



Mining and Neighboring Communities: The Helter-Skelter Relations between the Twangiza Highland Open-Pit Mining and Local Communities, within a Context of Co-Existence with Small-Scale Mining and Progressive Ecological Rehabilitation

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Abstract

This paper focuses on the cooperation between Twangiza Mining, an industrial highland long-term open-pit gold mine, in the eastern part of the DR Congo, and neighboring communities. Various projects have been implemented, including: water supply, education, health care, infrastructure, ecological rehabilitation, humanitarian assistance, and sustainable income generation through income generating activities. Results show that most people in the local community used to live in aggravated poverty, a landlocked environment and general scarcity of infrastructures of all kinds, before the onset of the mining industry. It implies that the mining industry could not change everything all of a sudden and that most projects would have a quick impact, and not be viewed as superficial or manipulative, as the need was real. Most conflicts occurred within administrative Divisions neighboring the Twangiza mine, with better economies from small scale mining, and more subject to resettlement, unlike communities within Divisions with limited economic opportunities which were more inclined to accept mining projects, as they perceived the potential economic benefits as outweighing the drawbacks. The Cinjira resettlement provided lessons about successes and failures and resilience strategies. The most preferred projects of mining companies for local communities are those that provide di-

rect benefits to the community such as infrastructure development and ecological rehabilitation. The role played by NGOs and Activist Groups is positive in that they advocate for community rights and environmental protection, though their involvement also contributes to conflicts. The co-existence of industrial mining with small-scale mining is also problematical. Unexpectedly, the detailed literature on achievements of multinational mining companies in neighboring communities and the related grievances is scarce in Africa; except for Nigeria and Ghana, and likely South Africa. This paper intends to provide some enlightenment on the topic.

Subject Areas

Mining, Ecological Rehabilitation, Community Perceptions

Keywords

Mining, Local Community, Relations, Projects

1. Introduction

Conflicts between mining companies and local communities stem from several key issues. Unequal distribution of benefits, as mining activities often generate significant wealth, but this wealth is not always equitably distributed among local communities. A significant disparity exists between the earnings of mine workers and those in managerial or ownership positions. Environmental degradation is another issue [1]-[3]. Mining activities frequently lead to considerable environmental damage, including deforestation, soil erosion, and water pollution, which may be directly or indirectly linked to activities of mining projects. These environmental consequences negatively impact the livelihoods of rural communities, particularly those dependent on agriculture and fishing. The degradation of land and water resources causes economic hardship and increased poverty, leading to conflict over resource access and environmental justice. Case studies illustrate the devastating impact on water sources and agricultural land, resulting in food insecurity and economic hardship [3]-[6]. In some cases, benefits are intensely localized, creating massive discrepancies between those who own land with resources and their neighbors [7].

Disputes over land rights and inadequate compensation for land appropriated for mining operations are major sources of conflict. Communities often feel that their concerns are not adequately addressed, leading to tension and mistrust [6]. Inadequate or poorly understood grievance mechanisms exacerbate conflicts. Companies should establish accessible, legitimate, and equitable grievance mechanisms that allow local communities to voice their concerns and seek redress. These mechanisms should be designed in a participatory manner, involving local communities in their design and implementation [5]. Meaningful community en-

engagement is essential for conflict prevention and resolution [3] [5] [8] [9]. Companies should engage with local communities throughout the project lifecycle, seeking their free, prior, and informed consent before undertaking any activities that may affect their livelihoods or cultural heritage [1] [10]. This includes providing opportunities for meaningful participation in decision-making processes, ensuring that local voices are heard and considered [3]. Building strong relationships based on trust and mutual respect is crucial for long-term success [2] [3] [11]. The lack of proper compensation for land lost or damaged due to mining activities is a recurring complaint [12]. Exposure to hazardous substances, inadequate safety measures, and lack of access to healthcare services at mining sites contribute to health issues among workers and surrounding communities [6]. These health risks further exacerbate tensions and fuel conflict.

A lack of transparency, whether genuine or supposed, in the operations of mining companies and inadequate accountability mechanisms contribute to conflict. Communities often lack access to relevant information, or lack trust and confidence in the information provided, about mining projects and their impacts, hindering their ability to participate in decision-making processes, leading them to hold companies accountable [13]. Corruption within local government further complicates matters, as it undermines trust and hinders equitable benefit sharing [1]-[4]; [12] [14] [15]. The influx of migrant workers and the concentration of wealth in certain areas can lead to shifts in social hierarchies and community relations. This social disruption can create tensions and conflicts within communities. The disruption of traditional livelihood practices and cultural norms also contributes to conflict [2] [6]. Significant power imbalances between mining companies and local communities often characterize these conflicts. Mining companies often possess greater economic and political influence, making it difficult for communities to effectively negotiate for their rights and interests [12].

Several strategies can mitigate conflicts between mining companies and local communities. These strategies require a holistic approach. A core issue is the unequal distribution of mining profits, highlighting the intense localization of benefits and creating disparities between landowners and their neighbors [11].

Establishing funds where a portion of mining profits directly benefits local communities requires transparency and accountability in how these funds are managed. Investing in infrastructure like roads, schools, and healthcare facilities benefits the wider community, not just those directly involved in mining. However, this investment is often concentrated around mining areas, leaving other communities underserved [2] [8] [16]. A more equitable distribution is crucial [1] [3] [6]. Prioritizing local hiring for mining jobs and awarding contracts to local businesses ensures that economic benefits are more widely distributed [7]. However, inconsistencies in the implementation of such policies, with discrepancies between the hiring practices of mining companies and their contractors do occur [12]. Diversifying the local economy reduces over-reliance on mining, making communities less vulnerable to price fluctuations and resource depletion. This could involve supporting agriculture, tourism, or other industries [6].

Mining's environmental impact is a major source of conflict that raises up issues like water pollution, deforestation, and soil degradation [2] [3] [6] [17] [13] [18]. Mitigation strategies, which include adopting modern technologies that minimize environmental damage, implementing effective waste management systems, and rehabilitating mined areas, are crucial. Regular monitoring ensures compliance with environmental standards and allows for timely responses to problems [6]. Independent monitoring, not just company-led assessments, is vital [13]. Fair compensation for environmental damage to land and resources is essential [19] [6]. However, compensation is often inadequate, non-existent, or subject to embezzlement [2] [3] [8] [13] [16] [19]. Stronger regulatory oversight is needed. Lack of transparency and accountability fuels mistrust. Open communication and stakeholder participation in decision-making processes are highly required. Meaningful consultation with local communities is crucial before, during, and after mining operations [6]. This includes providing access to information about mining projects and their impacts. E.g. making mining contracts public increases transparency and accountability [19]; Independent audits of environmental and social impacts, as well as financial transparency, are essential to ensure accountability [5] [12] [13]. However, there are limitations in current self-reporting and assurance mechanisms. Improving the functioning of local government institutions ensures that they can effectively represent community interests and hold companies accountable [12]. Disputes over land rights and inadequate compensation are major conflict drivers. Establishing clear and legally recognized land tenure systems prevents disputes over land ownership [7]. Providing fair and timely compensation for land acquired for mining operations is crucial [6] [7] [12] [19]. If resettlement is necessary, it should be planned carefully, with adequate provision for housing, livelihoods, and social support [19] [12]. Strengthening the capacity of both communities and local governments is essential for effective participation and conflict resolution. Providing training on sustainable development, negotiation skills, and monitoring mechanisms empowers communities to participate more effectively [6]. Supporting local NGOs strengthens their capacity to advocate for community interests and monitor mining activities [12].

Mining companies often undertake projects aimed at improving the social and economic well-being of local communities, more often in line with local community development plans and in consultation with local development committees. These projects frequently include infrastructure development (roads, schools, water supplies, healthcare facilities), support for alternative livelihoods, and job creation. However, there are consistent issues with the design, implementation, and reporting of these projects. There are concerns about the projects' actual benefits to the community versus the company, the lack of transparency, and the inadequacy of the projects compared to the wealth extracted from the area and the environmental damage caused [12] [13]. Cooperation also involves efforts to mitigate the environmental damage caused by mining. This includes implementing sustainable mining practices, environmental monitoring, and rehabilitation of mined areas. However, the environmental damage often outweighs mitigation efforts, leading to significant

conflicts [6] [12]. Mining companies often engage in stakeholder consultations to address community concerns and incorporate local perspectives into project planning and implementation. However, this engagement is often inadequate, lacking transparency and genuine participation from local communities. Power imbalances and lack of capacity within communities hinder effective engagement [12]. Cooperation should involve fair compensation for land acquired for mining and addressing land rights issues. However, that compensation is often inadequate or non-existent, leading to significant conflict [12].

The main positive contribution of mining companies to local communities include employment, infrastructure development, community development through projects and economic diversification - often through informal business development that leans on the sustainability of mining activities of the mining company. Mining operations create jobs, both directly within the mines and indirectly through supporting industries. This leads to increased income for some families and improved living standards in certain segments of the population, potentially improving access to education, healthcare, and housing. However, the nature of these jobs (often seasonal and informal) leads to employment instability, and the distribution of benefits is highly unequal [6]. Furthermore, discrepancies exist between the hiring practices of mining companies and their contractors, leading to concerns about local hiring and benefit sharing [12].

The current paper focuses on the cooperation between Twangiza Mining, an industrial highland long-term open-pit gold mine, with activities since 1938, including illegal small-scale mining within its perimeter, in the eastern part of the DR Congo. This tropical area is characterized by high yearly rainfall (1500 mm) with two seasons, in a mountainous topography with steep slopes (1900-2700 m asl). Various projects have been implemented, including water supply, education, health care, infrastructure, humanitarian assistance, and sustainable income generation through income-generating activities.

The overall objective is to contribute to the promotion of good relations between mining and the community. The Specific objectives are the following: (1) Describe the mining company's achievements in collaboration with the community; (2) Identify the major conflicts and the historical solutions put in place; (3) Identify the environmental and social impact of ecological rehabilitation; (4) Analyze community's opinions, and; (5) Elaborate future prospects.

2. Materials and Methods

2.1. Study Area

The Twangiza open-pit gold mine is located in the District of Mwenga, South Kivu Province, DR Congo, at 45 km south-southwest of Bukavu city, the capital of the South Kivu Province. The road access from Bukavu is at 85 km, through the national road (RN2). The lowest average temperature is 13 degrees Celsius, while the maximum is 22 degrees with a hilly topography averaging between 2,000 and 2,500 m asl. However, the highest close by hill goes up to 3,250 m asl. The mine area consists of

Burhinyi chieftdom profile [20]

The chieftdom of Burhinyi is a mountainous area, with agro-pastoral potential, located to the West of the Luhwindja chieftdom. Its surface area is 328 km² with an estimated population of 54,307 with an average density of 165 inhabitants per km². It comprises 18 administrative Divisions.

A sketch of the Burhinyi administrative map displaying the geographic distribution of small scale mining activities and their associated minerals is presented in **Figure 2**. Its landscape is dominated by grassy mountains and hills that are ideal for grazing large livestock. The high-altitude tropical climate offers an average temperature of between 14° and 25°C and average rainfall of between 1,500 and 2,500 mm/year, making it ideal for all the crops grown in temperate regions. Food crops include cassava, beans, bananas, sweet potatoes and maize. The region offers enormous potential for cash crops (tea, coffee, palm oil, ...). Natural forests cover 20% of the chieftdom's area. Woodland is almost non-existent except for small Cypress and Eucalyptus groves belonging to religious denominations. **Figure 3** shows the type of houses, scattered habitat and the general landscape in Burhinyi.

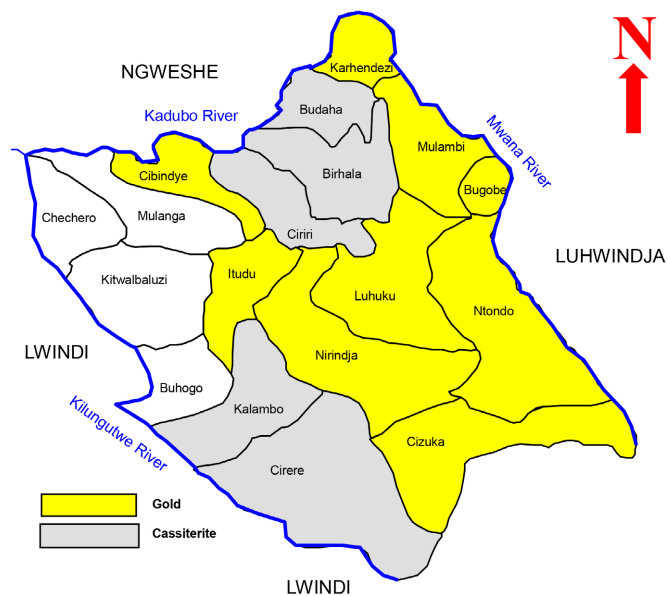


Figure 2. Geographic distribution of small scale mining plotted on a sketch of Burhinyi administrative map.



Figure 3. Burhinyi. a) improved houses; b) scattered landlocked habitat village; c) landscape overview.

2.1.1. The Likert Score Evaluation of the Projects and the Co-Existence of the Company with Small-Scale Mining

The popular Likert scale tool was used in surveys to measure opinions about the projects achieved by the mining company within the neighboring community, including the main indicator from the related literature as statements followed by a series of response options that indicate the degree of agreement or disagreement, *i.e.* a) Strongly disagree = 1; b) Disagree = 2; c) Neutral = 3; d) Agree = 4, and e) Strongly agree = 5.

For instance, among >80 criteria:

Projects' diversity and impact
Wealth is not always equitably distributed among local communities
A significant disparity exists between the earnings of mine workers and those in managerial or ownership positions.
Deforestation
Soil erosion
Water pollution or reduced quantity
These environmental consequences negatively impact the livelihoods of rural communities
Causes economic hardship and increased poverty
Conflict over resource access

This form was filled in by 5 key informants, strongly acquainted with the implementation of the projects achieved by the Twangiza Mining company.

2.1.2. Interviews Regarding the Environmental

Seven participants with the following profile were interviewed for this purpose.

Name	Position	Age	Area of Expertise
M. N. D.	Teacher, Farmer	60	Education, Agriculture, and Livestock
N. S	Farmer	56	Agriculture, Artisanal Gold Digger
W. B. W	Headmaster of secondary School, Journalist	42	Teaching, Journalism, Agriculture
B. B. D	Public Affairs, Former Principal Chiefdom Adviser	62	Community Relations (Twangiza Mining - Luhwindja Community)
K. B. V	Eco-entrepreneur	65	Environmental and Agricultural Planning
M. R. P	Geologist and Mining manager	70	Geology and Mining management
B.M.	Pastor, Farmer, Small trade	57	Church administration, Farming, Small enterprises

The following questions were asked:

1) Since when do you know about the Twangiza Mining project site and the surrounding areas (Mbwega, Cinjira, Buhamba, Ciramo, Kadumwa, etc.)?

- 2) What do you remember about the old vegetation on the site before Twangiza Mining's activities?
- 3) Should there be any new vegetation, which species would you consider to be the most interesting, and for what uses?
- 4) How would you compare the old situation with the current one, in terms of vegetation?
- 5) Are there any activities that you carry out or that you would be interested in carrying out in relation to this vegetation? (If not you, what about the members of your family and/or your circle of acquaintances?)
- 6) Have you observed any changes in relation to the animals and birds on the site? If so, which have become more abundant or rare?
- 7) What suggestions do you have for a better future in relation to restoring the vegetation cover around the Twangiza Mining site (how to identify threats and how to mitigate them)?
- 8) What can affect the chances of realizing your vision in relation to your proposals for a better future for the restoration of the vegetation cover in the vicinity of the Twangiza Mining site?
- 9) Have you observed any changes in the abundance, availability and quality of water in the vicinity of the Twangiza Mining site? If so, which ones and what could be the cause?
- 10) Are there any noticeable seasonal changes around the Twangiza Mining site?
- 11) Do you have any other ideas for improving Twangiza Mining's Twangiza la Verte ecological rehabilitation program?

2.1.3. Satellite Imagery

The Sentinel Satellite imagery, with 10 m resolution, was used to compare the West /Mining Site/East zones in terms of afforestation, so as to gauge its success as well as its adoption within the neighboring communities. Rectangles of 800 hectares each were selected within community Land, East and West of the Twangiza mining concession, in 2015 when communities started benefitting from project tree seedlings; and in 2023 when planted trees were supposed to have grown within the community. Increments in forest class were computed for this 7 years' interval with reference to built area, bare soils, and agro-ecosystems.

2.2. Data Analysis

The Likert scores were ranked and only the items which met agreement or strong agreement (scores 4-5) were reported. The interviews were qualitatively analyzed using N'Vivo, checking the most frequent words. The satellite imagery was classified into 4 land use categories: bare soils, infrastructure, agriculture and pastures, and forests. Comparison of means was conducted on Jamovi for Analysis of variance (non-parametric Anova, Kruskal-Wallis) and graphs. Projects were described, including their history and a few illustration pictures.

3. Results

3.1. Community's Livelihood before the Onset of the Mining Project

3.1.1. Community's Livelihood in Luhwindja Chiefdom [21]

Household income

Household income comes from four main sources: buying and selling agropastoral produce (over 80% of the population), small-scale trading in basic necessities, gold mining and wages (- 1%). Only a small proportion (less than 20%) of harvested produce is sold on the local market. Almost no farm products are exported to other markets, with the exception of sawn timber, charcoal and potatoes. The majority of residents estimate that the average household spends between \$4 and \$5 a day, which is equivalent to \$150 a month.

Of course, there are some households that live decently, including those who are gainfully employed (locally or through their families in Bukavu), employees of large institutions, church leaders, etc. In the same vein, there are also those who live on the land. Additionally, the majority of residents said that they were only entitled to between 1 and 2 meals a day, simple meals based on cassava flour bread (fufu), vegetables and ndakala, sometimes accompanied by a piece of meat. But at harvest time, the farmer's plate also contains beans, potatoes and sweet potatoes. However, in the lean season, the number of meals per person per household is extremely small.

Economic circuit

In addition to the trade in a variety of basic necessities on local markets, the trade in industrial drinks (Primus, Fanta, Amstel) is flourishing, as can be seen from the number of refreshment stands in the Lubanda and Kibuti centres and the Mbwege and Gone mining areas. This trade is gradually expanding, due in particular to the influx of gold diggers and traders into the mining areas and the presence in the area of numerous agents employed by Twangiza Mining and the humanitarian aid agencies.

It has to be said, however, that artisanal gold mining, although practiced by a small minority of the population, is in first place in terms of the flow of money allocated to this sector.

For example, artisanal mining at the Mbwege quarry produces between 20 and 30 kilos of gold, assuming that 600 working pits yield 3 to 5 grams each (at peak production). A tax of 40% of the daily production is levied directly in favor of the head of the community (the Mwami) and traders, mainly from the Kaziba chiefdom, buy the remaining quantity. The latter are responsible for export to Bukavu or abroad. The price difference on the Luhwindja market varies from 15% to 38% for the same items on the Mugogo market, while they are all supplied by the Bukavu market.

Acreage

Some land owners have between 2 and 5 hectares. But the majority of households in the community farm between 0.5 and 1 hectares, accounting for 39.4% of households as shown in **Figure 4**.

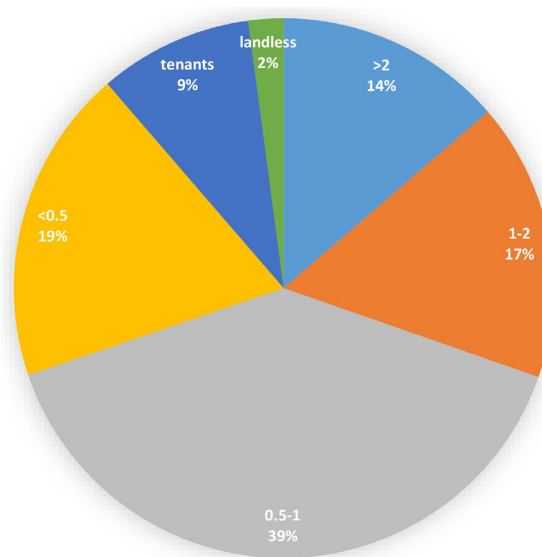


Figure 4. Land tenancy within the Luhwindja community.

There are also land tenants in the community, who form a group that is made up of people who have recently moved to the community or whose fields are no longer productive. Landless households are made up of immigrants who have come for artisanal gold mining or in search of employment. Two trends emerge in relation to the area cultivated per household. In the high-density clusters, the majority of the population cultivate only a small area, estimated at $25 \times 25 \text{ m}^2$, while in the other clusters they cultivate twice that amount, not counting woodland and grazing land. Luciga is the largest and most densely populated cluster, but it is also the cluster with the highest number of landless farmers, mainly due to the influx of people attracted by artisanal gold mining.

Around 65% of households consider themselves to be totally destitute. Ownership of land and prosperous livestock (large farms) are the main criteria for wealth, and trading is the unifying factor.

The average person, considered to be 'the resourceful', engages in ambulatory trade, which helps to improve family income and housing (a few new brick and tin houses). They account for 30% on average. This middle class is quite dynamic, as many of them own gold mines or deal in precious materials in the Twangiza mining area. They also include pastors and heads of schools and middle managers in private sector companies. Those considered to be "rich and/or prosperous" have simply migrated to the town of Bukavu, where they engage in commercial activities. These include prominent notables, pastors, doctors, lawyers and businessmen whose wealth, reinvested in the community, contributes to the economic development of many of their fellow citizens in the chiefdom.

Mining crafts

More than 5,000 people (diggers, traffickers, tax collectors, pit owners, women and children) make their living from this activity on the "Gone" and "Mbwega" sites, commonly known as "TWANGIZA". The majority are adult men, young

people (15%), women (2%) and children, estimated at 8% of the diggers. Of the residents, 70% are indigenous and 30% come from other communities, particularly Kaziba and Ngweshe.

It is estimated that diggers earn between \$90 and \$120 a day. Of course, the latter pay royalties and taxes to the customary authority amounting to 40% of daily production through the “Baganda”. To this must be added the charges, in particular the payment for the diggers’ labor and the food ration, which is estimated at 25% of production. In the final analysis, however, the structure of gross revenue suggests comparative advantages, and even high ones.

3.1.2. Community’s Livelihood in Burhinyi Chiefdom [20]

Burhinyi’s inhabitants derive their income from four main sources: the purchase and sale of agro-pastoral products (over 80% of the population), small-scale trading in basic necessities, and gold and cassiterite mining, an activity that absorbs between 20% and 30% of Burhinyi’s inhabitants. Only a small proportion (less than 20%) of the products harvested are sold on the local market. Almost no field produce is exported to other markets, with the exception of sawn planks and embers. The type of household dwellings, their acreage and their social ranking in Burhinyi are detailed in **Figure 5**.

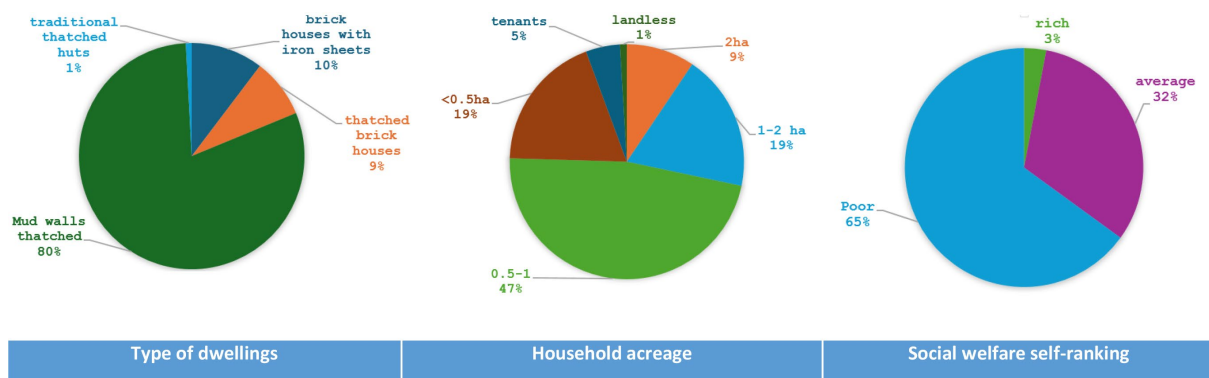


Figure 5. Household dwellings, acreage and social welfare ranking in Burhinyi.

The majority of residents estimate their monthly income at between \$90 - \$120 for an average family of 8. The majority of residents stated that they were entitled to only 1 to 2 meals a day, a simple meal based on cassava fufu, vegetables and ndakala (fretins), sometimes accompanied by a piece of meat (in middle-income households). More than 80% of the population lives in extreme food insecurity, are quite vulnerable and have a precarious life. The average household in Burhinyi farms 1.3 hectares of land. But it has to be said that only a third of this available area per household is farmed, due to the lack of helping labour. Field work is reserved for women. According to estimates, on average 75% of households do not own any trees, and for those that do, the number is around 20 trees per household. Around 65% consider themselves to be totally destitute. The small number of people considered “rich and/or prosperous” have abandoned the area to take refuge

in the town of Bukavu, where they trade. Their lorries transport goods and people from Bukavu or Luhwindja.

The rich man owns a farm with more than 10 cows and several fields, produces and sells agricultural produce, is a charitable person whose wealth helps others, has an improved house (brick with metal sheets) and his children go to school (locally and elsewhere). The average person has at least one cow, a field and a small business, does not buy food, has a tin house and his children do not go to the nutritional centre. The poor man eats by grace, with his unschooled children dependent on the nutritional centres, and has only his hut and a few guinea pigs as possessions.

Apart from this agropastoral potential, the community of Burhinyi has enormous mineral resources in the subsoil, with almost all the Divisions hosting gold or cassiterite. The most important mining squares include: Mwana (Twangiza), Karhwa, Cikubi, Tshondo, Nkambye and Bisengi. In fact, by virtue of its location, Burhinyi lies in the natural extension of the gold belt commonly known as “The Twangiza-Namoya Gold Belt”. In this area, artisanal mining is the dominant activity, affecting more than 60% of the working population. At its peak, the Twangiza site in the Ntondo district alone attracted more than 2,000 artisanal miners. It should be noted, however, that this is a small-scale alluvial artisanal operation. Artisanal mining is the main source of income, the benefits of which are used to fuel small-scale local trade and improve infrastructure, particularly housing, schools and churches.

Ntondo, on the banks of the Mwana river is one of the divisions with the highest concentration of gold ore. The “Gone” quarry on the Mwana river is often overcrowded during the rainy season to “trap” alluvial gold originating from Mbwega, the main pit of Twangiza Mining’s gold extraction plant in the Luhwindja community. Other small gold and cassiterite deposits are scattered throughout the above groups.

Artisanal gold and cassiterite mining is the mainstay of the Burhinyi economy. Despite the fact that the community of Burhinyi has been landlocked for several decades, the population has taken care of itself, thanks in particular to artisanal gold mining. The small-scale trade that has developed in Burhinyi is linked to mining. The Gone mine (the largest deposit) has between 300 and 600 operators (owners and independent diggers). It is estimated that daily production per miner could be between 2 and 3 grams of gold per shaft at peak times, *i.e.* during periods of heavy rainfall, which creates cracks in the Mbwega hill and washes the earth down the Mwana river.

3.2. Community Projects Funded by Twangiza Mine

A number of community projects have been implemented to reduce the pain of local community, especially with road infrastructure which reduced the travel days from a number of days to a few hours when the mine is operational. A synopsis of some projects undertaken is presented in **Table 1**.

Table 1. Community projects undertaken by Twangiza Mining in its surrounding area.

No	Project	Qty	Beneficiaries	Success signs	Difficulties
1	Primary schools construction	4	Ciburhi P. school Bigaja P. school Mulambi P. school Burhuza P. school	All these schools are functional and well equipped	
2	Secondary school	1	Ifendula Institute	Up and running	
3	Water supply project, executed by Caritas	1	Serving 18,000 Luhwindja residents		
4	Water Provision to Luciga (12 km pipe line, from Bushushu village to Ciramo, and from Lukungurhi to the Kibuti Health Centre)	2	Most of the population of the Luciga constituency	25 public taps along the line and 28 taps in schools, health centres and private homes	Inappropriation by some members of the local community who vandalize the line, calling for multiple repairs on the line
5	Bridge construction and/or reinforcement	6	The population of Luhwindja, Burhinyi, Walungu and Kabare	The bridges facilitate movement of people and goods	Frequent repairs required due to wear and tear and failure to comply with load capacity of trucks
6	Road construction and/or maintenance	2	Luhwindja-Burhinyi-Ngweshe-Bukavu section Luhwindja-Kaziba-Nyangezi section	Easy access, compared to time before the establishment of the mine	Lack of resources when needed for maintenance and poor behavior of commercial truck drivers
7	Gabion wall erection for erosion control and infrastructure stabilization		Luhwindja- Burhinyi-Kaziba and Walungu	Many gabion walls erected to support road infrastructure	
8	Lubanda, Mulambi and Biral stadium renovation and rehabilitation		Luhwindja and Burhinyi	Stadium operational	
9	Adult literacy program in Luhwindja and Burhinyi		Luhwindja and Burhinyi		
10	Scholarships for secondary (ITFM), university (UOB, UCB) and postgraduate studies (University of Pretoria)	5 3 2	Luhwindja residents (and Twangiza workers for postgrad studies)	Most of them completed their studies (85%)	Some students dropped studies for lack of skills
	Ecological rehabilitation through the Twangiza la Verte Project	1	Luhwindja Burhinyi Kaziba Walungu	100 ha planted directly within the mine site and <800 ha in the surrounding communities	Bushfire, saplings grazing by wandering cattle, tree cutting and vandalism.

3.3. The Progressive Ecological Rehabilitation and Its Impact Within Local Community

The Twangiza La Verte project, initiated in 2012 aimed at environmental rehabilitation, slopes stabilization and tree planting. Seeds were purchased, platforms prepared for nurseries, local women selection, training and sensitization conducted for nursery activities. Seedlings from nurseries were transplanted all over the mine site. The plant species that were selected from the onset of the rehabilitation program are presented in **Table 2**.

Table 2. Germination status of species involved in the rehabilitation program. (From April 2012 to December 2024)

Nurseries	Period	Species sowed	Germination status from 2012 to 2024	Observation
CINJIRA, NAMIHOMBO and BUGOBE	2012-2024	<ul style="list-style-type: none"> -<i>Acrocarpus fraxinifolius</i> -<i>Adansonia digitata</i> -<i>Albizzia adianthifolia</i> -<i>Calliandra calothyrsus</i> -<i>Casuarina equisetifolia</i> -<i>Cedrela serrulata</i> -<i>Grevillea robusta</i> -<i>Hagenia abyssinica</i> -<i>Jacaranda mimosifolia</i> -<i>Leucaena glauca</i> -<i>Maesopsis eminii</i> -<i>Markhamia lutea</i> -<i>Moringa oleifera</i> -<i>Pinus patula</i> -<i>Podocarpus usambarensis</i> -<i>Prunus africana</i> -<i>Senna notabilis</i> -<i>Spathodea campanulata</i> -<i>Terminalia sp</i> -<i>Theobroma cacao</i> 	On the 20 species sowed in the 3 nurseries over the period, 18 species (85.71 %) have pricked.	<ul style="list-style-type: none"> - Growth rate has been found to be slower in the Cinjira nursery, and attributed to the high altitude of the location. - Three species (covering 14.28%), namely: <i>Adansonia digitata</i>, <i>Theobroma cacao</i> and <i>Moringa oleifera</i> did not prick in the Burhinyi nursery, probably due to the very low altitude, as compared to the other 2 nurseries.

The number of tree planted adopted a declined trend from 2018 due to financial constraints faced by Twangiza Mining, which led ultimately to the halt of operations since December 2019. However, owing the necessity of maintaining a safe environment, the Twangiza La Verte Project remained active while all other activities of the mine came to a halt. With this, the planting and tree seedlings distribution continued. With no financial means to purchase seeds for planting seasons, the mines' Environmental department and the Twangiza la verte embarked on a search of seedlings from already grown up species and hence continued the activities, though with less trees planted, as there was also a lack of polyethylene bags that helped move the seedlings from nurseries to the planting areas. This is highlighted in the years 2023 and 2024 as shown on **Table 3**. However, in 2024, significantly more seedlings were distributed than planted.

Table 3. Trees planted from April 2012 to December 2024 within the Twangiza Mining perimeter.

Rehabed sites / Period	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total (2012-2024)
Cinjira resettlement site	7,763	28,435	15,564	13,360	17,059	15,022	11,823	8,955	11,116	14,485	8,359	3,265	4,770	159,976
Burhinyi – Cinjira access roads	2,654	11,600	10,789	12,060	11,190	5,368	1,514	4,620	0	1,440	0	490	460	62,185
Plant site slopes	19,177	16,031	15,194	6,925	14,811	5,805	7,321	8,580	10,773	4,506	5,510	1,501	3,810	119,944
Operators' Camp	1,177	260	0	0	0	0	0	0	0	0	0	0	0	1,437
Security Complex	0	455	0	0	0	0	0	0	0	0	0	0	0	455
Laydown Yard	0	1,791	1,503	0	400	0	0	0	810	0	0	0	0	4,504
Exploration Camp	0	1,048	85	0	105	120	140	0	0	0	0	0	0	1,498
TMF access road	0	1,850	0	0	0	0	0	0	0	3,342	0	0	0	5,192
Katuba resettlement site	0	0	0	0	0	0	0	0	0	205	3,969	2,666	920	7,760
Total	30,771	61,470	43,135	32,345	43,565	26,315	20,798	22,155	22,699	23,978	17,838	7,922	9,960	362,951

The status of rehabilitation at the Operators' Camp and surroundings and the Cinjira resettlement village is shown in **Figure 6**.

**Figure 6.** Planted trees around the Operators' camp and at the Cinjira resettlement village.

A number of beneficiaries received trees after a training and sensitization session and assurance of follow up on growth rates. Over 60 institutions were concerned, including: The Burhinyi, Luhwindja and Ngweshe chiefdoms, their Divisions, health centres and the Ifendula Hospital, 34 schools (primary and secondary) and over 20 churches. The number of tree distributed in the community is presented by December 2024 is presented in **Table 4**.

Table 4. Number of trees distributed to the community institutions during the period 2012-2024.

2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total (2012-2024)
25,500	71,905	70,229	44,858	48,781	85,265	63,441	72,213	43,479	63,232	39,754	27,760	50,645	707,062

Tree nursery preparation activities

The main activities at the tree nurseries consisted of planting seeds in the nurseries, watering, weeding, transplanting into polyethylene bags and planting onto the identified and targeted sites. **Table 5** shows the number of polyethylene bags that were filled with soil and organic fertilizers (produced at the Twangiza domestic waste dump with aid of Effective Microorganisms [EM]).

Table 5. Filling of polyethylene bags with organic fertilizers and transplantation of seedlings into those bags.

Nurseries	Filling of polyethylene bags	Transplanting into polyethylene bags
Namihombo	732,007	714,487
Cinjira	526,720	529,793
Bugobe (Burhinyi)	633,213	533,762
Total	1,891,940	1,778,042

Figure 7 shows the various steps described above from seeding to getting ready for planting.

**Figure 7.** Nursery plot preparation, seeding, watering, weeding and transplanting into polyethylene bags.

Environmental education

In order to help maximize the success of the rehabilitation project, Twangiza la

Verte embarked on environmental education from the onset of the project. This had resulted in a gradual but consistent buy-in by the community of the importance of the project – hence the continuation of the project over 10 years. The target population was mainly women and children as they are the ones that are mainly seen around the mine site, in quest of fire wood and have been the ones lighting bushfire in the surroundings.

Environmental education was most of the time coupled with tree seedlings distribution, mostly in favor of schools as shown in **Figure 8**.



Figure 8. Environmental education and tree distribution.

Table 6 provides a breakdown by gender and the number of people who benefited by the environmental education sessions.

Table 6. Number of people who were taken through the environmental education and sensitization program.

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Men	532	924	316	888	1,092	694	753	646	519	564	318	418	476
Women	769	1,203	341	754	897	443	535	592	480	434	291	434	240
Children	764	5,479	1,178	1,177	2,094	5,343	2,066	1,136	1,964	913	331	849	843
Total	2,065	7,606	1,835	2,819	4,083	6,480	3,354	2,374	2,963	1,911	940	1,701	1,559

Sensitization and demonstration of sustainable agricultural good practices were intensified targeting local employees and the local communities. These activities stressed on the preservation and/or restoration of soils and household self-reliance in line with sustainable development practices.

The consequences of criminal bushfire that is frequently lit in the vicinities is also a major source of concern as shown in **Figure 9**.



Figure 9. (a) Bushfire on the plant site slopes; and (b) Women and children collecting fire wood on the plant site slopes.

Land use dynamics within the community as a witness of adoption of the afforestation project

Land use dynamics over time using satellite images show a clear change between the years 2015 and 2023 in terms of land use as shown in **Figure 10** as well as **Table 7**, indicating a dynamic situation.

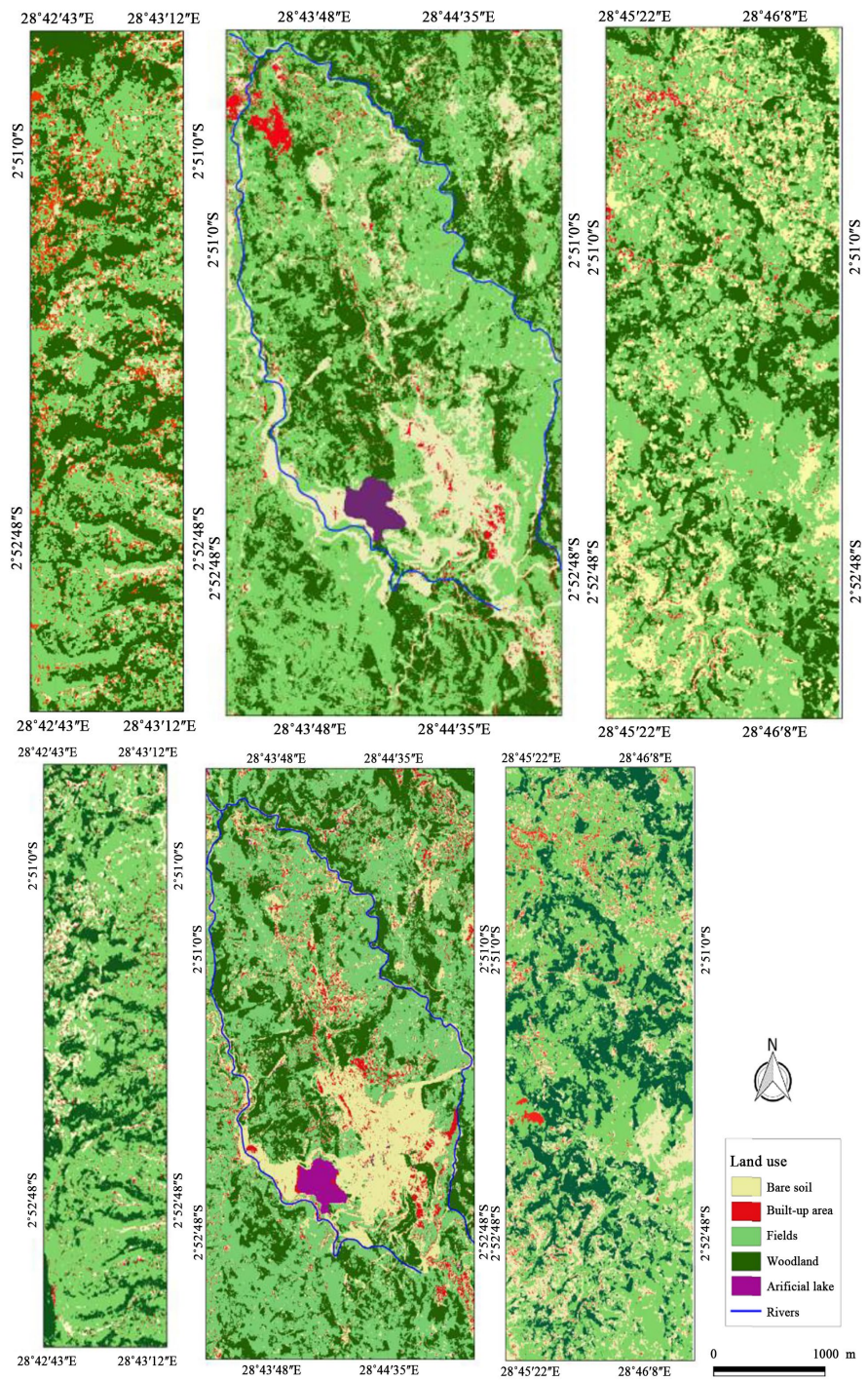


Figure 10. Land-use. a) upper line 2015. West-Mining area-East; b) lower line 2023; West-Mining area-East.

Table 7. Land use dynamics between the years 2015 and 2023.

Land Use	Fields						Bare soil					
	East		Mining		West		East		Mining		West	
Year	2015	2023	2015	2023	2015	2023	2015	2023	2015	2023	2015	2023
Area (ha)	50.7	49.3	53.3	49.06	43.7	55.8	20.2	19.8	15	18.3	8.3	11.6
Land Use	Built-up area						Woodland					
	East		Mining		West		East		Mining		West	
Year	2015	2023	2015	2023	2015	2023	2015	2023	2015	2023	2015	2023
Area (ha)	2.7	3	3.7	4.9	9.6	4.0	26.5	27.9	27.0	26.7	38.4	28.6

Figure 11 presents graphs of the observed land use between 2015 and 2023 for the fields, bare soil, built-up area and woodland.

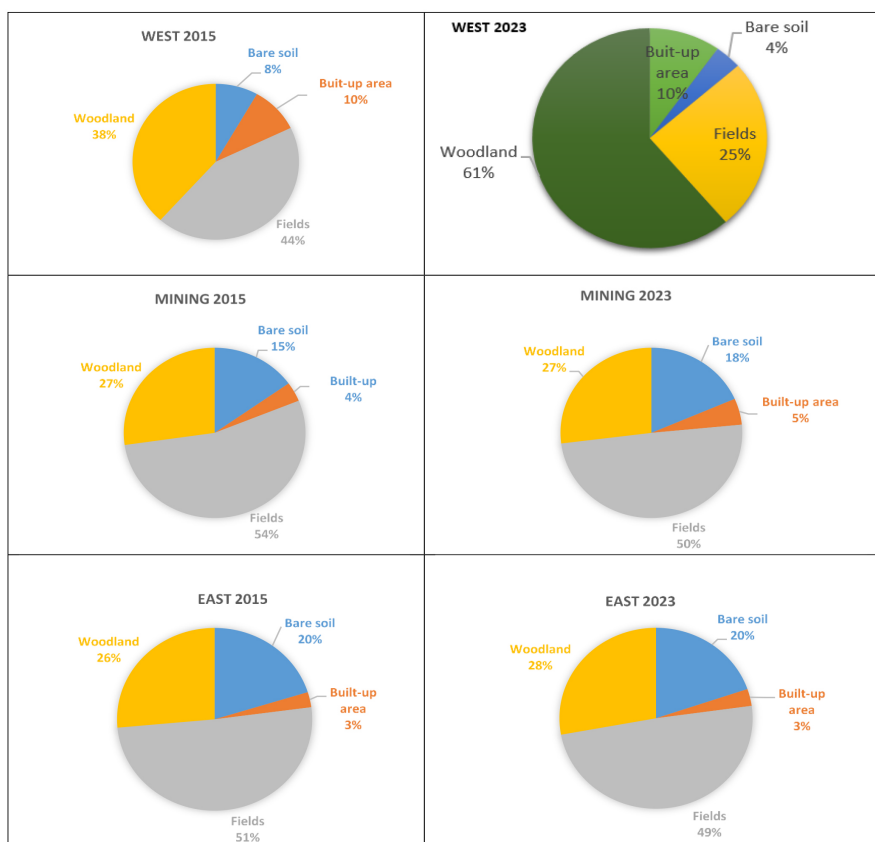


Figure 11. Graphs displaying the land use observed in 2015 as compared to 2023 in the West, Mining zone and the East.

Within the community land, the woodland area gained 2% in 2023 as compared to 2015, having replaced fields, which lost 2% of their area. Within the mining, the woodland remained unchanged, as it was just growing up. In the West, the woodland strongly increased from 38% to 61%, thus gaining 23% or 187 hectares, including 19% derived from the shift of fields and 4% from newly planted former bare soils.

In this area, where the modal acreage amounts to 0.5-1 ha, the area dedicated

to woodland is <0.2 ha per household. So, the increment of 187 hectares in 2023 vs 2015 represents 935 households which invested more in woodland production in the western side vs 26 ha in 130 households in the eastern side near the boundaries of the mine.

3.4. The Results of the Likert Score Evaluation of Twangiza Mining Community Projects

Only items strongly agreed or agreed upon are reported here. The results of the Likert score evaluation show that the company community projects are diverse and they have an impact. Among the main issues there is deforestation and soil erosion. The local communities often feel that their concerns are not adequately addressed, leading to tension and mistrust. It is imperative to establish funds where a portion of mining profits directly benefits local communities. There is agreement that investing in infrastructure benefits the wider community, not just those directly involved in mining, and that mining operations create jobs, both directly within the mines and indirectly through supporting industries. Regular monitoring ensures compliance with environmental standards and meaningful consultation with local communities is crucial before, during, and after mining operations. Around the Twangiza Mining, an influx of job-seeking migrant occurs and in-migration due to mining leads to increased housing costs and pressure on infrastructure such as schools. To some extent, there is lack of differentiation between projects that benefit the company directly and those that genuinely benefit the community; and a disconnection between reported achievements and on-the-ground realities. There is a strong agreement that the wealth generated from mining can stimulate investment in other sectors. The boom-and-bust cycles of the mining industry do lead to fluctuating income levels and economic instability.

In fact, it is true that corruption, weak governance, and a lack of effective regulation exacerbates conflicts between the mining company and local communities, here. Thus, corruption within local government undermines trust and hinders equitable benefit sharing. While NGOs do play a positive role in advocating for community rights and environmental protection, their involvement also contributes to conflicts. Also, wealth is not always equitably distributed among local communities.

Moreover, the environmental consequences of mining negatively impact the livelihoods of rural communities and cause economic hardship and increased poverty. So, there are conflicts over resource access, and benefits are intensely localized, and there is concentration of wealth in certain areas and increased income for some families and improved living standards in certain segments of the population. Massive discrepancies between those who own land with resources and their neighbors are observed. This leads to disputes over land rights. Traditional livelihood practices and cultural norms have been disrupted. Increased crime and social problems, such as prostitution, have been associated with mining operations.

Strategies to mitigate conflicts between mining companies and local communities should focus on prioritizing local hiring for mining jobs; although low-skilled jobs often pay low wages, particularly for those working for contractors rather than the mining company, directly. Community Development Projects, *i.e.* supporting agriculture, or other industries, adopting modern technologies that minimize environmental damage, implementing more and more effective waste management systems are contemplated. In this regard, the TMF has shown a very high performance and efficiency in the sequestration of heavy metals, even as compared to the baseline study era in 2008; when there was intensive and scattered small-scale mining before the onset of industrial operations. The rehabilitation of mined areas is imperative. This includes implementing sustainable mining practices and environmental monitoring. The progressive ecological rehabilitation covers 100 hectares so far within site and it impulsed the afforestation of more than 770 hectares within the community by providing seedlings and training.

The need for open communication and participation in decision-making processes is clearly expressed. Providing training on sustainable development, negotiation skills, and monitoring mechanisms, and empowering communities to participate more effectively is necessary. Providing access to information about mining projects and their impacts is imperative. Independent audits of environmental and social impacts should be championed. Improving the functioning of local government institutions will ensure that they can effectively represent community interests and hold companies accountable. Whenever resettlement is necessary, it should be planned carefully, with adequate provision for housing, livelihoods, and social support. Infrastructure development that benefits both the Company and the Community must be put forward. The reporting of these projects should not obscure the extent to which they serve the company's interests versus the community's.

Some participants have been aware of the Twangiza Mining project since its inception, which began with the arrival of the mining company and the initiation of environmental restoration efforts. This indicates a long-term familiarity with the project and its impacts on the local environment. The Twangiza la Verte project, aimed at restoring vegetation cover, has been a focal point for community engagement, suggesting that participants have been involved or aware of the project for several years. There are indications that local residents have observed changes in the area, such as the presence of certain animal species and vegetation, which implies a longstanding connection to the land and its developments.

The area previously had a variety of local tree species, which were primarily planted by NGOs and local initiatives before the mining activities began. These included trees like Eucalyptus and Cypress introduced by missionaries, as well as other local species. Participants recall that certain wildlife, such as partridges, crickets, and frogs, were abundant in the area prior to the mining operations, indicating a rich biodiversity associated with the old vegetation. The old vegetation likely included a mix of native plants that supported local fauna, as the presence

of these animals suggests a healthy ecosystem before the disturbances caused by wars and community pressure over resources. There is a mention of the invasive occupation by mining workers leading to the migration of some species, which implies that the original vegetation was significantly altered or diminished due to human activities.

The species *Pinus patula* is valued for its ability to resist strong winds, making it an effective windbreak. Its wood is also used for constructing fences and supporting crops like beans, while it helps combat soil erosion. This makes it particularly interesting for local agricultural practices. *Grevillea robusta* is known for its fast growth, its agroforestry potential and is appreciated for its potential in reforestation efforts. It provides timber for various uses and contributes to soil stabilization, which is crucial in areas affected by mining activities. The species *Cypripedium lusitanica* is recognized for its durable wood, which is used in construction, particularly for framing. Its introduction has been part of reforestation initiatives aimed at restoring the ecological balance in the area. Eucalyptus was initially introduced by missionaries. It is valued for its rapid growth and ability to provide firewood and timber. Its presence has been beneficial for local communities in terms of resource availability. *Calliandra calothyrsus* is noted for its utility in producing planks and firewood, contributing to local livelihoods while also playing a role in environmental restoration efforts.

The old vegetation was characterized by a diverse range of native species that supported a rich ecosystem, including various wildlife such as partridges and frogs, indicating a healthy environment prior to mining activities. In contrast, the current vegetation has seen significant changes, with the introduction of new species like *Pinus*, *Eucalyptus*, and *Grevillea*, which are now being utilized for timber and firewood, reflecting a shift towards more commercially valuable plants. Previously, the landscape was dominated by short grass used for grazing livestock, while today, it is increasingly covered by tall trees, which help in climate regulation and erosion control, showcasing a transformation in land use. The current state of vegetation has been impacted by mining activities, leading to a deterioration of natural cover in some areas, while reforestation efforts have been initiated to restore ecological balance. Overall, there is a clear difference in vegetation cover, with a notable increase in tree density today compared to the past, where many areas were bare and prone to erosion.

A participant has actively participated in reforesting efforts, specifically working on the ecological restoration of mountain forests around Kahuzi-Biega national Park, which includes shoot protection and silvicultural enrichment using indigenous wildlings. This initiative has resulted in a mini-park that supports tourism after 20 years of monitoring. He has planted over 600 trees at home and has fenced his plot using pruned branches from these trees, demonstrating a commitment to enhancing local vegetation and protecting it from roaming animals. He is interested in learning how to better manage woodlands, including sustainable practices such as cutting down some trees for domestic use while ensuring that

others are replanted. Another participant witnessed a community interest in setting up nurseries that focus on native tree species, which would involve collaboration with local authorities, schools, and churches to promote reforestation efforts. Another participant has observed a growing trend among acquaintances to engage in tree planting and maintenance activities, reflecting a collective effort to restore and protect the local environment around Twangiza and within the Luhwindja chiefdom.

There has been a noticeable decline in the diversity of wildlife, with species such as crowned cranes, ox-guards, hyenas, and various monkeys becoming rarer in the area. This reduction is attributed to habitat loss and environmental changes over time. Conversely, certain bird species, particularly crows and ravens, have become more abundant. Their presence has increased, likely due to changes in the environment and human activities that have altered the local ecosystem. The disappearance of bamboo, which previously supported a variety of wildlife, has led to a decline in the presence of animals like monkeys and antelopes. This shift indicates a significant impact on the local fauna due to habitat changes. Despite the decline in some species, there is hope for rehabilitation, as successful restoration of vegetation could potentially bring back some of the wildlife that has been lost.

The Participatory Management Approach involve local communities in decision-making regarding land management and revegetation efforts. This includes defining areas for replanting and establishing clear rights and responsibilities for all stakeholders. A participatory management committee can help identify threats and propose strategies to combat them.

The mining company should expand tree planting efforts to all areas that have been compensated. This will help restore vegetation cover and enhance local biodiversity and promote community awareness and environmental education. In the aim of raising awareness among community members about the importance of vegetation restoration and the negative impacts of activities such as cattle roaming, which can hinder tree growth. Educational programs can foster a sense of responsibility towards local ecosystems.

It is necessary to set up nurseries that focus on local tree species to ensure the availability of native plants for reforestation efforts. This can be done in collaboration with local authorities, schools, and churches. Threats have to be identified, monitored, and controlled. These include bushfires, tree-cutting, and livestock grazing. Natural threats such as bushfires can devastate newly planted areas, as evidenced by recent incidents where homes were lost to fires. This poses a significant risk to restoration efforts. Strategies have to be implemented to mitigate these threats, such as community patrols and firebreaks, to protect newly planted areas.

Insufficient funding and resources for ongoing monitoring and maintenance can hinder the success of reforestation projects, as it takes time to ensure the viability of newly planted trees. This is crucial for achieving long-term goals. If the local community does not actively participate in the Twangiza La Verte project, it

may lead to a lack of ownership and commitment, ultimately affecting the project's success. A lack of concrete planning and failure to implement strategies effectively can lead to unmet expectations and project failures (Mutti *et al.*, 2012).

. Continuous monitoring is essential to ensure that goals are being met. Ambiguities regarding the boundaries of mining concessions can lead to conflicts and sabotage, as local residents may feel threatened and target restoration efforts. Clear communication and delineation of areas are necessary.

There has been an increase in turbidity in local rivers, such as the Kabindi and Mwana rivers, indicating a decline in water quality. This change may be attributed to small-scale mining activities and waste discharge from the site, which has resulted in brown-colored water in nearby reservoirs. In the village of Kalaga, residents have reported a lack of drinking water, suggesting that while some areas have abundant water, others are facing scarcity. This disparity may be linked to the mining operations affecting local water sources. Some residents have noted that the quantity of water has decreased in areas where boreholes were dug during the exploration phase, leading to complaints from the surrounding population about reduced water availability. Overall, while there are abundant water sources in certain regions, the mining activities have created localized issues that affect both the quality and availability of water for the community.

There has been a noticeable shift in rainfall patterns, with rains now occurring more regularly compared to previous years, which experienced disrupted rainfall frequency. This change has led to a more stable seasonal cycle. Previously, the area experienced consistent rain every Wednesday and Saturday, but now rainfall is less predictable, often lasting only a couple of hours. This indicates a shift in the seasonal weather patterns. The rainy season continues from September to June, with a short dry spell at the end of February, but the intensity of rainfall has increased nowadays. Some residents have reported that their potato crops are now harvested four months later than before, suggesting that seasonal changes are impacting agricultural cycles. The presence of small forests developed by the Twangiza la Verte project has been linked to changes in the local climate, indicating that vegetation can influence seasonal patterns.

It is imperative to boost community awareness programs to educate locals about the importance of environmental restoration and the benefits of the Twangiza la Verte project. This can help foster community support and participation in restoration efforts. The variety or diversity of plant species must be increased in germination areas, focusing on local and fertilizing species such as *Leucaena leucocephala* and *Grevillea robusta*. This will improve biodiversity and resilience in the ecosystem. Fencing should be implemented around the Twangiza Mining site to protect it from human activities that could hinder restoration efforts, such as unauthorized mining and vandalism.

Native plants nurseries that primarily contain native tree species must be set up to ensure that the restoration efforts are aligned with the native ecosystem and promote local biodiversity. The environmental impact of the restoration program

should be regularly assessed and strategies adapted, based on observed changes in vegetation, wildlife, and water quality to ensure the program's effectiveness.

Industry and small scale mining co-existence issues

The results show that local authority and other actors in the chain reduce the income of small-scale miners and small-scale miners' products sale goes through multiple actors in the chain to the detriment of local miners. Furthermore, it is true that small scale miners were displaced from their traditional mining areas, leading to job losses and economic hardship. Informalization of small-scale mining occurred as well, making it more difficult for small-scale miners to access credit, markets, and other support services. Competition for resources led to conflicts between the multinational company, and small-scale miners, and local communities. Around Twangiza, the cumulative environmental impacts of both types of mining operations are likely much greater than the sum of their individual impacts. As it happens elsewhere, small-scale gold mining involves exposure to hazardous materials (e.g., mercury) and unsafe working conditions, leading to significant health risks for miners and their families. Small-scale gold mining attracts migrants to the area, leading to rapid population growth and pressure on resources and infrastructure. Increased illiteracy is real and due to the fact that children are used for manual works and gain access to

cash at early age, not allowing them to go to school. Increased crime, immorality, violence and mismanagement of uphazard income is also observed here. Increased accidents take place due to lack of work safety. Water pollution is obvious as small-scale gold mining involves the use of mercury and other chemicals, leading to water pollution and contamination of water sources. The turbidity of river waters is very high at exploitation sites. There is an improper disposal of mining waste which contaminates soil and water resources.

4. Discussion

4.1. The adoption of Afforestation

It is important to note that the company management paid due respect to environmental and social aspects of the mine, accepting to embark on the afforestation project, from the onset of the project. This has led to the current success as funds were regularly made available and management was eager to hear the progress that was being made overtime. Mine planning was sharing information with the environmental department indicating the amount of material displaced, the surface area disturbed and area that were being gradually released for rehabilitation as part of the life of mine plan.

However, we concur with [9] that changes in ownership of mines affect the way progressive rehabilitation plans are implemented as new owners tend to focus more on production than remediation and rehabilitation activities. This is not different at Twangiza; hence the need to document what is going on to provide incentives of new leadership, as time goes on. It is therefore important to work on closure plans and constantly update them as exploitation of mineral resources and

operations change with passing time [9].

The local community has, over time, come to realize the many benefits that may be derived from the progressive ecological rehabilitation and praise it as well as the focus and dedication the mine has put on it. It is easy to see how the local population was feeling pain when trees are being vandalized, when criminal bushfire is lit or vegetation destroyed. They offer to follow up and report culprits. Most of the population has linked the presence of the ecological rehabilitation with soil stabilization, rainfall stable patterns, wind breaking. Benefits like fire wood, sticks for agricultural uses are among the immediately perceived benefits. Furthermore, it is to be noted that with the mine action on infrastructure development, the reach to woodlots has increased, hence increasing the value of trees as compared to subsistence farming. This is confirmed by the number of trucks that are seen transporting wood to the city of Bukavu, in strong demand. A similar situation as found at the edges of Bagira and Kabare, in South Kivu, where a small plot was found to be less productive with subsistence farming but far more interesting when planted with trees, with wood plots pricking and developing after 3 - 5 years.

4.2. The adoption of Other Projects

Other projects involving road infrastructure, school construction, water supply and provision, adult literacy, etc. were much needed that they were adopted almost immediately with many more requests coming in a pipe line. With the new mining legislation applicable in the DR Congo since 2018, a local development committee (CLD) must be established to help review and channels all developmental projects and align them with the local development plan. This unfortunately arrived when the mine was experiencing operational difficulties and ultimately entered a state of care and maintenance. Immediately when the activities and production resumes, the CLD must be reinstated for a requirements specification to be drawn and approved at the appropriate levels. This will definitely ease the adoption of projects as they will be much more transparency and accountability in the running of projects.

What do people like vary from the general community and their leaders. The general community is always in quest of income generating jobs while opinion leaders tend to manipulate the local community in order to obtain negotiations, which end with the opinion leaders benefiting projects or employment quota to the detriment of the local community. Once projects are conceived and cost a lot of money, opinion leaders shout to be on the decision table. Hence, the general community benefit more of small and cheap projects. These are, unfortunately, fought back by opinion leaders who argue that the mine is not spending enough in the community.

This situation, which revolves around individual financial gains, causes lots of conflicts. Theft of mine assets, intrusion for mineral smuggling by children and the unprofessionalism of security elements fuel tension and cause conflicts.

4.3. Causes of Conflict

Conflicts are believed to be caused mainly by the lack of trust in the midst of the various stakeholders. Three major groups form what is termed stakeholders here. These are: the local leadership (The Chief and his entourage), the opinion leaders (leadership of the Luhwindja local development committee [CODELU], that of the Civil Society and Human Rights NGOs), and the local community. With the mistrust coupled with a search for individual gains, unverified and sometimes ill-intentioned messages are spread in social media and from mouth to mouth.

For instance, opinion leaders believe that traditional leaders are being given a preferential treatment over them, including cash, projects with initial capital funds, and other benefits. In the Memorandum of Understanding that was signed by the community, a statement indicated that the issues related to the Mwami (local traditional chief) have been discussed separately. The traditional leadership also claims at times that the mine engages with the opinion leadership separately to weaken its power over the population. And the local population feel, for those who can reflect on the recurring issues, that both the traditional leadership and the opinion leaders are manipulating them to obtain what they claim to be the local population needs while they are only after their own personal gains. This situation favors no one, including the mine which is pinpointed by everyone negatively.

Furthermore, while stakeholders pretend not to understand the level of investment made so far by the mine (amounting to millions of US dollars), the company need a lot of time to reach the break-even point, turnaround time, for it to start making profit. While discussing projects, only expensive projects seem to be of interest to opinion leaders, though most of the time with minimal incidence on sustainable development. The concept of sustainable development is poorly understood by the stakeholders who need to select projects that are likely to be easily run by the local population beyond the life of mine, they hence need to be affordable by the population and with minimal technical skills requirement so as to be executed by the local community with no need to outsource skilled workforce.

Another conflict arises from the presence of the illegal small-scale mining. Findings have shown that small scale mining benefit very few people and the majority of the artisanal miners are manipulated for the benefit of those few. Political interference has been seen as well with individuals in search of votes tend to promise more than the can realize and since they cannot make it, they point the finger to the mine, as if the mine was their instrument to fulfil their empty promises.

As most of the local community are expecting jobs within the mine, this situation has been taken advantage of by those who were claiming that the workforce was being hired from other areas, except locally. When an employment committee was established with community members, the latter turned out to be collecting money, cows or goats to get the local population on the lists; defeating the whole purpose.

We believe that the best negotiation strategy consisted in engaging with every-

one and letting everyone express, favoring fruitful and constructive discussions. This way, self-esteem would be restored. However, this process is very time consuming. With time, key stakeholders found that it was meaningless to develop negative attitude against each other and that unity brings about strength and achievement.

4.4. The Effect of Pre-Existing Living Conditions

Results show that most people in the local community used to live in aggravated poverty, landlocked environment and general scarcity of infrastructures of all kind, before the onset of the mining industry in 2010 [20] [21] and, even when some of them were making money, they had no instrument or strategy to help them make good use of it, other than spending for mere show off; and in the view that more money will be found in the coming days. Projects that were initiated by the Company focused as usual on health, education, and social welfare, creating employment opportunities, providing training and skills development programs, and promoting entrepreneurship [2] [8] [14] [15] [22] [23]. It implies that the mining industry could not change everything all of a sudden and that most projects would have a quick impact, and not viewed as superficial or manipulative [3]. Many conflicts could be expected in Luciga and Ntondo Divisions neighboring the Twangiza mine. Luciga, being the largest and most densely populated division in Luhwindja, has the highest number of landless farmers, mainly due to the influx of people attracted by artisanal gold mining. Ntondo, on the banks of the Mwana river is one of the divisions with the highest concentration of gold ore in Burhinyi. The 'Gone' quarry on the Mwana river is often overcrowded during the rainy season to 'trap' alluvial gold originating from Mbweza, the Twangiza Mining's min deposit for the gold extraction plant in the Luhwindja community. Communities with limited economic opportunities may be more inclined to accept mining projects, even with associated risks, if they perceive the potential economic benefits as outweighing the drawbacks. Conversely, communities with diverse and thriving economies may be more resistant to mining projects that threaten existing livelihoods [3] [4]. Smaller-scale mining projects, particularly those involving local participation and ownership, may be more acceptable than large-scale operations dominated by multinational corporations, except in times where they are involved in incidents that lead to death of community members. The type of mining (e.g., open-pit vs. underground) and the associated environmental impacts also play a role [17] [14]. Communities with prior experience of mining, either positive or negative, may have different perspectives than those encountering mining for the first time [3].

Communities in environmentally sensitive areas, or those with strong cultural ties to the land, are likely to exhibit greater resistance to mining projects perceived as posing significant environmental risks [1] [3]. Though this is correct, the opposite was witnessed in the Twangiza area, with local people forcing to be resettled in quest of financial gains, even when avenues were available otherwise. This sit-

uation prevails, over 10 years from the first resettlement, indicating that the general community was well treated during the process, or the community was and still is in a situation of demand. Both Luhwindja and Burhinyi are mountainous with sparsely located fertile soils and few marshlands and plateaus.

4.5. Lessons from the Arduous Negotiations Linked with Chinjira Resettlement

Mining operations can displace traditional livelihoods like farming and artisanal mining, leading to direct economic hardship and resentment [1] [3] [10]. During the community consultation process in relation to resettlement at the Twangiza Mine site, it is true that the general community was manipulated to claim for “the Chinjira resettlement site or nothing”, and this among many other options. As a rationale was to be provided, the concerned community claimed that Chinjira was much closer to their agricultural farms and this led all parties (resettlement working group, constituted of the provincial government agencies and the community forum, comprised of all local community’s representatives) to a consensus. However, Chinjira later became a good spot for resettles, a situation that did not please those who were against the project. Chinjira, as it is today, is a very good spot which can attract tourist owing to its geographic position. Its local health post is advancing in the right direction to become an autonomous clinic. Its vegetation is prominent and would have been much better, if not for the multiple criminal fire incidents [24]. Resilience strategies mostly include the fact that the Twangiza La Verte is composed of Twangiza Women residents who are doing their best for the success of the project, in addition to the road access maintenance project with ASSODEC association.

4.6. Issues Related to Company Projects within the Community

Companies should work to address these underlying issues, such as unemployment, poverty, and lack of access to services [2] [4] [14] [15]. Mining companies often invest in infrastructure such as roads, railways, and transportation networks, which benefit not only the mining industry but also other sectors of the local economy. However, this development is often concentrated around mining areas, leaving other rural communities underserved [6]. Infrastructure projects sometimes bypass local authorities, leading to conflict [12]. Companies often undertake projects aimed at improving community well-being, including investments in schools, healthcare facilities, and water supplies [12] [13]. However, the reporting and evaluation of these projects are strongly criticized, highlighting issues such as misleading information, ambiguity, and a lack of differentiation between projects that benefit the company directly and those that genuinely benefit the community. The value of these projects is often perceived as minimal compared to the wealth extracted from the area and the environmental and social costs borne by local people. Specific examples of inadequate water projects and educational initiatives are detailed, illustrating the disconnect between reported achievements and on-the-ground realities [13]. The wealth generated from mining can stimulate invest-

ment in other sectors, contributing to the growth of a more diverse economic base. However, this effect is not always realized, and the boom-and-bust cycles of the mining industry can lead to fluctuating income levels and economic instability [6].

While mining creates jobs and generates revenue, the benefits are often not equitably distributed. Transparency and accountability in revenue management are major concerns [1] [2] [8] [14]. Boom-and-bust cycles in the mining industry cause fluctuating income levels, affecting the financial security of families reliant on mining wages. Mining jobs are often seasonal and informal, leading to employment instability [6]. Low-skilled jobs often pay low wages, particularly for those working for contractors rather than the mining company directly [8] [16]. Corruption and nepotism in hiring practices further disadvantage local communities. In-migration due to mining can lead to increased housing costs and pressure on infrastructure such as schools [12]. Increased economic activity does not always translate into improved living standards for all community members. Community mobilization and the potential for collective action to influence project outcomes is linked to traditions, such as referendums [1] [3] [10]. The lack of meaningful consultation and free, prior, and informed consent violates both ethical principles and international law [25].

Specific issues related with ecological rehabilitation

The progressive ecological rehabilitation at Twangiza is on the right track. It is known that companies should plan for mine closure from the outset, ensuring that environmental remediation and social and economic transition plans are in place [2] [3] [15] [26]. This includes providing support for local communities to diversify their economies and develop sustainable livelihoods after the mine closes [2] [3]. Failure to adequately plan for closure can lead to significant post-mining conflicts. Mining activities cause significant environmental damage, including deforestation, soil erosion, and water pollution [6] [13] [18] [27] [28]. These impacts negatively affect agriculture, fishing, and other livelihoods, leading to economic hardship and food insecurity [1] [2] [6] [13] [17] [26]. Water pollution poses serious health risks to communities and wildlife [13] [6]. The acquisition of land for mining operations often leads to the displacement of communities and the loss of traditional livelihoods [1] [2] [12] [13] [17] [18] [29]. Inadequate compensation for land and assets further exacerbates the negative impacts [12]. As recommended by [1]-[3] [17] [30], at Twangiza, [23] [31]-[33] investigated on the dynamics of vegetation; and water quality (heavy metals, chemicals, and other pollutants, affecting human health, agriculture, and aquatic ecosystems), and air dust pollution and soil quality – mainly as benchmarks to assess the “success” of the ecological rehabilitation project - and found that the progressive ecological rehabilitation project had a positive impact on the impact on the ecosystem, making it conducive for human and wildlife.

The influx of migrant workers and the concentration of wealth in certain areas can lead to shifts in social hierarchies and community relations. Traditional live-

lihood practices and cultural norms can be disrupted [6] [12]. Increased crime and social problems, such as prostitution, are often associated with mining operations [12]. Exposure to hazardous substances, inadequate safety measures, and lack of access to healthcare services contribute to health problems among workers and surrounding communities [6] [12]. The lack of clean water and sanitation facilities increases the risk of waterborne diseases [6]. A lack of transparency in the operations of mining companies and inadequate accountability mechanisms contribute to conflict and mistrust. Communities often lack access to information about mining projects and their impacts, hindering their ability to participate in decision-making processes and hold companies accountable [1]-[4] [6] [12] [13]. Corruption within local government further complicates matters [12].

The role played by NGOs and Activist Groups

While some work to facilitate dialogue and promote sustainable development, others may employ confrontational tactics that escalate tensions [1] [3] [5] [10] [22]. We have observed that a number of NGOs, in quest of project funding, used rather unlawful techniques, to the level of lying to the general community indicating to them that Twangiza Mining was ready to provide employment or project funding if the latter could fill some forms. These forms were later manipulated against the company as community claims. Later on, the same community after realizing that they were manipulated, confessed. A number of activist groups, even after being unmasked by the local community continue to manipulate the latter with other words and sometime succeed, though for a short period of time.

The co-existence of industrial mining with small-scale mining

Industrial mining operations often claim large concessions, directly overlapping areas already used by small-scale miners for their livelihoods. This creates direct competition for access to land, water, and mineral resources, leading to conflict [1]. The lack of organized exploration by industrial miners prior to mining in areas where artisanal miners operate also contributes to this conflict, as miners operate in a “trial and error” manner, leading to environmental liabilities and resource depletion [17]. We have observed that small scale miners use opportunistic methods, knowing that they are not entitled to be within the premises as mining titles cannot overlap. However, knowing that they cannot be moved off by force, to the risk of converting into militias or armed groups due to unemployment, their presence is also a call for alternative livelihood, which they claim for in the project area. Having learnt of international best practices, they have gained more assurance as compared to the beginning (2005).

4.7. The Most Preferred Projects of Mining Companies for Local Communities

The most preferred projects of mining companies for local communities are those that simultaneously address the company’s needs and present a positive image of corporate social responsibility (CSR). Infrastructure Development that Benefits both the Company and the Community. Projects like road construction, water pipelines, and improvements to local transportation networks are frequently cited.

These projects are beneficial to the community, but they also directly support the mining operation's logistics and workforce. The reporting of these projects often obscures the extent to which they serve the company's interests versus the community's. While health clinics and schools are presented as community benefits, the focus is often on the health and education of the mine's workforce and their families, rather than the broader community. Mining companies tend to favor projects that are relatively inexpensive and straightforward to implement, rather than those that require significant long-term investment or complex management. This can lead to projects that have limited impact on the community's overall well-being. The emphasis on reporting and evaluation suggests that mining companies prefer projects whose outcomes are easily measured and presented in a positive light in CSR reports [34]. This can lead to a focus on easily quantifiable metrics, rather than projects that address more complex social or environmental issues.

4.8. The Need for Environmental Regulations and Better Enforcement

The need for environmental regulations and better enforcement can allow mining companies to operate with impunity, leading to environmental damage and community grievances [1] [3]. However, this seem not to be possible in the DR Congo, except for companies that are inclined for corruption. The current regulations and civil servant push for penalties for wrongdoers and at times, force those in compliance to pay penalties for issues that are inadequately assessed. It is advisable for those behaving lawfully to be adequately recognized and acknowledged.

5. Conclusions

Various projects were achieved within the community. These included Primary schools construction, Secondary school, Water supply project, Water Provision, Bridge construction and/or reinforcement, Road construction and/or maintenance, Gabion wall erection for erosion control and infrastructure stabilization, 3 football stadiums renovation and rehabilitation, Adult literacy program in Luhwindja and Burhinyi, Scholarships for urban technical secondary (ITFM), and universities and postgraduate studies (University of Pretoria), and Ecological rehabilitation through the Twangiza Green (la Verte) Project.

Including Burhinyi, Luhwindja and Ngweshe chiefdoms, their Divisions, health centres and the Ifendula Hospital, 34 schools (primary and secondary) and over 20 churches covering ca. 770 hectares within the community by providing seedlings and training. In order to help maximize the success of the rehabilitation project, Twangiza la Verte embarked on environmental education from the onset of the project. The target population was mainly women and children as they are the ones that are mainly seen around the mine site, in quest of fire wood and have been the ones lighting bushfire in the surroundings. So far, 37,625 people were taken through the environmental education and sensitization program. The Likert

score evaluation of Twangiza Mining community projects shows that there is agreement that investing in infrastructure benefits the wider community, not just those directly involved in mining, and that mining operations create jobs, both directly within the mines and indirectly through supporting industries. In fact, it is true that corruption, weak governance, and a lack of effective regulation exacerbates conflicts between the mining company and local communities, here. It is true that small scale miners were displaced from their traditional mining areas, leading to job losses and economic hardship. While NGOs do play a positive role in advocating for community rights and environmental protection, their involvement also contributes to conflicts. TMF has shown a very high performance and efficiency in the sequestration of heavy metals, even as compared to the baseline study era in 2008; when there was intensive and scattered small-scale mining before the onset of industrial operations.

Socio-economic impacts of the Twangiza projects were not measured in this study as they were out of its scope. The latter rather focused on the company-community projects and activities. This is, however, important to be considered in perspectives for a socio-economic study to be conducted within communities.

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Conflicts of Interest

The authors declare no conflicts of interest.

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