturally appropriate and grounded.
- Avoid short-term fixes. Design interventions with a 10–50-year perspective, accounting for climate change, species migration, and socio-economic shifts.
- Use low-maintenance, self-sustaining systems wherever possible.
- Create buffer zones between restored areas and ongoing land-use (agriculture, industry) to reduce edge effects and protect restored zones from external pressures.
- Work with local communities, farmers, and indigenous groups. They often possess deep knowledge of the land and its rhythms.
- Set up simple, repeatable monitoring protocols for key indicators: vegetation cover, species return, water quality, etc.
- Be ready to adjust techniques based on changing conditions or unexpected outcomes (adaptive management).

■ Do's	✕ Don'ts
Use native and local species adapted to the ecosystem.	Don't use exotic or non-native species that could become invasive.
Support natural regeneration whenever possible.	Don't rely solely on artificial planting without assessing natural recovery potential.
Maintain soil structure and fertility. Use minimal disturbance.	Don't over-dig, compact, or strip the topsoil unnecessarily.
Protect and restore natural water flows (streams, wetlands).	Don't block or alter water courses with hard infrastructure.
Encourage biodiversity and structural variety (canopy, understory, ground).	Don't create monocultures or overly simplified ecosystems.
Incorporate deadwood, rocks, and habitat features for wildlife.	Don't "clean up" all debris—many organisms rely on decaying matter.
Monitor outcomes and adapt management over time.	Don't assume the plan is final. Nature changes, and so must your approach.
Engage local communities and incorporate their knowledge.	Don't ignore traditional ecological knowledge or community input.
Plan for climate change and long-term resilience.	Don't choose species or designs vulnerable to future climate stress.
Use low-impact, sustainable materials and methods.	Don't depend on chemical inputs or energy-intensive techniques.
Align your project with legal protections and conservation policies.	Don't overlook local laws, protected areas, or conservation agreements.
Include maintenance and stewardship plans post-restoration.	Don't walk away after planting. Continuous care is critical for success.

Field Checklist for Practitioners

- Field Checklist for Practitioners
- Is there a baseline survey for comparison?
- Have I mapped the surrounding ecosystems, land use, and natural features?
- Is this site connected to larger wildlife corridors or protected areas?
- Have I identified key ecological stressors (erosion, invasive species, hydrological changes)?
- Are there any culturally or ecologically significant species or habitats to protect?
- Am I using native species suited to the region?
- Are my species selections also locally adapted (local ecotypes)?
- Have I avoided invasive or exotic species?
- Are the chosen species functionally diverse (trees, shrubs, ground cover, pollinators)?

- Have I restored or protected natural water flows (streams, wetlands, drainage)?
- Are natural processes like decomposition, seed dispersal, and pollination supported?
- Have I retained deadwood, logs, and natural materials as habitat?
- Are there features supporting fauna (e.g., bird perches, nesting areas, insect hosts)?
- Have I planned for climate resilience (e.g., drought-tolerant species, fire breaks)?
- Am I using low-impact tools and machinery?
- Are locally sourced materials (mulch, compost, rocks) being used where possible?
- Are interventions designed to be low-maintenance in the long term?
- Have I consulted or involved local communities, farmers, or indigenous groups?
- Is there a plan for local capacity-building or training?
- Are restoration goals aligned with local land use and cultural practices?
- Are there clear, measurable indicators (e.g., vegetation cover, species return)?
- Is there a schedule for ongoing monitoring (e.g., 6 months, 1 year, 5 years)?
- Is an adaptive management plan in place to adjust strategies over time?
- Is the site designed to function with minimal human input over time?
- Is funding or local support available for long-term maintenance?
- Are education or awareness activities included to build long-term stewardship?
- Optional Field Tools
    - GPS or smartphone for mapping
    - Soil testing kit
    - Plant ID guide or app
    - Data sheets or mobile monitoring tools
    - Camera for photo documentation

2. Economic Sustainability: Ensuring Financial Viability

Economic sustainability means developing solutions that provide long-term financial stability for projects and the surrounding communities. By aligning mine closure with economic development, projects can generate revenue, create jobs, and support local economies while promoting environmental health.

Key Approaches for Economic Sustainability:

1. Diversify Income Sources

- Encourage multiple revenue streams (e.g., ecotourism, sustainable harvesting) to reduce financial risks.
- Support local enterprises tied to sustainable natural resource use.

2. Promote Resource Efficiency

- Optimize use of inputs like water, energy, and materials to reduce costs and environmental impact.
- Implement technologies and practices that minimize waste.

3. Invest in Capacity Building

- Provide training and education to local communities and stakeholders for sustainable business and resource management.
- Foster entrepreneurship and innovation aligned with sustainability goals.

4. Support Market Access for Sustainable Products

- Develop and strengthen value chains for sustainably produced goods (e.g., certified timber, organic crops).
- Facilitate connections between producers and buyers emphasizing sustainability credentials.

5. Implement Sustainable Financial Mechanisms

- Use Green financing, carbon credits, or biodiversity offsets to generate additional income and link with other finance leverage Plan/scheme.
- Develop microfinance, SME, MSME, etc. focused on sustainable initiatives.

6. Encourage Long-Term Planning and Risk Management

- Account for environmental risks in economic decision-making.
- Promote flexible business models that can adapt to changing conditions.

7. Align Economic Activities with Social and Environmental Goals

- Ensure that economic benefits support community well-being and ecological health.
- Foster inclusive participation to balance profit with fairness and sustainability.

Tips for Practitioners:

- Start with small-scale income activities and scale up based on community interest and results. Don't launch large-scale enterprises without testing viability.
- Promote a diverse mix of livelihoods (e.g. agroforestry, eco-tourism, small-scale farming, beekeeping) to reduce economic risk. Don't rely on a single source of income or market.
- Ensure all economic activities are environmentally sustainable; they should restore or protect ecosystems, not degrade them. Don't promote income strategies that harm the environment.
- Build on existing local skills, traditions, and resources to ensure economic activities are realistic and community-owned. Don't impose unfamiliar or overly complex business models.
- Involve communities in planning, implementation, and benefit-sharing to build long-term ownership and accountability. Don't control projects from outside or leave communities out of planning.
- Use low-cost, locally available materials and tools to increase affordability and replicability. Don't create dependency on expensive or imported equipment.
- Encourage the formation of group enterprises or cooperatives to improve efficiency, market access, and resource sharing. Don't overlook the power of collective organization and shared responsibility.
- Identify and connect to reliable markets early; Don't wait until after production to consider where and how to sell.
- Provide training in financial literacy, including budgeting, saving, pricing, and record-keeping.
- Include financial planning for ongoing maintenance and future expansion from the start. Don't assume people already have the skills to manage small enterprises.
- Support the creation of community savings groups or microfinance access to enable small investments in sustainable activities.
- Continuously monitor the economic outcomes of projects (e.g. increased income, cost savings, reinvestment in land or tools). Don't ignore results—what works in one place may not work in another.

Do's	Don'ts
Build trust through consistent field presence and follow-up.	Don't disappear after initial training or project launch; ongoing support matters.
Co-design economic activities with the community, not for them.	Don't bring in pre-designed models without adapting to local realities.
Encourage experimentation and learning from failure.	Don't treat failure as a sign of project collapse; use it to refine approaches.
Support informal income strategies as valid pathways (e.g., small trades, seasonal work).	Don't overlook or undervalue informal or non-traditional economic practices.
Include youth and women in enterprise training and leadership roles.	Don't let dominant groups monopolize project benefits or decision-making.
Assess the community's appetite for risk before introducing enterprise models.	Don't assume everyone is ready or willing to take business risks immediately.
Stay flexible; adjust project goals to fit changing economic conditions.	Don't rigidly follow a plan that no longer suits the market or local needs.
Encourage gradual independence from donor support or external inputs.	Don't create reliance on continuous outside funding for basic operations.
Use visuals, real-life examples, and hands-on methods during training.	Don't rely heavily on written materials or theory in low-literacy contexts.
Track unintended consequences (e.g., overuse of land due to income pressure).	Don't focus only on profits.

Field Checklist

Use this checklist during project planning, implementation, and monitoring phases to ensure that economic aspects of your work are practical, community-owned, and ecologically sound.

A. Planning Phase

- Have I conducted a basic livelihood assessment of the community?
- Did I consult different social groups (e.g., youth, women, elders, informal workers)?
- Have I identified existing local income-generating practices that are already working?
- Are the proposed activities aligned with local skills and interests?
- Have I discussed the community's tolerance for risk and change?

- Are there multiple income streams being considered (not just one main idea)?
- Did I map out market access and potential buyers or demand for products/services?

B. Implementation Phase

- Have I ensured active community involvement in decision-making and setup?
- Is there a plan to train participants in financial and business skills?
- Are tools, inputs, and materials affordable and locally available?
- Are we using low-risk models (e.g., pilot project) to start?
- Is there support for women and marginalized groups to participate equitably?
- Are income-generating activities designed to be ecologically sustainable?

C. Monitoring & Adaptation Phase

- Am I tracking both financial outcomes (e.g., income, savings) and non-financial benefits (e.g., confidence, resilience)?
- Have any unintended consequences emerged (e.g., overuse of land, conflict)?
- Is there a plan to scale or replicate successful models gradually?
- Are local groups or individuals increasingly taking ownership of activities?
- Are adjustments being made based on real-time feedback and results?

D. Long-Term Viability

- Have I developed a simple maintenance plan with community input?
- Is there a system for saving, reinvestment, or cooperative management?
- Have I identified local partners or institutions for continuous support or mentorship?
- Are the benefits likely to continue without external funding?

Field Tip

Use this checklist periodically, not just once. Economic sustainability isn't a one-time decision; it evolves with the project.

3. Social Sustainability: Supporting Local Communities

For mine closure efforts to be sustainable, they must be supported by local communities. Social sustainability ensures that communities can benefit from mine closure, both economically and socially, and that their cultural values and knowledge are respected.

Key Strategies for Social Sustainability:

- **Community engagement:** Involve local communities in decision-making and restoration planning to ensure their needs and knowledge are considered.

- **Community engagement:** Involve local communities in decision-making and restoration planning to ensure their needs and knowledge are considered.
- **Job creation and skill development:** Provide training and employment opportunities in restoration activities, such as habitat restoration, sustainable agriculture, and green energy projects.
- **Equitable access:** Ensure that local people have access to restored resources, whether it's clean water, forests for gathering or recreational spaces, etc.

Tips for Practitioners

- Involve community members from day one. Don't wait until later stages to seek input.
- Identify and actively include marginalized groups (women, youth, elders, minorities) who are often left out. Don't allow dominant groups to control discussions or decisions.
- Take time to listen carefully to local stories, concerns, and traditional knowledge. This builds trust and relevance.
- Use participatory methods like community mapping, focus groups, and storytelling instead of just surveys or lectures.
- Build local leadership by mentoring individuals who can champion the project within their communities.
- Keep communication clear, simple, and frequent. Avoid jargon and use local languages or visuals.
- Be aware of existing social tensions or conflicts; address these early and involve neutral facilitators if needed.
- Design activities that fit community daily rhythms; don't disrupt important cultural or livelihood practices.
- Encourage peer learning and exchange visits so communities can learn from each other's successes and challenges.
- Plan for ongoing support and follow-up, as social dynamics change and projects need to adapt.
- Promote shared ownership of outcomes, so benefits aren't concentrated in a few hands but spread widely.
- Respect local decision-making structures, but gently challenge exclusionary practices when needed.
- Document and celebrate small wins and stories of positive change to motivate ongoing participation.
- Prepare for long-term engagement; social sustainability doesn't happen overnight or end when funding stops.

Do's	Don'ts
Do show genuine respect and humility toward the community.	Don't come with a "savior" mentality or act superior.
Do practice patience; social change takes time.	Don't expect immediate buy-in or fast results.
Do prioritize building relationships before pushing agendas.	Don't rush implementation without building trust.
Do listen more than you speak.	Don't dominate conversations or dismiss community input.
Do remain culturally sensitive and aware of social norms.	Don't impose values or practices that conflict with local culture.
Do ensure transparency about project goals and limitations.	Don't make promises you can't keep or overpromise outcomes.
Do be flexible and ready to change plans based on feedback.	Don't rigidly stick to a plan that isn't working socially.
Do support community empowerment and self-determination.	Don't create dependency on outside support or expertise.
Do maintain confidentiality and respect privacy when needed.	Don't disclose sensitive information or break trust.

Field Checklist: Social Sustainability for Practitioners

Use this checklist before, during, and after project implementation to ensure your work supports inclusive, resilient, and community-led outcomes.

A. Community Engagement & Inclusion

- Have I met with a wide range of community members, not just local leaders?
- Are women, youth, elders, and marginalized groups actively involved in project planning?
- Have I conducted informal conversations or visits to understand community dynamics?
- Is community feedback actively shaping project goals and methods?
- Have I identified and included both formal and informal local leaders?
-
- Participation & Ownership
- Are project activities scheduled at times and locations that work for the community?
- Are roles and responsibilities shared and clearly understood by all groups involved?

Cultural Sensitivity & Trust

- Have I taken time to understand local customs, language, and practices?
- Am I using locally appropriate communication tools (e.g., visuals, local language, storytelling)?
- Are local traditions and knowledge respected and incorporated into project design?
- Have I taken care not to disrupt important cultural or livelihood routines?

Equity & Social Dynamics

- Are project benefits being shared fairly across different social groups?
- Have I assessed any existing conflicts or tensions that may affect participation?
- Is there a plan to resolve disputes or misunderstandings quickly and fairly?
- Have I identified and avoided reinforcing power imbalances or social exclusion?

Sustainability & Follow-up

- Are there local systems or groups in place to continue project activities after external support ends?
- Is the project helping build community confidence, skills, or networks?
- Are there clear next steps the community agrees with after the project phase ends?
- Have I committed to follow-up visits or communication to support continuity?

Field Tip:
Use this checklist with the community when possible. Turning it into a participatory discussion tool builds trust and shared understanding.

6.3
Stewardship: The Long-Term Care of Restored Ecosystems

Stewardship is the ongoing, long-term care of ecosystems and natural resources after restoration has been completed. It's about ensuring that the efforts put into restoration are maintained and that ecosystems continue to function and evolve over time.

Key Aspects of Stewardship:

- Monitoring and evaluation: Implement a robust monitoring system to track the health and progress of the ecosystem post-restoration.
- Adaptive management: Use the data gathered through monitoring to adapt and adjust management practices to better address emerging challenges.
- Community involvement: Empower local communities to take responsibility for the continued care of the ecosystem.

Tip for Practitioners:

Establish a stewardship plan that includes continuous monitoring and adaptive management. The success of your project depends not only on its initial restoration but also on its care and evolution over time.

6.4
Building Resilience into Stewardship Plans

The challenges of today like climate change, biodiversity loss, and resource depletion, require that our stewardship plans are flexible and capable of responding to uncertainty. Building resilience into these plans ensures that ecosystems can withstand shocks and continue to evolve positively.

Strategies for Building Resilience:

- Diversifying restoration techniques: Use a mix of methods, such as natural regeneration and active planting, to ensure ecosystems can thrive under a range of conditions.
- Climate adaptation strategies: Consider future climate scenarios and integrate adaptive measures such as planting climate-resilient species or improving water management systems.
- Building community networks: Resilient stewardship depends on strong local networks that can mobilize and respond to crises, whether natural disasters or environmental threats.

Tip for Practitioners:
Plan for future uncertainties by building flexible, adaptive strategies into your stewardship approach. Climate resilience and community engagement are essential for long-term success.

Tips for Practitioners

- Build genuine relationships with community members through regular visits and open dialogue. Don't rush relationship-building or skip community consultations.
- Recognize and involve all relevant stakeholders, including informal user groups and elders.
- Respect and incorporate traditional knowledge and local customs in resource management plans.
- Encourage communities to take ownership by involving them in setting rules and monitoring activities.
- Keep stewardship activities simple and manageable to ensure they can be sustained without heavy external input.

- Use participatory monitoring methods that community members can easily apply and understand.
- Provide hands-on training and refreshers to strengthen local capacity for managing natural resources. Don't rely solely on one-time workshops or lectures.
- Facilitate clear, written or visual resources and materials about resource use, responsibilities, and consequences.
- Be flexible and ready to adapt stewardship plans when ecological or social conditions change.
- Promote shared responsibility rather than putting the burden on a single group or individual.
- Identify and support local champions who can inspire and lead stewardship efforts.
- Encourage celebrating milestones and successes to maintain motivation and community pride.
- Address conflicts quickly with neutral facilitation to prevent long-term damage to community trust.
- Plan for ongoing support and connection even after initial project funding ends.

Do's	Don'ts
Do let community members define what stewardship means to them.	Don't assume one definition or model of stewardship fits all contexts.
Do observe quietly first to understand existing informal practices.	Don't jump in with tools or frameworks without understanding the setting.
Do support ongoing informal conversations, not just structured meetings.	Don't rely only on formal training or workshops to drive engagement.
Do identify natural stewards (e.g. farmers, elders, youth leaders) who already care for the	Don't overlook quiet contributors who aren't in leadership roles.
Do make stewardship visible through signs, stories, or demonstration plots.	Don't assume people will stay motivated without seeing results or recognition.
Do use stewardship to strengthen community ties, not just care for the land.	Don't treat stewardship as only technical or environmental—it's social too.
Do be honest when the project or partner can't meet a community request.	Don't overpromise or raise expectations you can't support long term.
Do encourage small, consistent actions (e.g. monitoring, patrolling, planting).	Don't push for high-effort activities that aren't realistic to maintain.
Do allow for flexibility in rules to adjust as needed over time.	Don't enforce rigid rules that don't reflect changing conditions or needs.
Do recognize and respect local taboos, sacred areas, or cultural boundaries.	Don't unknowingly violate places or practices of cultural significance.

Field Checklist: Stewardship

Use this checklist at different stages of your project (planning, implementation, and follow-up) to ensure stewardship is community-driven, ecologically sound, and sustainable.

A. Planning & Relationship Building

- Have I taken time to build trust with the local community before introducing stewardship plans?
- Have I identified key community members, traditional leaders, and resource users?
- Have I held informal discussions to understand local resource use, customs, and values?
- Do community members understand what "stewardship" means in their own context?

B. Community Involvement & Ownership

- Are local people directly involved in planning for resource care?
- Are there regular community meetings to discuss roles, responsibilities, and updates?
- Have I supported the formation (or strengthening) of local stewardship groups or committees?
- Do all social groups and local communities have a voice in how resources are managed?

C. Integration of Local Knowledge & Culture

- Are traditional practices and local ecological knowledge included in stewardship plans?
- Have I avoided introducing external tools or techniques that local people cannot maintain?
- Are cultural and spiritual values related to the land and resources being respected?

D. Tools, Training & Monitoring

- Have I provided simple, practical training in stewardship techniques (e.g. monitoring, protection, restoration)?
- Are the tools and methods affordable and manageable for the community?
- Is there a system in place for community-based monitoring and reporting?
- Do local people know how to adapt or revise rules if things change?

E. Fairness, Transparency & Conflict Resolution

- Are guidelines for resource use clear, fair, and agreed upon by all groups?
- Is there a plan or committee to resolve disputes fairly and locally?
- Have I ensured the process doesn't benefit only one group or exclude vulnerable members?

F. Long-Term Commitment & Follow-Up

- Is there a plan for continued community engagement after the initial project phase?
- Are there local champions or leaders ready to carry the work forward?
- Have I supported linkages with local institutions or networks for ongoing support?
- Have I scheduled future visits or check-ins to support long-term success?

Field Tip:
Keep it community-centered, not project-centered. Stewardship succeeds when local people see the value, feel respected, and have the tools and voice to lead.

6.5
Strategies for Sustainability and Stewardship

To ensure the success of your sustainability and stewardship efforts, there are several tools and methodologies you can adopt:

- **Sustainability Audits:** Regular assessments of the environmental, social, and economic impacts of your projects.

- **Ecological Monitoring Tools:** Technologies like remote sensing, drone surveys, and GIS mapping can help track ecological changes over time.

- **Partnerships:** Collaborating with local governments, NGOs, businesses, and international agencies to share knowledge, resources, and funding.

6.6
Summary: Tips for Practitioners

1. Involve Communities from the Start

- Build trust through early, consistent engagement; not just during closure phase.
- Identify and support local champions who can lead stewardship efforts on the ground.
- Create space for local voices in decision-making, not just consultation.

2. Invest in Community Capacity Building

- Train local residents in environmental monitoring, reporting, and land care practices.
- Use accessible, non-technical language and practical demonstrations during trainings.
- Tailor capacity-building programs to reflect community literacy, livelihoods, and cultural context.

3. Establish Community-Led Stewardship Programs

- Formalize roles for communities in post-closure monitoring and site maintenance.
- Provide stipends, tools, or microgrants for local stewardship groups.
- Encourage co-ownership of outcomes — make success theirs too.\

4. Use Knowledge Sharing as a Two-Way Tool

- Organize workshops, field visits, and peer learning events that bring together different stakeholders.
- Blend scientific and traditional knowledge for more grounded solutions.
- Document and celebrate local innovations and successes.

5. Practice Adaptive Management

- Build flexibility into closure and repurposing plans to evolve with changing conditions.
- Use monitoring data to guide periodic plan updates — involve communities in these reviews.
- Recognize that ecosystems and livelihoods recover at different paces — allow for that.

6. Apply Appropriate Technologies

- Use drones, GPS, and mobile apps for monitoring, but ensure local teams are trained to operate them.
- Choose tools that match local capacity and can be maintained without constant external support.
- Combine modern tech with traditional knowledge for a more holistic approach.

7. Ensure Knowledge Transfer and Succession Planning

- Avoid knowledge loss due to staff turnover by documenting processes and training local stewards.
- Encourage mentorship between experienced staff and younger or local participants.
- Embed sustainability thinking in every phase of the closure process — not just the end.

8. Plan for Long-Term Stewardship

- Set up long-term financing mechanisms like community-managed environmental funds.
- Clarify who will manage the site 5, 10, or 20 years post-closure.
- Design for durability — minimize dependence on constant external inputs.

Dos	DON'Ts
• Empower local communities through training and inclusion in post-closure stewardship.	• Don't treat community involvement as symbolic or optional; avoid tokenism.
• ·Establish and support community-led monitoring and maintenance programs.	• Don't centralize stewardship roles with external agencies alone.
• Facilitate regular workshops and peer learning exchanges with stakeholders.	• Don't rely only on top-down dissemination of information.
• Incorporate local and Indigenous knowledge in monitoring and land care strategies.	• Don't overlook traditional practices or culturally rooted land management techniques.
• Build capacity at all levels (mine, area, company, community, government) for long-term stewardship.	• Don't assume skill transfer will happen without intentional, structured support.

• Implement adaptive management — review and revise closure plans based on monitoring outcomes.	• Don't freeze plans; avoid rigidity in evolving environmental or social conditions.
• Establish regular review mechanisms with measurable indicators (ecological, social, economic).	• Don't neglect feedback loops. Lack of monitoring leads to unmanaged failures.
• Use appropriate technology (e.g., remote sensing, GIS, AI models) for efficient stewardship.	• Don't over-engineer with complex tech that communities cannot maintain or interpret.
• Pilot new sustainability innovations in partnership with local stakeholders.	• Don't introduce technologies without evaluating local feasibility or training needs.
• Document and share lessons learned and success stories across the industry and government platforms.	• Don't keep successful practices siloed; knowledge hoarding weakens broader sectoral resilience.
• Plan for long-term stewardship funding (trusts, endowments, PPP models).	• Don't end support abruptly at mine closure; it leads to system collapse and community distrust.
• Co-create post-mining land use goals with all stakeholder groups.	• Don't design land use plans in isolation or without cross-sector input.

6.7
Conclusion: The Power of Sustainability and Stewardship

By embracing sustainability, practitioners commit to designing systems that balance ecological health, social equity, and economic viability. Stewardship calls us to act as responsible caretakers, honouring the interconnectedness of all life and the finite resources we share. Together, they empower us to restore damaged landscapes, nurture biodiversity, and build stronger, more adaptive communities.

Ultimately, the power of sustainability and stewardship lies in our collective ability to protect, nurture, and pass on a living planet, a legacy of hope and vitality for future generations. It challenges us not only to restore but to respect, not just to manage but to cherish, ensuring that the natural world remains vibrant and life-sustaining for all.

CONCLUSION

Mine Closure is not an afterthought, it is a companion of mining. Every shovel of earth removed carries with it a responsibility to restore. When backfilling is timely, topsoil is cared for, slopes are shaped, and water is guided with wisdom — the land heals even as mining continues.

For practitioners, the lesson is simple: Do the small things right, at the right moment, and repeat them without fail. Because effective reclamation is not built on one grand act, but on steady, thoughtful steps, year after year, season after season. Remember – true success lies in leaving behind land that is safe, fertile, and full of life... a land ready to serve communities long after mining is gone.

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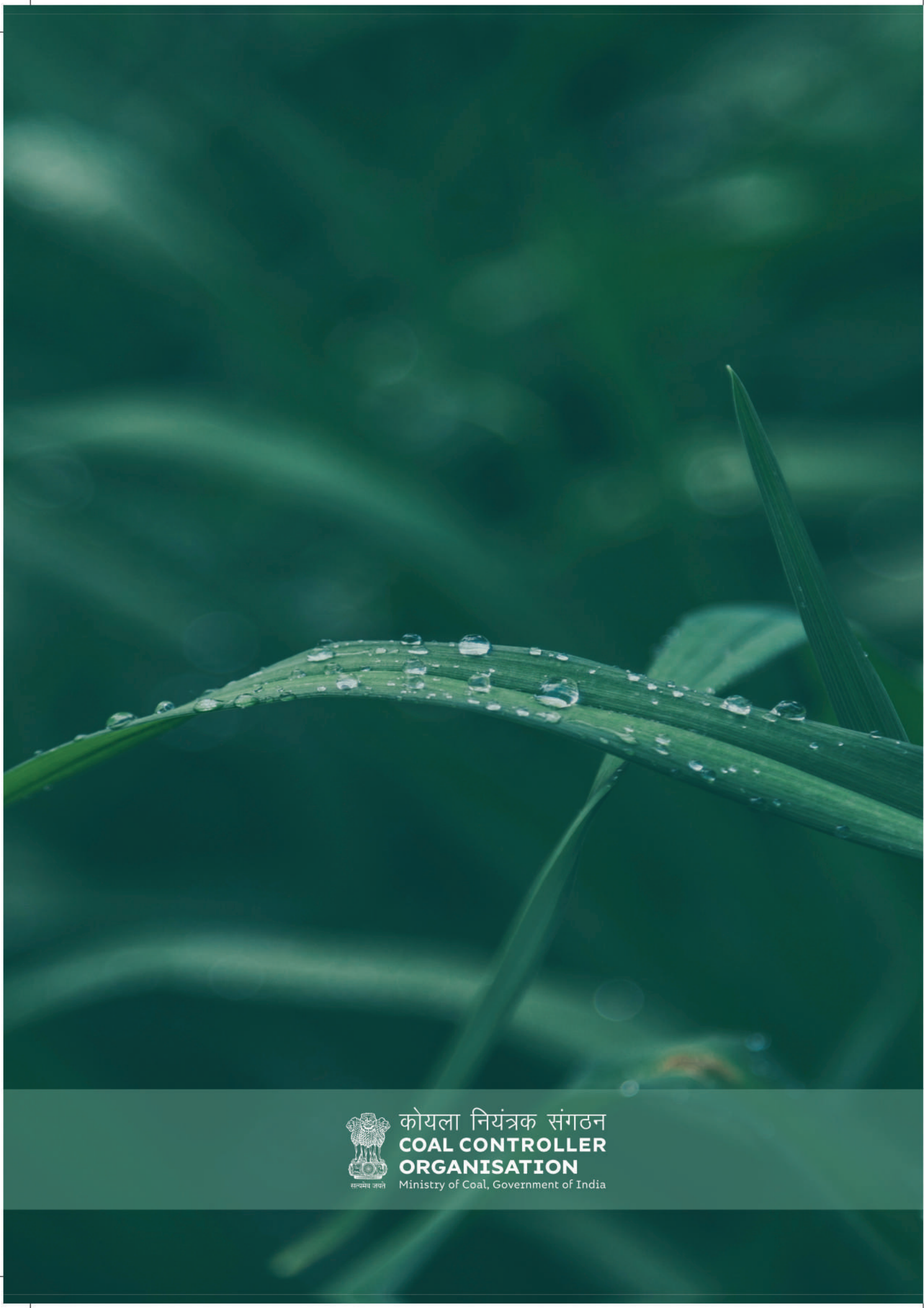

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COAL CONTROLLER ORGANISATION
Ministry of Coal, Government of India