

# Progressive mine closure: rehabilitation and community engagement

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## Abstract

*Kinross Brazil Mining (KBM), located in the northwest region of Minas Gerais, Brazil, integrates ecological, social, and economic pillars into their strategy for progressive mine closure, reclamation activities, and management of protected areas, including legal reserves, permanent preservation areas, and compensatory areas. This holistic approach aims to achieve regional sustainable development.*

*Currently, more than 5,000 hectares are designated for conservation, contributing to ecological connectivity and the formation of corridors with other protected areas. This ensures the availability of resources necessary for the establishment and development of local fauna and flora. To enhance this conservation mosaic, it is essential to consider areas under reclamation and actively engage and involve neighbouring communities.*

*The social aspect of mine closure is critical for fostering community resilience and ensuring long-term sustainability. KBM's strategy includes comprehensive community engagement programs that involve local stakeholders in the planning and implementation of reclamation activities. These programs aim to address community concerns, provide education and training opportunities, and promote alternative livelihoods to mitigate the socio-economic impacts of mine closure.*

*By integrating social considerations into the mine closure process, KBM not only enhances environmental outcomes but also supports the socio-economic development of the region. This approach ensures that the benefits of mine closure extend beyond environmental restoration, contributing to the overall well-being and sustainability of the local communities.*

**Keywords:** *community engagement, socio-economic impacts, environmental conservation, alternative livelihoods, regional sustainability, stakeholder involvement*

## 1 Introduction

The exploitation of mineral resources has always been criticised in terms of sustainability, since it involves the use of non-renewable resources. However, Kinross Brazil Mining (KBM) believes that if a given project properly manages its impacts during its operational life, while also generating social, economic and environmental benefits for the community, region and country, these benefits can be maintained and improved over time, continuing beyond the end of its operations. In such cases, the project can be considered to have promoted sustainable development.

For KBM, sustainable mining, which values the maintenance of local and regional biodiversity, is only possible when operations are carried out with respect for the communities in which we operate. Our work is based on a partnership with the development of the city of Paracatu, aligning our operational activities with socio-environmental issues that are relevant to the community. This approach reflects our corporate values, which place responsibility for people and the environment first and foremost.

The idea behind this concept is that a mining operation adequately manages its social, economic and environmental impacts during the life of the mine, and adopts compensatory and value-adding actions that

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result in a positive legacy for communities after closure. Thus, the legacy must be positive and the benefits long-lasting. This is a key priority for the business.

KBM believes that all phases of a mining project should be considered in the context of sustainability and biodiversity protection. Thus, the sustainable development approach begins when the decision is made to explore a new business, and continues into project planning, its implementation and operations, and extends to mine closure, including progressive closure actions. Finally, sustainability must be confirmed through independent analysis and indicators, by evaluating the economic, social and environmental (ESG) conditions after closure in comparison to the ones that existed before the project was set up. In other words, the local community and the environment should be better off than before in these areas.

Increasingly, as part of global pressures, ESG agendas are being challenged to demonstrate how they include natural capital as part of business variables. In this sense, KBM is committed to a strategy that values community engagement and responds to its key needs. We believe that by doing so, we can generate shared value, grow together, transform challenges into opportunities, and strengthen a relationship based on mutual respect and trust between the company and the community. In this context, preserving biodiversity is not only essential for life on the planet but has also become an important criterion for investors in new projects.

Any mining operation seeks the greatest possible acceptance from its stakeholders, particularly the neighbouring communities that will be impacted. Communication and engagement from the start of a mineral exploration process, through the development and implementation of the operation and after closure, are therefore essential to balance the positive and negative impacts of the mine's activity. Having defined biodiversity as part of its strategy, KBM has sought to maximise opportunities combining biodiversity and community engagement.

One of the key pillars of KBM's management practices is the protection of biological resources (aquatic and terrestrial flora and fauna) from the potentially harmful effects of mine operations and infrastructure. Best management practices include, for example, the protection and fencing off of chemical storage and industrial areas to avoid the entry of local fauna, reducing cyanide concentrations at discharge points, as well as strict establishment and periodical review of operational procedures to include environmental controls.

Protecting biological resources and minimising impacts includes identifying, monitoring and protecting both biodiversity and biological habitats. The management of biological resources is sufficiently robust to guarantee protection throughout the life cycle of KBM activities. This includes the establishment of a biological resources plan, which defines protected areas and buffer zones, recovery of degraded areas, fauna management and a mine closure plan to guide the operation to sustainable closure in the future.

In addition, we have a communication and engagement process that seeks appropriate ways to identify, monitor and evaluate the performance of a mining operation in relation to stakeholder concerns, especially neighbouring communities. These interactions are carried out on an ongoing and periodic basis, using language appropriate to various audiences.

## 2 Context

The availability of natural resources and raw materials is fundamental to the development of society, which increasingly demands new products and solutions from companies and industries. The loss and threat to biodiversity also threatens essential ecological functions, such as pollination, which impacts our ability to produce food, wood, energy sources, and medicines, and opportunities for a life connected to nature. Biodiversity is important in many ways – it holds ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values.

Actions and initiatives that value biodiversity and promote research, preservation and recovery of flora and fauna – as well as the promotion of diversity in social environments – are increasingly being pursued by companies and institutions. This principle guides our activities in all areas, from mining and ore processing to the recovery of used areas and revegetation with native plants.

Promoting the necessary and relevant changes for each business is a long journey that can begin gradually and consciously. Capital has been reallocated rapidly in search of sustainable assets, promoting companies to revise their business models.

In this sense, from the very beginning of the implementation of the Morro do Ouro Project, there was a challenge to overcome. The municipality of Paracatu, in Minas Gerais, where the ore is mined, is part of the Cerrado biome which is rich in diversity. The Cerrado has been suffering a progressive replacement of natural landscapes due to the massive effects of anthropomorphic activities.

The challenge was to intensively manage biodiversity, especially in relation to fauna, since many vertebrate species (fish, amphibians, reptiles, birds and mammals) are important bioindicators of environmental quality.

Much of the work involves environmental reclamation through the adoption of a set of measures, tools, techniques and materials in areas previously used for mining operations. One of these actions is revegetation, which restores the ecosystem to levels similar to before the mining activities began.

Another methodology is 'nucleation', a technique that consists of depositing 'nuclei' of topsoil, which is the soil removed from a given location, for example, to open an access road or even a mining area (Reis et al. 2010). The material removed is placed on a site to be used for environmental recovery. The 'cores' are piles of this topsoil placed in a particular area to be reclaimed. Between these mounds, seedlings of native species that have the capacity to improve the environment are also planted, facilitating the use of the material.

This approach has helped reduce ecosystem fragmentation and connect previously isolated areas. The greater richness and diversity of vegetation in these areas contributes to the movement of fauna and flora between them, promoting the return and development of different species and the return of wild animals. Complementing this work, environmental inspections to prevent fires and the assessment of fences to avoid the presence of invasive species, such as cattle from neighbouring rural properties, have been essential as cattle can compact the soil and hinder the development of plant species.

At the same time, the ongoing management and monitoring of fauna and flora carried out by KBM in its protected areas has contributed over the years to the preservation of regional biodiversity.

### **3 Methodological aspects**

Among the main activities that KBM carries out to promote the protection and maintenance of local and regional biodiversity, as well as its engagement with the neighbouring communities, the following stand out:

**Environmental reclamation:** the environmental recovery process in the project area is carried out by adopting a set of measures, tools, techniques and materials in areas that have already been used in mining operations. One of these actions is revegetation, which restores the ecosystem to levels similar to or better than before the mining activities commenced (Felfili et al. 2008; Durigan 2010). The borrow areas, for example, are in the recovery phase, where seedlings of native species have already been planted, which naturally serve as an attraction for wildlife and form ecological corridors.

In addition to the techniques of topographical reconfirmation and planting seedlings of native species, a technique employed by the company is 'nucleation', which consists of depositing 'nuclei' of branches and topsoil. The material removed is placed in a location to be used during environmental recovery. Between these piles, seedlings of native species with the capacity to enhance environmental conditions are also planted, facilitating the establishment of other species and attracting wildlife. These actions support the preservation of local biodiversity and encourage the return of fauna to areas previously impacted by human activities.

**Community nurseries:** with the aim of promoting community participation in the process of recovering degraded areas, forest nurseries were built to produce seedlings of native species. The project, called 'Community Nurseries', began in 2017 in the community of Santa Rita, in the rural area of Paracatu, Minas Gerais (a community neighbouring the project). It involved the construction of 20 forest nurseries in the region, as well as the supply of all the necessary materials and inputs. The seedlings produced in these nurseries are used to recover degraded areas, and rural producers and community associations are paid per unit.

Figure 1 illustrates the environmental education process as a training approach for individuals responsible for managing community nurseries.



**Figure 1 (a) Community resident maintains seedling nursery; (b) Community receives training on seed collection and planting of seedlings**

The Community Nurseries project is one of several initiatives through which KBM fosters community interdependence, with a focus on future land use and the post-mining period. The project empowers local stakeholders by supporting their productivity and providing financial compensation. In addition to supplying all necessary inputs for seedling production, KBM has been purchasing 10,000 seedlings annually since 2017, generating approximately USD 102,000 in income for rural producers and community associations.

As part of the community engagement process and to ensure clear understanding, KBM also developed a booklet using simplified and visual language to explain how to select the seeds, and how to carry out the planting and the maintenance necessary for the sustainability of the seedlings.

Protecting and fencing off springs: developing collective awareness of the value and importance of preserving springs. With this premise, the 'Espalha Project' was born in mid-2009 – a KBM initiative to protect the springs of the Córrego Espalha, guaranteeing the flow of the Córrego Rico, and the environmental preservation of the Espalha Basin, reconciling it with existing agricultural activities in a sustainable manner. The project included environmental education for small farmers, fencing off springs, protecting waterholes, and preventing livestock from grazing, and had the fundamental support of rural landowners. The positive results in the Espalha basin served as an impetus to pursue even more transformative goals. In 2010, KBM, the non-governmental organisation Movimento Verde de Paracatu (Paracatu Green Movement) and the State Forestry Institute (IEF) founded the Project for the Protection of Springs and Footpaths in the Paracatu River Basin, the most important tributary of the São Francisco River, among the three largest rivers of Brazil.

Since 2010, 276 springs have been fenced on 187 rural properties (Paracatu river basin, Paracatu municipality), with the installation of approximately 167 km of fences, totalling 1,964 hectares of protected areas, as can be seen in Figure 2.



**Figure 2** Detail of water spring protected through the spring protection and fencing program, in partnership with the community and rural producers

Fauna and flora monitoring: faunal monitoring consists of systematically monitoring the fauna using selected indicator groups, with an emphasis on endangered and endemic species recorded in the areas of direct and indirect influence of the Morro do Ouro mine. For flora monitoring, KBM uses indicators such as the Shannon-Wiener diversity index ( $H'$ ), which measures the richness and diversity of flora species in areas undergoing recovery that are subject to continuous monitoring.

The fauna monitoring program carried out by KBM is continuous, and is carried out on a seasonal basis (campaigns in the dry and rainy seasons), focusing on the indicator groups: reptiles, amphibians, birds, non-flying mammals, and insects, with the aim of improving the focus of investigations into effects more directly related to the operation of the project. Through the installation of camera traps throughout the KBM areas, more than 200 species of birds, over 30 species of mammals (small, medium and large) and more than 20 species of reptiles and amphibians have already been recorded.

It's important to note that a key indicator of the success of the company's program to recover and maintain protected areas is the measurement of populations and the presence of species that have been threatened or even disappeared from the region for a long time. An example of this was the presence of the vinegar dog (*Speothos venaticus*), with puppies, in one of the company's protected areas.

The register of specific wild animals in the protected areas, such as those at risk of extinction, as well as large species of mammals, for example (Figure 3), indicated the success of this management, reinforcing the importance of connectivity between areas and the creation of a protected areas mosaic by the conservation and management actions. All this work and commitment to preserving the environment has a direct impact on the territory, and on the quality of life of the communities in Paracatu.



**Figure 3** (a) Records of *Puma concolor* and (b) *Myrmecophaga tridactyla*, endangered wildlife species (mammals), along protected areas of Kinross Brazil Mining, Paracatu, Brazil

Using ecological indicators, it is assumed that once the reference values are reached, the areas under restoration will be able to evolve to a more advanced stage, increasingly resembling non-degraded native areas, without the need for further interventions. The reference values vary according to the type of vegetation (grassland, savannah and forest formations) established as the target for restoration. They may be based on original vegetation, remaining areas in the surroundings, or other vegetation types better suited to the degraded or transformed environment.

Among the indicators used by KBM is the Shannon-Wiener diversity index ( $H'$ ), which measures the richness and diversity of flora species in areas undergoing recovery and continuous monitoring. Currently, the diversity index is equivalent to 3.12, i.e. it reflects considerable diversity in the areas, as well as indicating a process of ecological succession.

**Paracatu State Park:** Paracatu State Park came into being in 2011, after KBM regularised the land and donated the area as a form of forestry compensation. Covering 6,400 hectares and administered by the IEF, the conservation unit has the important function of preserving the region's fauna and flora, protecting the area's water resources and ensuring local biodiversity. The park's location was strategically chosen at the headwaters of the Santa Isabel stream, the main contributor to the water catchment area used by the local water company (Copasa) to supply the city of Paracatu.

Paracatu also protects 5,241 hectares of Kinross-owned land, including legal reserves and other lands arising as environmental compensation. Kinross is also investing in the park's infrastructure through civil works and donations of machinery and equipment. It has already donated 4x4 pickup trucks, an agricultural tractor and a drone, among other items. Kinross is currently carrying out renovation/infrastructure work and building ecological trails in the park area, with the aim of contributing directly to strengthening ecotourism in the region. Furthermore, at least 20 km of firebreaks are built every year on the park's borders, contributing directly to preventing forest fires.

With the aim of making the park an important destination for leisure, environmental education and ecotourism, activities are organised for the population. Some examples are the Rustic Water Race and Biking in the Cerrado, which combine environmental education and health in a natural environment through a 6 km run or walk and a 20 km mountain bike ride. On these occasions, information is passed on about the local biome, fauna and flora, as well as the importance of preserving water resources. The birdwatching event, also held at Paracatu State Park, brings participants into contact with nature and raises awareness about the species and the importance of their conservation.

**Environmental education:** as part of its Environmental Education Program, KBM promotes relations with educational institutions by giving lectures on environmental and mining issues to various universities and schools in the municipality. The main objective is to promote communication and environmental education through actions and activities that help broaden perceptions of both contemporary and local environmental issues, as well as transmitting information on the positive and negative aspects and impacts of mining activities. In the region's public schools, for example, the theme of sustainability is addressed with students through the Telling and Retelling Stories to Enchant and Transform Ideas project, which offers eco-literary workshops and theatrical performances.

The following are some of the results of the environmental process over the last year. More than 13,300 seedlings were donated to employees, third parties and the Paracatu community. Approximately 1,000 people took part in the Rustic Water Race, Bird Watching and Biking at Cerrado events. Under the Integrar project, which focuses on environmental education, five lectures were given with the participation of over 1,300 students. Through its environmental education activities, the company demonstrates its commitment and engagement with neighbouring communities with topics that address the environmental aspects, impacts and control of mining activities in the municipality of Paracatu.

**Meetings with local government:** as part of its mine closure strategy, KBM holds regular meetings with the Paracatu Municipal Council for Sustainable Development (CMDSD), community leaders, and organises an annual Mine Closure Workshop. These events bring together key stakeholders from the community and local government to present updates on the closure plan, share progress on technical studies, and gather

community expectations on the subject. This participatory approach enables a more sustainable and locally aligned progressive closure process.

The CMDS was established by Law No. 3,355 of 24 November 2017 (Municipal Laws 2025) and serves as a high-level collegiate body responsible for proposing, consulting, and deliberating on the municipal planning and management system. Its role is to ensure that strategies, actions, programs, and projects support sustainable economic and social development in the municipality of Paracatu.

Therefore, when the company closes its operations, the social, economic and environmental outcomes must be positive in relation to the impacts generated during and prior to the period of operation. The company must leave a legacy that improves the quality of life for the community and the environment, one that outweighs the benefits of a scenario in which the company had not set up in Paracatu.

For the environmental reclamation, specific plans are developed for degraded areas, either by anthropic or natural actions. These plans list a set of measures, tools, techniques and materials that will contribute to dynamic reclamation, bringing usefulness to the soil and integrating the landscape. Revegetation actions promote the structure stabilisation, recovering the ecosystem's ecological functions to self-sustainable levels or like what existed before the intervention for the commencement and operation of mining activities. In this context, some actions that take place simultaneously with the operation are part of the mine closure process, which involve specific studies, risk assessments, research and partnerships with federal institutions.

In addition, nucleation consists of an innovative technique through the formation of topsoil and brushwood cores, composed of plant species with ecological capacity to improve, significantly, the environment, facilitating the occupation of the area by other more demanding species and providing adequate ecological succession (Reis et al. 2010). Therefore, it is possible to restore biological processes and favour physical-chemical cycles and microclimatic adjustment. Considering the native seedlings, KBM promotes the acquisition of seedlings produced in partnership with neighbouring communities, annually, through social and environmental projects. From this strategy, the community is directly involved in this process and actively contributes to the sustainable development of the region. Complementarily, the management and monitoring of fauna and flora that KBM performs in its protected areas has contributed, over the years, to maintaining regional biodiversity. A clear sign that the action has been successful is the occurrence and return of regional wildlife animals in these areas.

## **4 Innovative aspects of practice**

KBM intensively promotes partnerships with research and teaching institutions, seeking to implement viable technical solutions, disseminate knowledge and fill knowledge gaps in the Paracatu region.

The conservation and preservation work in the areas for which KBM is responsible has the fundamental support of academic experts. We currently have a partnership with the Federal University of Viçosa to develop research projects related, among other objectives, the management of acid mine drainage and the improvement of revegetation processes in areas that will progressively cease to be used.

In 1991, the site initiated the implementation of a strong research program that developed the key control actions to manage the acid generation from its sulphide ores. These defined controls have been implemented since the early stages of the sulphide ore mining (1998) and covered all stages of the mine including the ore extraction, treatment and tailings disposal. Measures include the segregation of non-acid generating (NAG) and potentially acid generating (PAG) materials in the mine, recovery of the sulphides in its processing plant (with controlled disposal in specific sealed sumps) and the addition of crushed limestone to final tailings disposed in its tailings dam. Furthermore, the site has installed alkaline drains on the slopes contributing to surface drainage, to treat the acidic water. Another important scope of this partnership is the monitoring of areas undergoing environmental recovery, providing input for actions to improve this process.

An innovative initiative by KBM relates to the mapping of a potential ecological corridor in the Paracatu region to guarantee the preservation of Cerrado species, especially those threatened with extinction.

To achieve this goal, the company plans to recover its areas as part of a mosaic of protected areas in the region, ensuring areas of connectivity and allowing gene flow between previously degraded areas.

In other words, once mining operations cease, an ecological corridor will be guaranteed in the region, which is essential for maintaining biodiversity. Species richness will be measured as the rehabilitation processes take place. KBM also carries out scientific monitoring of the different environmental recovery processes carried out on the company's premises, using scientific indices that are known worldwide (Shannon's index, for example, which reflects the diversity of the areas) (Kent & Coker 1992).

To develop a technological protocol for the definitive revegetation of tailings dam slopes, a technical cooperation agreement was signed last year with Embrapa Cerrados. Embrapa has a track record of innovation and environmental sustainability, which is recognised nationally and internationally, with an excellent reputation in terms of technological development and economic-territorial transformation.

Sustainable development and biodiversity conservation are premises for planning activities and conducting socio-environmental projects. Our initiatives have very strong sustainability criterion, reinforcing environmental awareness and a sense of belonging among the stakeholders involved (e.g. community nurseries and fencing off springs).

In addition, KBM's strategy is grounded in the values and principles of corporate responsibility, aligned with the Sustainable Development Goals for Mining (SDGs) of the United Nations Development Program - United Nations Organization. It also considers the Paracatu 2030 Agenda, a local forum aimed at promoting sustainable development.

In recent years, different initiatives have been implemented to try to curb the effects of climate change. KBM recognises that climate change is one of the most important issues facing society today and believes that the mining industry has a responsibility to contribute positively to mitigating the associated risks. The strategy and targets set are not only essential to protecting the environment, but also vital to the long-term success of the business.

Therefore, to increase our energy efficiency, we seek the best performance with the lowest possible energy expenditure, seeking to eliminate process waste and misuse, improve the use of renewable sources, eliminate non-renewable sources and/or those with a high greenhouse gas generation capacity, and implement clean solutions, monitoring results and continuously improve processes and their controls.

We are seeking to improve the perception of communities in relation to mining, through a process of listening to the interests of communities before implementing biodiversity initiatives and projects. Conducting opinion polls with the communities, understanding what the communities want, including possibilities for future use (post closure) is an essential part of this process, focusing on a better relationship with the communities and other stakeholders and generating new dialogues and opportunities.

## 5 Conclusion

Paracatu has implemented a robust biodiversity strategy focused on enhancing connectivity between conservation areas to protect endangered species and actively involve local communities. This multifaceted approach integrates ecological, social, and economic pillars to support sustainable regional development. Key actions include progressive land reclamation, proactive management of protected areas – such as legal reserves, permanent preservation zones, and compensatory areas – and the creation of ecological corridors.

A notable initiative is the planned protected corridor linking the mine site to the Paracatu State Park, located approximately 15 km away in the Santa Izabel basin, a critical freshwater source for the city. This corridor will help preserve water resources for future generations and strengthen regional ecological networks.

To date, over 5,000 hectares have been designated for conservation, contributing to habitat connectivity and biodiversity. More than 600 hectares, previously used for geotechnical purposes, have been recovered or are undergoing restoration. KBM employs innovative soil rehabilitation techniques, including nucleation,

seedling planting, and direct seeding, which have proven effective in reestablishing native vegetation and attracting wildlife – marking significant progress in ecological restoration models.

Community engagement is a cornerstone of KBM’s strategy. The company maintains a close relationship with local stakeholders to understand and respond to community needs. This includes regular meetings with the CMDS, community leaders, and local government, as well as the annual Mine Closure Workshop, which brings together all relevant stakeholders. KBM also runs several socio-environmental and capacity-building programs, such as community nurseries that generate income and empower local producers. Since 2017, the company has purchased 10,000 seedlings annually, generating approximately USD 102,000 in income for rural producers and community associations. Additionally, educational materials in simplified, visual language help ensure knowledge transfer and long-term sustainability.

Together, these efforts are building a lasting legacy for the Cerrado biome and securing the environmental and social resilience of Paracatu.

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