Research Article

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Mines' Characteristics and Their Links with Agriculture as the Main Livelihood for Rural Households in Burundi

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Abstract

Mining activities create positive links with agriculture. They are also characterized by uprooting of agricultural land and labour, and water pollution. The objective of this paper is to characterize mining activities and their links with the livelihoods of rural household. A survey with 140 households, interviews and observations were conducted in July and August 2022 in Mabayi commune, on Gahoma and Ruhororo hills, where the Russian mining company 'Tanganyika Mining Burundi-TMB' and the local mining cooperative Dukorere Hamwe Dusoze Ikivi-DHDI were carrying out their activities respectively, since December 2018. The results showed that TMB and DHDI inject money into the local economy, and strengthen social ties by creating farmers and mutual aid's associations/cooperatives. They are also characterized by competition in land and labour markets, environmental degradation, rising food and arable land prices, and corruption in the compensation awarding process. DHDI absorbs considerably local labour force and improves social infrastructure, unlike TMB. Although it is characterized by survival mining activities which are dangerous to health and live of employees, DHDI contributes positively to agricultural production, whereas TMB contributes negatively to agricultural production, despite having sufficient capacity and skills to improve performance and ensure the safety of its employees.

Keywords: *Mining, Agriculture, Livelihoods, Burundi*

1. Introduction

African countries are increasingly turning to mining as a potential internal resource for their economies (OECD, 2016). A significant proportion of foreign direct investment is directed towards the extractive industries sector (*Ibid*., 2016). Currently, mining constitutes a second sector of activity after agriculture for the economies of these countries. Indeed, mines stimulate growth in the

countries that own and develop them, thanks to their positive effects on Gross Domestic Product (GDP) (Alhasan, 2014; WB, 2015; Mokam and Tsikam, 2017). According to the Ghana Chamber of Mines, in 2008 mining activities generated around 45% of total export revenue, 12% of government's fiscal revenue and attracted almost half of foreign direct investment and contribute around 6% to GDP (Aragón and Rud, 2012). In the Central African Copperbelt (Democratic Republic of Congo - DRC- and Zambia), mining activities account for a major part of export earnings and they contribute substantially to GDP (Balasha and Pesa, 2023). Mining enables an improvement and increase in agricultural activity among certain households thanks in particular to the wages of the jobs created and the mining companies' community development programs (Adjei, 2007). Also, mining sites offer a remunerative consumption market for agricultural products, a shorter sales cycle, and a strong attraction for traders (Zabsonré et *al*., 2016).

Nevertheless, in-depth empirical studies relating to the effects of mining on agriculture remain limited, although they are currently emerging (WB, 2015). Economic and social spin-offs of mining activities in rural areas remain considerably limited, and that the scale of its negative effects in mining areas raises questions about its ability to play an important role in local socio-economic development (Musokotware, 2016). In African countries, questions remain as to whether they improve the livelihoods of local rural populations; and more particularly their agricultural activities, given their negative effects in mining areas alongside and given that mines are an exhaustible resource (*Ibid*.). According to Musokotware (2016), the effects of mining are numerous, both social and economic, and affect both political leaders, local communities especially those living in the vicinity of the sites, the environment and health, etc. For example Zabsonré et *al*. (2016) emphasized direct negative effects such as the reduction in time devoted to agricultural activities due to the fact that work in the mines is more rapidly profitable than farming, the withdrawal of certain crops due to the fear of an untimely land claim by the mining companies, difficult access to active agricultural labour as this is captured by the mines, the loss of family farm labour (especially young people), which is no longer under the control of heads of families; the scarcity of land, leading to higher purchase or rental prices; the relocation or uprooting of land, often followed by the destruction of plantations; the occupation of large areas of arable land by housing developments around mining sites; the destruction of soil structure; high input prices, etc. Apart from these direct effects, the impact on agriculture is also indirect. This is the case, for example, of the reduction in agricultural production that is said to result from environmental pollution (groundwater pollution above all) (Adjei, 2007; Musokotware, 2016). In Ghana, mining has generally reduced agricultural productivity in mining settings, due to mine pollution, but not to unavailability of inputs (Aragón and Rud, 2012; Assan and Muhammed, 2018). Additionally, mining activity is generally associated with an increase in poverty, child malnutrition, and respiratory diseases (*Ibid*.). In Katangese Copperbelt (DRC), land expropriation, population displacement, pollution, ecosystem degradation, and human rights abuses have been widely reported (Scheele et *al*. 2016, Balasha and Pesa, 2023).

In Burundi, in an attempt to cope with a weak economy, the government resolved in 2005 to diversify its sources of revenue, especially by developing its mining sector as a potential source of income (Vircoulon, 2019). The country holds 6% of the world's nickel reserves, as well as reserves of gold, tantalum, tin, tungsten, vanadium, rare earths, construction materials and industrial materials including kaolin, phosphates and limestone (AAIB, 2019). Mining proper began in 2014 (AAIB, 2019). It is the second-largest source of export revenue after coffee and employs, especially cooperatives, a national workforce estimated at nearly twenty-five (25) thousand people (Vircoulon, 2019). Although its share in state financing is still low as noted in 2019, i.e. 1% in GDP, 3% in export earnings and 1.71% in the financial budget (AAIB, 2019), this is proof all the same that it stimulates the country's growth at the level of its GDP. Despite this contribution to GDP growth and job creation, questions remain as to whether the presence of mining activities also improves the livelihoods of farming households in the vicinity of mining sites, given that Nsabimana's (2019) study characterized them as causes and amplifiers of soil erosion in Mabayi commune. Given the lack of empirical studies on the negative and/or positive effects of mining activities on agriculture, it is essential to conduct a study

contributing to a broader understanding of the relationship between mining and agriculture in developing countries. The purpose of the present paper is to provide the characteristics of mining operations, as well as their links with agriculture as the main livelihood of rural households, on the Gahoma and Ruhororo hills of the Mabayi commune, where respectively the Russian company *Tanganyika Mining Burundi -TMB* and the local cooperative *Dukorere Hamwe Dusoze Ikivi-DHDI have been* conducting their activities since December 2018.

2. Materials and methods

The paper is based on an in-depth examination of secondary data; and primary data collected in July and August 2022 using a questionnaire, three interview guides (two individual interview guides: one for opinion leaders and one for the communal agronomist and public and community relations officers at *TMB* and the *DHDI* cooperative, and one group interview guide-the same for *focus groups*) and observations. It should be noted here that the only national institution responsible for collecting and analyzing data in Burundi (Institut National de la Statistique du Burundi [INSB]), can currently only disaggregate data down to provincial level. This makes it impossible to obtain secondary data at hill level, let alone data covering several years. With the help of two local interviewers, the questionnaire was sent to the heads of 140 households at home (70 households/hill for the two mining hills Gahoma and Ruhororo) to collect quantitative data on agricultural production before and during mining activities (campaign 2017-2018 and campaign 2020-2021). The Gahoma and Ruhororo hills have an average of 800 households each, giving an average total of 1,600 households. The sample size was determined using the simple random sampling formula (Yoann, 2021):

$$n = \frac{z^2 p(1-p)}{e^2} * \frac{N}{N+\frac{z^2 p(1-p)}{e^2}}$$, where N = the source population (households) or 1600 households; z = 1.96 for a confidence level of 95%; e = margin of error of 5%; p = proportion of the characteristic of interest in the population (households), set at 0.50. Using this formula, the sample size n becomes roughly equal to 309 households for the two hills. Statistically, a sample of fewer than 30 respondents is worthless, but once there are 30 or more randomly chosen, all is well (Bouchard, 2011). Thus, taking into account the practically similar characteristics of the households and their very close location, but also and above all the budget and time constraints, we opted to take into account almost half of the sample, i.e. 140 households for the two hills, and 70 households per hill. It was then necessary to include 35 households who had lost all or part of their agricultural land, along with 35 other households who had not lost any land, in order to assess the impact of mining activities on the livelihoods of both categories of household. However, as only 17 households in Ruhororo hill had lost land (80 households in total had lost land in Gahoma), we included them all in the sample, along with 53 other households who had not lost land. These households were selected using the interval 4 random sampling method. On both mining hills, individual interviews were conducted with opinion leaders (2-man and woman/hill), public and community relations managers at *TMB* and the *DHDI* cooperative, and the communal agronomist. Group interviews were conducted with miners, students and other household members (other than household heads, but known to the hill head as possessing important information about changes since the advent of the mining company/cooperative's activities or since December 2018); while *focus groups were* conducted with students. These informants were chosen teleologically because they were known in advance to possess important information about the changes that had taken place. A meeting was held with these informants during the exploratory phase, in the presence of the hill leaders, to facilitate understanding of the research interest and maximize the validity (and reliability) of the interviews. In the questionnaire and interview guides, questions were based on five variables corresponding to the five basic capitals for rural household livelihoods: natural capital, human capital, physical capital, financial capital, and social capital. The questions related in particular to the size of farms before and during mining activities, the quantity of agricultural production per season and per crop before and during mining activities, the income from farms per season and per crop before and during mining activities, the

purchase/rental or other price of land before and during mining activities, the number of household members by level of education, the number of household members who worked in the mines, the remuneration of the manual agricultural worker before and during mining activities, capacity building in agriculture, etc. The quantities produced were measured in kilograms (kg) using local units of measurement. These quantities were then multiplied by the local unit prices for each product. Possible semi-structured questions in the interview guides focused on the causes of the changes since the advent of the mining company/cooperative (or since December 2018), the general perception of their effects on farm production and income, and hence on the livelihoods of farm households. For further clarification, prices for seven products grown by the majority of households in Mabayi (maize, beans, bananas, cassava, sweet potatoes, potatoes and colocase) were collected at local markets: the Muhungu market for the Gahoma hill and the Ruhororo market for the Ruhororo hill. All survey participants were aged 18 or over, and had to have lived in the communities since before 2018, with the exception of the communal agronomist and the public and community relations officers. Data analysis was carried out using "mixed triangulation", which consists in reasoning by crossing qualitative and quantitative data, and allows for reliable results that are quantitatively verified (De Sardan, 2003; Musokotware, 2016); and by comparing situations before and during mining activities within the same community. The data was collected and entered into Excel. Quantitative data were analyzed using descriptive statistics, and qualitative data were analyzed using content analysis (Patton, 2002; Duriau et al., 2007, Srivastava and Thomson, 2009). To ensure the reliability and validity of the results, we compared average household (agricultural) income per adult person per day with the national poverty line per adult person per day in 2021.

3. Results and Discussion

Thanks to the community commitments of mining companies/cooperatives and the wages of employees, mining can stimulate the agricultural sector and improve the livelihoods of rural households (Adjei, 2007; DFID and ePact, 2019). But, in the absence of good governance in the mining sector, sufficient skills and capacities of mining companies/cooperatives, and regular monitoring of the latter's commitments, the effects resulting from negative linkages may exceed those resulting from positive linkages, and contribute to a loss of agricultural production, and thus to a deterioration in livelihoods (Zabsonré et *al*., 2016). Following a characterization of the mining activities of the *DHDI* cooperative and the *TMB* company vis-à-vis livelihoods in general, this paper discusses the links that exist between mining activities and agriculture as the main means of livelihood for rural households in the communities covered by the study.

3.1 Characteristics of mines and household livelihoods

3.1.1 Characteristics of mines

Until 2013, mineral exploitation was only artisanal, and carried out by individual nationals. This exploitation and the mineral trade were largely informal and largely beyond state control, and the tax revenues derived from it could not improve public finances (Vircoulon, 2019). In 2013, the government introduced the new mining code requiring artisanal miners to have organized themselves into cooperatives before obtaining the right to work as artisanal miners, in an attempt to limit leakage. Despite this, cooperatives still have their shortcomings, and can make little contribution to public finances. The *DHDI* mining cooperative has significant shortcomings in terms of operational capacity and worker skills. Artisanal mining remains a survival activity, where the workers' dominant tools are picks and hoes, even though it is a godsend in a very depressed job market, for a significant number of local workers. Apart from a few high school graduates who are diggers for another job, the majority of contract workers are illiterate, as are some of the shareholders who are simply traders who have made a lot of money elsewhere. Other workers are mostly

schoolchildren who dig irregularly during the vacations to finance their schooling. The cooperative has no tools or techniques for mineral detection, resorting to intensive digging as a hazardous method of detection. Foreign mining companies have also invested in this sector thanks to the 2013 mining code, which has opened the doors to them. *TMB* has sufficient capacity and skills, but employs a small workforce due to its high degree of mechanization. Job creation is their main feature of most interest to local farming households (WB, 2016). The industrial mining company *TMB* employs a total of 250 people, 150 of whom are direct national employees (employees with a contract with the mining company), 50 of whom are natives and residents of the Gahoma hill where it currently operates. This means that the total number of direct national employees of industrial mining companies could be as high as 1,200, for the 8 industrial mining companies currently operating in Burundi. For mining cooperatives, estimates of the number of national employees ranged from ten thousand to twenty-five thousand in 2019 (Vircoulon, 2019); and the "*DHDI*" cooperative currently pays 200 direct national employees, including 106 natives and residents of the Ruhororo hill where it operates. Estimates of the number of national employees in the mines are often difficult because there are also indirect employees (irregular workers without contracts) (*Ibid*., 2019); but if we consider that 26,200 people are currently employed there, this number represents around 0.7% of the 3,673,591 workers in Burundi (ADDS, 2022).

3.1.2 Income from mining activities

The ability of mines, especially local mining cooperatives, to absorb both a significant number of people living in the same community, through the jobs they create upstream, and in other downstream activities including agriculture via the wages given to upstream employees, demonstrates their importance in rural livelihoods following the improvement in household financial capital. The multiplier effect of wages paid to the *DHDI* cooperative and the *TMB* company is difficult to quantify here. However, what is certain at present is that for every person working there under contract, more than six dependents instead of five in 2016 (WB, 2016), would largely draw their livelihoods from its mining income. Salaries earned by nationals generally vary depending on whether they are direct or indirect workers, whether they live in their households or not, and the position they hold. They range from 50,000 Burundian franc (BIF) per month to 80,000BIF at the *DHDI* cooperative and the *TMB company* for indirect workers (without contracts), are fixed at 150,000BIF and 180,000BIF for small-scale workers (with contracts) at the *DHDI* cooperative and the *TMB company* respectively, and can go up to 1,200,000BIF and 2,000,000BIF respectively to the *DHDI* cooperative and the *TMB company* if the worker is qualified and has been forced to leave his family to reside temporarily in the mining community.

Although relatively too small, they are around $72.3 and $86.7 per month for small-scale contract workers, and $578 and $963 at most for skilled workers forced to live away from their families, at *DHDI* and *TMB* respectively, if taking into account the cost of living (a household meal costs an average of 10,000BIF per day in the communities concerned by the study; whereas the daily wage for small-scale workers is 5,000BIF per day in Ruhororo, and 6.000BIF in Gahoma), and a digger extracts an average of 1ton of soil per day (20 x 50kg sacks) at the *DHDI* cooperative according to information gathered during the group interviews, these wages still improve the overall budget/income of some farming households (compared with the 2021 national poverty line of 1,580BIF/day/adult equivalent, the rate of households with a general income ≥ this threshold before the mines [2017-2018 campaign], improved by 54.3% and 27% during the mines [2020-2021 campaign] from 21.4% and 20% to 75.7% and 47%, respectively in Ruhororo and Gahoma). The improvement in itself is not that significant due to the low wages, and does not mean that the livelihoods of the households benefiting from it are secure. However, miners are known to have access to money at any time. As a result, their households are often targets of robbery and sometimes fatal violence, according to information gathered from interviews. Households that benefit directly or indirectly from these mining salaries must then seek to reconcile the maintenance of this income with the

development of agriculture as their viable long-term resource, to improve agricultural production and income, in an attempt to secure their livelihoods in the long term. And mining companies/cooperatives are called upon to support them in this (articles 40 and 41 of the agreement signed with the government).

3.1.3 Extraction techniques

Mining is a hazardous activity for workers' health (Rau et *al*., 2013; Von der Goltz and Barnwal, 2014), although there is still the difficulty of collecting related data (WB, 2019). This can easily give rise to a negative impact on low wages and household budgets received from mining activities, as well as on their human capital in the event of illness or death (*Ibid*., 2019). In the case of the *DHDI* mining cooperative, due to the poverty-driven nature of artisanal operations and limited know-how, and the lack of technical support, miners work with rudimentary tools under severe constraints of long working hours, and consequently limited priority given to their well-being. This inevitably exposes them to the risk of illness. One example of the dangerous nature of mining activities is the death of 15 indirect employees (irregular workers without contracts, who mined gold artisanally on the Gafumbegeti hill in the Butahana zone, and sold it to the *DHDI* cooperative) in March 2023. In the absence of shaft protection equipment, these deaths were caused by the overflowing waters of the Rugogo river, which spilled into two shafts where these artisanal miners were located, following a torrential downpour that fell on the locality (SOS Media Burundi, 2023). The ongoing demand for new concessions by the mining cooperative and company, is leading to the gradual disappearance of the artisanal (informal) mining sites of indirect workers in the study area; sites which offer an income opportunity to these workers who, unfortunately, are sometimes forced to lose it after their disappearance (inclusion of these sites in the mining concessions).

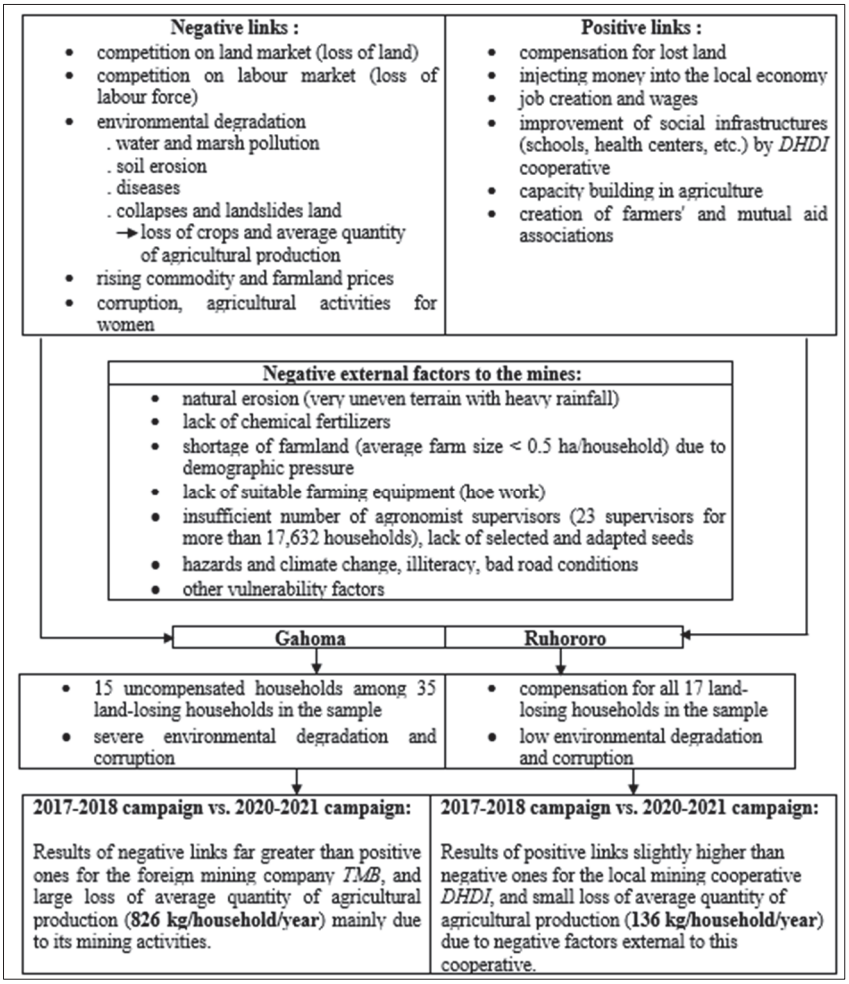
4. Mining and its Links with Agriculture

Agriculture should be able to provide a secure livelihood for over 90% of rural households in Mabayi, for whom it is the main source of income and livelihood (Pedro, 2011; OECD/FAO, 2016; MAE, 2016; Ndagijimana, 2021). In addition to being in a rainier region, i.e. experiencing 200mm of water per month (Bahati and Gahama, 2017), most of the land in Mabayi is mountainous, and therefore presents a very high vulnerability to water erosion (Nsabimana, 2019). Cultivated and inhabited areas are only the gently sloping slopes and the piedmonts, despite the region's overpopulation of between 500 and 650 inhabitants per km² (MAE, 2016; Nsabimana, 2019). The crops grown by the majority of households are maize, beans, bananas, cassava, sweet potatoes, potatoes and colocase; and due to the very rugged terrain, breeding generally concerns small livestock such as goats, sheep, pigs, chickens, etc. According to participants in the interviews and questionnaire, achieving an average yield from each of these crops requires the use of sufficient chemical fertilizers, mainly because of soil's degradation. However, apart from the fact that these chemical fertilizers are not accessible to everyone, they are not always available in sufficient quantity and quality for all applicants to be served; in addition to insufficient land for cultivation, lack of adequate agricultural equipment (the use of the hoe), insufficient agronomic supervisors (23 agronomists for the whole commune with over 17.632 households according to the INSB (2020) projections for 2010-2050), climatic hazards and changes (MAE, 2016), and the lack of selected and adapted seeds (MEAE, 2022). In addition, a significant proportion of farmers have not even reached primary school level, i.e. 35.7% of heads of households surveyed in Gahoma and Ruhororo. Added to this is the lack of road infrastructure in good condition (photo 1 & 2) to transport agricultural produce to urban markets, which are relatively more profitable than local markets.

Figure 1. Condition of the Mabayi-Ruhororo road Photo 2. Condition of RN 10 Rugombo-Mabayi (Gahoma)-Kayanza
Source: Taken on site at time of survey

As a result of the bad state of the road infrastructure, farmers are choosing to sell their produce at local markets rather than pay high prices for transport to the Mabayi or Rugombo markets. For example, 1kg of beans which cost 2,200BIF at Ruhororo and Gahoma hills cost 2,300BIF at Mabayi market and 2,450BIF at Rugombo market, at the survey time. All this only contributes to the weakening of agriculture in the study area. The lack of infrastructures in good condition leads to opportunity costs and contributes to information asymmetries among producers (Gaal and Afrah, 2017). At 2017-2018 agricultural campaign, just before the advent of mining activities in Gahoma and Ruhororo, data from the quantitative survey of household samples in Gahoma and Ruhororo, indicate that there were average agricultural productions per household of 2648kg and 2933kg (all productions combined) respectively, with average agricultural incomes of 162,330BIF and 179,850BIF per month per household, or around $78 and $86.6 per month per household at the official US dollar rate in 2022 (1$USA = 2,076BIF) respectively. From December 2018, the advent of mining activities in Gahoma and Ruhororo has created both positive and negative links (interactions) with agriculture, and these combined with negative external factors to *TMB* company and *DHDI* cooperative, have influenced agricultural production and household income in these localities. Average agricultural productions per household passed to 1822 kg and 2797 kg (all production combined) at 2020-2021 agricultural campaign, with average agricultural incomes of 197,400BIF and 303,030BIF per month per household, or around $95 and $146 per month per household at the same exchange rate (1$ = 2,076BIF), in Gahoma and Ruhororo respectively. With the advent of mining, the living conditions of the population have deteriorated, with the high cost of living exacerbated by inflation, which continues to rise in the country. This trend is characteristic of the areas where mining activities are carried out (Balasha and Pesa, 2023). These average quantities of agricultural production showed that the Gahoma hill lost an average of 826 kg per household, largely as a result of the activities of the *TMB* mining company, while the Ruhororo hill lost an average of 136 kg per household as a result of negative factors external to the *DHDI* mining cooperative (Figure 1).

Table 1. Mines and their links with agriculture



Source: Designed by the authors

Despite these average losses in agricultural production, 19 households (12 who had lost land and 7 who had not) and 38 households (10 who had lost land and 28 who had not) had improved their agricultural output thanks to the presence of mining activities in Gahoma and Ruhororo respectively. They had all benefited from capacity-building programmes run by the mining company *TMB* and the mining cooperative *DHDI* respectively.

4.1 Negative links with agriculture

The main negative links (interactions) between agriculture and mining that have been identified in the study area are competition on land and labour markets (implying loss of land and labour force respectively), environmental degradation, higher prices for land and agricultural products, corruption, and an increased burden of agricultural activities on women.

4.1.1 Competition on land market

The mining operator is seen as a profitable short-term customer, compared to the agricultural operator (DFID and ePact, 2019). As a result, mining codes take precedence over agricultural codes in the political economy of most African countries (*Ibid*.). During our survey, no cases where farming households were adequately compensated for losing their land and the assets on it. Either the compensation was not proportional to the losses (as in the case of Ruhororo hill); or it was not granted for most households, and not proportional for the few who had received it (as in the case of Gahoma hill); and this despite article 107 of the 2013 Burundian Mining Code, which stipulates that "*fair and prior compensation for all or part of the land that is affected by mining exploration or exploitation, as well as the crops and constructions thereon, shall be granted to the owner of the land by the operator*". At the same time, however, the same article also stipulates that "*no landowner may oppose the exploitation of mines*", without mentioning the sanctions that will be imposed on a mining operator who begins mining activities without compensation or with unfair compensation to the landowner. Furthermore, the operations Director at the Burundian's Office of Mines and Quarries (BOM) mentioned that there is no framework for consultation between the Ministry of Mines and the Ministry of Agriculture, or between the latter and mining companies/cooperatives, with regard to the links between mining activities and agriculture. There is only consultation between the two ministries on the links between mining activities and the environment. According to him and the information gathered during the interviews, there are also no direct channels of communication and negotiation between the mining company/cooperative and the community. A total of 52 households in the Gahoma and Ruhororo samples lost an average of 0.2 ha of land per household; and only 37 households had received compensation (20 households in Gahoma and 17 households in Ruhororo). The latter nonetheless claimed that they had been forced by local authorities, without free and prior consent, to accept these compensations, which they judged to be extremely below the real value of their lost land and property. Legally, the compensation was 4,000BIF/m² for bare land and 146,200BIF/m² for a brick-built dwelling, according to people interviewed and to Ministerial Order N° 720/CAB/304/2008 on compensation rates for land, crops and buildings in the event of expropriation for public utility. For crops, compensation is set out according to the type of crops (table 1):

Table 2. Compensation rates for crops

Type	**Culture**	**Rate/are (in BIF)**
Annual crops	Cassava	66.367
	Bean	15.788
	Colocase	43.504
	Onion	72.819
	Corn	17.542
	Leek	55.901
	Sweet potato/Potato	35.279
	Cabbage	36.254
	Tomato	203.488
	Eggplant	112.464
Perennial crops	**Culture**	**Rate/foot (in BIF)**
	Coffee	3.360
	Banana	14.009
	Avocado tree	32.553
	Mango tree	59.204
	Palm tree	126.388
	Trees	3.300

Source: Ministerial Order N° 720/CAB/304/2008

The economic consequences of this loss of land (and property) by small-scale farmers who are not or unfairly compensated, to make way for mining, in an area already threatened by overcrowding, are to exacerbate farmers' difficulties and unplanned expenditure to re-access land. This has a negative impact on the livelihoods of these small-scale farmers. If households fail to re-access their lost farmland, they lose their quantity of agricultural production, as they often lack the means to intensify the latter (MAE, 2016). Inclusive and/or participatory governance for all stakeholders would constitute viable and sustainable socio-economic development. It will eliminate the injustices associated with compassions.

4.1.2 Competition on the job market

As mines are often located in rural areas, the opening of a mine implies a tightening of labor markets in agriculture and in the mine. And since work in mines is rapidly and more profitably than work in agriculture (DFID and ePact, 2019), the effect of opening a mine is that a large number of young men and some women move from the former main agricultural activity to a new activity that becomes their main activity in the mine, in search of a relatively better economic opportunity (Dialga, 2017). Agricultural work is left in the hands of the elderly and especially women. In the study area, a household may have two to three young members working in the mines at the same time in addition to their father or mother. Agricultural labor became scarce and normally more expensive than before. The cost of farm labor has risen from 2,000BIF per day, or $0.96 in 2018 (before the advent of mining activities) to 3,000BIF or $1.45 in 2022 (with mining activities). The feminization of agriculture as an effect of mining may be exaggerated. In Africa, women tend to spend far more time than men on agricultural work, even when mines are not present (Ragasa et *al*., 2012). In the study area, mining has reinforced the already existing burden on women at all stages of the agricultural production process. Indeed, out of a total of 140 households surveyed in Gahoma and Ruhororo, 77.8% (i.e. 109 households) were headed by men, and 42% of them (i.e. 46 male heads of household) were miners who spent a large part of the day in the mines, compared with only 19 female heads of household who also worked in the mines. Some households gradually lose their identity as "agricultural households" to another identity that may not last, given the "exhaustible" characteristics of mining resources and "progressively mechanical" mining companies and cooperatives.

4.1.3 Environmental degradation

Mining has a significant effect on the local environment (WB, 2015; Zabsonré et *al*., 2016; DFID and ePact, 2019). In Ruhororo, the haphazard digging of numerous shafts close together has led to the onset or amplification of soil erosion, as well as landslides. According to local residents, several crops and plantations have already collapsed as a result of landslides, as shown on photo 7, where a banana plantation was on the verge of disappearing. As for Gahoma Hill, it is a victim of pollution from the Muhira River, where wastewater containing mining residues from the *TMB* company is discharged. This has led to the disappearance of the sorghum, maize and bean crops grown in the marshland drained by this river (photo 4), as well as a drop in production from the banana plantations planted all along the river (photo 3). It is also victim of land collapses, which have washed away crops and homes of households close to mining sites located along the 'Muhira' river (photos 5 and 6).

Figure 3: Decrease in banana production

Figure 4: Disappearance of crops
Source: Photos taken on site at the time of the survey (Maruri site).

Photo 3 and 4: Groundwater pollution by chemicals and mine tailings, disappearance of sorghum, maize and bean crops in the 'Muhira' river swamp, and reduction in production of the banana plantation grown along this river at Gahoma.

Figure 5:

Figure 6:

Figure 7:

Photos 5 and 6: Landslides and loss of crops and homes near the site next to the Muhira River in Gahoma (Bihahe site). Photo 7: Landslides and loss of a banana plantation in Ruhororo (Butare site). Source: Photos taken on site at the time of the survey

We found no evidence of compliance with the implementation of environmental regulations by

mining operators, due to ignorance at *TMB*; and lack of sufficient knowledge and resources, as well as technical support by the State at *DHDI* cooperative. The challenges associated with the application of these regulations are deplorable, and it is becoming necessary for the State to monitor mining activities, while supporting cooperatives with demonstrations of mining techniques that both improve economic returns and protect the environment.

4.1.4 Rising food and farmland prices

If mining increases the quantity and quality of food demand through increased consumer numbers and the income effect of employees, and this should stimulate the agricultural sector to prosper and produce more food in response, at some point we might expect prices on food markets to stabilize (DFID and ePact, 2019). Mining is one of the factors destabilizing and driving up prices. Indeed, having led to a sharp drop in agricultural production at Gahoma, and an insignificant increase at Ruhororo in relation to the increase in consumers and the drop in agricultural production linked to negative external factors (negative result), demand for food products has become increasingly greater than supply. With prices rising at an average annual rate of 16% nationally since 2017 (MEAE, 2022), they have almost doubled over the 2017-2021 period, which has been marked by mining activities since December 2018 in the study area. For example, 1kg of beans or maize, which cost 1,200BIF and 1,000BIF respectively in 2017, cost 2,200BIF and 1,800BIF respectively at Ruhororo and Gahoma in 2021. While this benefits a few households who sell their agricultural surpluses on the local market, it has a strongly negative effect on the food security of a large number of smallholders who are unable to produce all the food they need, especially at Gahoma where 53% of households had an overall income per adult member per day of less than 1,580BIF (i.e. < $0.76, well below the international poverty line of $1.90 per adult member per day) per adult equivalent, despite increase in prices of agricultural products on local markets. In addition, mining has further weakened the agricultural sector by taking over arable land. These have become scarce, and the price of buying 1ha of arable land has risen from 20,000,000BIF before mining activities (before December 2018) to 50,000,000BIF during mining activities (in August 2022), while that of renting 1/2ha has risen from 450,000BIF to 480,000BIF per calendar year. This being the case, households are receiving unfair compensation, not allowing them to access the same area of lost land, or not even receiving any, as is the case for most households on Gahoma hill.

4.1.5 Corruption

In the absence of clear sector governance, mining is sometimes associated with corruption (Brollo et *al.*, 2013; Caselli and Michaels, 2013). In the study areas, the lack of direct communication and negotiation channels between the mining company/cooperative and households that have lost their land and property is a source of corruption by ill-intentioned local authorities. When it comes to compensation, the company/cooperative's authorities take advantage of the lack of transparency in drawing up lists of beneficiary households, and in channeling compensation to these households, to draw up fictitious lists and award lump sums of money. According to the heads of households who have lost land and property, the amount of compensation they receive is far lower than the amount they forcibly sign under the influence of the Mabayi communal administrator at the time of the loss inventories. This is because, according to them, the compensation is illegally channeled through the administrator's bank account, and he in turn gives them lump sums. Two examples of this corruption can be given here. Firstly, on Gahoma Hill, 35 households in the sample had lost land and property, and the mining company *TMB* had compensated only 20 households up to August 2022. According to the head of Gahoma hill, there has been a halt in compensation payments, and this is linked to the shenanigans that were observed in drawing up the lists of beneficiaries, where households were found to be on the lists when they didn't even belong to Gahoma mining hill. The second example is that of two households that were named by the same hill head, where one had signed for 4,000,000BIF, and

the other for 3,500,000BIF in compensation after the inventory of losses, but only received 1,300,000 BIF and 1,000,000BIF respectively. All this makes households that lose their land vulnerable to a decline in their livelihoods, as they are unable under these conditions to access the same portion of land as before to at least produce the same quantity of agricultural goods as they were producing, or struggle to do so by spending financial resources not intended for this purpose.

4.2 Positive links with agriculture

Positive linkages involve positive resource transfers from mining to agriculture, and vice versa (DFID and ePact, 2019). In this sense, some negative linkages on the agricultural sector are at the same time positive linkages it causes on mining, such as the loss of land and labor. In our study area, the main positive links that have been highlighted, from the mining company or cooperative to agriculture, are the creation of jobs and income, the injection of money into the local economy through an effective demand for food and other services (compensations), the improvement of social infrastructure by the *DHDI* mining cooperative, capacity building in agriculture, and the creation of farmers' associations and mutual aid finance.

4.2.1 Job and income creation

The *TMB* mining company has 150 national employees out of a total of 250, including 50 direct employees (with contracts) who are natives and residents of Gahoma hill and who receive a salary of 180,000BIF per month; and the *DHDI* mining cooperative has 200 national employees, including 106 direct employees who are natives and residents of Ruhororo hill (photo 8 & 9) and who receive a salary of 150,000BIF per month. During our survey, the miners told us that they use part of their salaries for agricultural investment purposes, buying chemical fertilizers, domestic animals, farming equipment and paying for labor. However, apart from the low wages, these agricultural investments do not enable them to increase average production, due to lost land that has not been or only partially replaced; the environmental effects of mining; the scarcity of labor ; negative factors external to the mining company or cooperative, such as overpopulation, lack of quality and quantity of chemical fertilizers, climatic hazards, especially unpredictable heavy rainfall in the locality, and climate change, natural soil erosion due to the locality's very uneven terrain, lack of selected and adapted seeds (MEAE, 2022), lack of adequate agricultural equipment, lack of road infrastructure in good condition to transport agricultural produce to better-paying markets, illiteracy, etc.

Figure 8: Many national and native gold miners at Ruhororo

Figure 9. Few national and native miners in Gahoma
Source: Photo taken on site by the author

The nominal increase in average household farm income shown in point 2 is not due to increased production. Rather, it is due to higher prices on local markets. Moreover, these incomes remained far below the international poverty line of $1.90 at PPP rates per adult person per day, even in the presence of agricultural investments from mining wages, i.e. $0.5 and $0.8 respectively in Gahoma and Ruhororo, taking into account the average number of adult household members, which was six (06) at the time of the survey in 2022. Nevertheless, considering that the national poverty line is1580BIF ($0.76) per day per adult person (INSB, 2021), the average agricultural income per day per adult person of households in Ruhororo is slightly higher ($0.8) even though there has been a loss in average agricultural production due to negative factors external to the *DHDI* cooperative. However, while agriculture is the main livelihood option for rural households, we note that their average income, taken together in both communities, i.e. around $0.65 per adult per day, has remained insufficient to meet the needs of their members, despite the investment of mining wages and compensation (compared with the international threshold of $1.90). This is particularly true in Gahoma, where this income ($0.5) is below even the national poverty line ($0.76). According to information from our interviews, it is important to note that the employees who receive large salaries (including the shareholders at the *DHDI* cooperative who share the profits), up to 1,200,000BIF ($578) at the *DHDI* cooperative and 2,000,000BIF ($963) at the *TMB* company, are not natives or regular residents of Ruhororo and Gahoma, respectively. They invest their salaries elsewhere, and sometimes in the construction of housing at the Mabayi communal center for some of them who are natives of other hills in the commune.

4.2.2 Money injection into the local economy

The impact of currency entering the local economy as a result of mining activities should not be underestimated (DFID and ePact, 2019). One hundred and fifty-six miners with contracts, native residents of Gahoma and Ruhororo, represent a cash injection of 298,800,000BIF, or US$143,930 each year into the local economy. This has a significant impact on a rural local economy that is linked to a single semi-urban communal market by a single road that may be difficult to pass for several years. Prices of foodstuffs and other goods and services rise on the local market thanks to the presence of cash and the increase in demand, to the benefit of certain households who, above all, generate a surplus from their production. And as mining sites coexist with farming households, farmers often sell their produce directly to customers. This shortens the sales cycle, reducing the value chain for these products, and enabling customers to purchase other local goods and services. In this way, income from the sale of food products and other goods and services is passed on to all sectors of rural socio-economic life. Apart from the ease of selling goods and services, survey participants also

emphasized the ease of borrowing from their friends who work at the mining company or cooperative. This enables households to meet needs that suddenly require a certain amount of money.

4.2.3 Improving social infrastructures

As participation in the development of basic infrastructure is one of the commitments made by mining companies and cooperatives in the agreement they sign with the Burundian government (articles 40 and 41 of the agreement), the *TMB* mining company has failed to meet this commitment. It has neither built nor rehabilitated any basic infrastructure at Gahoma. However, thanks to the contribution paid by the *DHDI* mining cooperative for local communities, as part of its commitments in the sense of this participation (WB, 2016), a school and a developed water source have been built, while a health center, two schools and two developed water sources have been rehabilitated at Ruhororo. All the construction and rehabilitation work was carried out by native employees living on Ruhororo hill. So, as well as improving the socio-community situation, this also contributed to the injection of currency into the local economy at some point.

4.2.4 Capacity-building in agriculture and creation of farmers' and mutual financial aid's associations

In this kind of capacity building, farmers receive useful support from the cooperative or the mining company. Farmers in Ruhororo (54.3%) appreciate the work of the *DHDI* cooperative. Indeed, there are a number of projects aimed at strengthening household capacities by creating new agricultural techniques, such as growing maize during the B cropping season by irrigating the fields from July onwards; introducing new crops such as non-swamp rice; improving pig and goat rearing in the barns; and creating farmers' and mutual financial aid's associations in which farmers learn how to cultivate and to organize themselves to create activities complementary to farming. At the time of the survey, while Gahoma and Ruhororo hills had only one farmers' and mutual aid association at any one time (SANGWE association) prior to the advent of the mining company and cooperative's activities, according to survey participants, 33 mutual financial aid associations and 15 farmers' associations growing maize, beans, potatoes and cassava had been set up at Ruhororo by *DHDI* cooperative. *TMB* has also initiated capacity-building projects in B-season maize cultivation, non-marsh rice cultivation, and in the improvement of pig and goat breeding. It also played an important role in the creation of farmers' and mutual financial aid's associations, so that Gahoma hill had 8 and 17 respectively at the time of the survey. But around 73% of households surveyed on this hill denounced the lack of monitoring, by the company, of the projects it initiated.

4.3 Conclusions, Recommendations and Limitations

It appears to be difficult for *DHDI* mining cooperative to implement environmental regulations. This is due to the limited knowledge of artisanal miners, who only master simple manual backfilling techniques; to insufficient financial and material resources; to lack of technical support, to lack awareness of legal requirements, and to lack of follow-up by state services in implementation. The absence of compliance with environmental regulations is also the case for *TMB* company, on a large scale and due to its ignorance and lack of follow-up by state services in implementation. Despite this, mining presents benefits to household livelihoods in the communities covered by the study, such as job and income creation, injection of money into the local economy, improvement of social infrastructure by *DHDI* cooperative, capacity-building in agriculture and the creation of farmers' and mutual financial aid's associations ; benefits which, nevertheless, have been degraded differently in these communities by three major constraints: loss of land, failure to comply with the environmental standards mentioned above, and loss of labour force, in addition to negative external factors which are the same for the company and the mining cooperative. Indeed, agricultural lands are being lost to

the benefit of mining company or mining cooperative, which are relatively more profitable than the farmer for the government, with unfair compensation, or even no compensation in the case of TMB company at Gahoma; agricultural and mining labour markets are tightening to the benefit of the more remunerative mining sector (a mining worker can earn a higher monthly income than a "smallholder" farming household with six members to support), negatively affecting agricultural households which do not have enough human capital. As a result, agricultural land and labour force are becoming scarce, expensive, and not as accessible as before to some households, especially those who have lost land, and particularly those who have not received compensation for it. Environmental regulations that have not been properly implemented have led to greater instability and tension among some households, most notably in Gahoma, with immediate negative impacts for downstream users and farmers living near mining sites. In other words, water, air and soil pollution; erosion, collapses and landslides impose real costs on these farming households by causing the disappearance of some of their crops, reduction in quantity produced for certain others (upstream and downstream), and diseases, especially at Gahoma. The agricultural sector in both communities receives a boost from local demand for food by miners, but is unable to adequately meet this demand due in part to these causes, and so food prices are rising to the detriment of food security, and this among the majority of households at Gahoma (53%) where this sector has been largely weakened by environmental destruction, in addition to the lack of compensation among many households who have lost their land. Despite warnings from the 'Observatory for the Fight against Corruption and Economic Malversations-OLUCOME', and the Organization 'Friends of the Environment-Abagenzi b'ibidukikije', the absence of the state to enforce its laws to protect land rights and the environment reinforces negative effects; and corruption is also the element that makes it difficult for farming households to recover their livelihoods, in the event of a shock which takes away their main capital or asset 'land', especially at Gahoma.

In other words, the links are mixed, with contrasting results from one mining community (hill) to another. Indeed, the foreign mining company *TMB* has not compensated a large number of households, and is responsible for a large scale of environmental degradation and corruption. The results of the negative links are therefore far greater than the positive ones, and its average contribution to quantity of agricultural production is largely negative, hence a large loss in the average quantity of agricultural production of 826 kg/household/year at Gahoma hill generally due to its mining activities, comparing 2017-2018 and 2020-2021 agricultural campaigns. In contrast, the local mining cooperative *DHDI* has compensated all households, and results in a small scale of environmental degradation and corruption. The results of the positive links are therefore slightly higher than the negative ones, and its average contribution to quantity of agricultural production is slightly positive, hence a small loss in the average quantity of agricultural production of 136kg/household/year at Ruhororo hill due to negative factors external to mines, also comparing 2017-2018 and 2020-2021 agricultural campaigns. In the case of the community of Gahoma where the foreign mining company *TMB* is operating, and where there is already a great loss of agricultural production, questions arise about the long-term future of agriculture, at moment where mining companies continue to expand their operations, where agricultural subsidies are absent or progressively decreasing, where local authorities are corrupt, and where state is absent on the ground to monitor the implementation of commitments, and ensure a viable profit for households and mining companies/cooperatives, by reconciling agricultural and mining development at the same time.

We recommend that the mining company and cooperative strictly adhere to their commitments to grant compensation at the appropriate time, to give households sufficient time to buy other alternative land before the start of the next farming period. The compensation must also be proportional to the real value of the losses at market prices. In this sense, we recommend genuine participatory governance between all the stakeholders involved in mining, as this would make it possible to eliminate injustices in the granting of compassions. The physical presence of the public services responsible for managing the mining and agricultural sectors is therefore necessary, in order

to ascertain the prices of the various goods, particularly land, and to ensure fairness in the payment of compensation. They must also enable the households concerned to negotiate a fair value for their assets themselves. To this end, the Ministry of Agriculture must be rigorously involved in the links that are created between mining and farming activities, in order to guarantee households land rights and security. In addition, instead of compensation being granted for a portion of land taken as a mining concession in accordance with current practice in the communities concerned by the study, it would be better to compensate all the land near mining sites. This is because the study reveals that the farms near the sites, and even the health of the people living in their vicinity, suffer many negative effects from mining activities. We also recommend assisting households in their choice of compensation investment strategies. Financial support in the form of subsidized agricultural inputs including fertilizer and improved seed is needed for households as a whole, in addition to compensation to those who have lost land and other assets, to increase yields on the small farms available. Another way of supporting households' livelihoods would be to provide low-interest financial loans repayable after the harvest or sale of the goods and services produced; loans that would enable them to improve farming activities, create new ones, and create or diversify alternative activities to forestall a livelihood crisis in the event of poor agricultural production. It is essential to support and encourage farmers' associations by setting up an insurance service that would give them access to subsidized insurance for their farms, helping households in mining communities to cope with losses in agricultural production due to mining activities. It would also help to improve the size of farms, and to grow different crops separately to increase production.

The study was unable to track changes in agricultural production before and during mining activities because of the lack of disaggregated (down to hill level) and multi-year secondary data on agricultural production. The INSB should make these data available to facilitate future research into the effects of mining activities on the livelihoods of local farming communities. In addition, the study only covered two hills – Gahoma and Ruhororo within *TMB* and *DHDI*. Future similar studies combining quantitative and qualitative methods throughout the country where mining takes place would enable a generalization of the positive and/or negative impacts on agriculture and livelihoods.

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