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IMPACT OF MINE-RELATED STRUCTURES AND PROCESSES ON LIVELIHOODS OF FARMING HOUSEHOLDS IN MABAYI, BURUNDI

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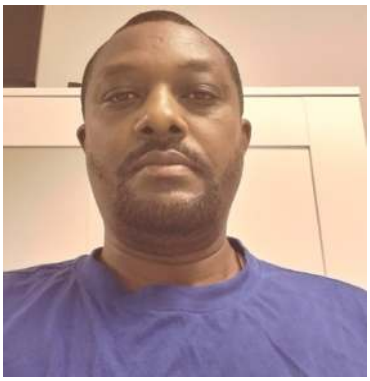

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ABSTRACT

The creation of a new income source requires transformation of old structures and processes, and introduction of new ones. This is crucial for the livelihoods of local farming households, especially in their ability to access and use available resources. Among factors that make up structures, levels of government and private sector-mining companies in this case, can be mentioned. As for factors that make up processes, laws, policies, institutions and power relations can be mentioned. This article aims to analyse the influence of structures and processes on average agricultural production and average general household income, and thus, on livelihoods' households. A survey of 210 households (70 households per hill), group interviews and focus groups with key informants, and observations were carried out in June-August 2022 in Mabayi commune, on Gahoma and Ruhororo hills where the foreign mining company ''Tanganyika Mining Burundi-TMB'' and the local mining cooperative *"Dukorere Hamwe Dusoze Ikivi-DHDI"* had been respectively operating gold since December 2018. Buhoro hill, which has never experienced mining activities, served as a reference to allow comparison between it and the two experimental hills (Gahoma and Ruhororo). Comparing 2017-2018 and 2020-2021 agricultural campaigns, results show that the reference Buhoro hill experienced a reduction in average agricultural production of 153 kg/household/year due to negative factors external to the mines (structures and processes put in place). Gahoma and Ruhororo hills experienced a reduction of 673 kg/household/year and an increase of 17 kg/household/year respectively, as a result of structures and process' factors. However, they experienced an increase in average general income of BIF 48,690/household/month and BIF 155,730/household/month respectively, due to increase or maintenance of agricultural production and alternative activities among certain households. Well-functioning structures and processes are important, inclusive and/or participative governance of all stakeholders should contribute to more viable and sustainable socio-economic development.

Key words: structures and processes, mining, agricultural production, general income, livelihoods, Burundi

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INTRODUCTION

African countries are increasingly turning to mining as a potential internal resource for their economies [1]. A significant proportion of foreign direct investment is directed towards the extractive industries sector [1]. Currently, mining constitutes a second sector of activity after agriculture for the economies of these countries, although research has shown that its economic and social spin-offs 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 [2]. Indeed, it is true that mines stimulate growth in the countries that own and develop them, thanks to their positive effects on Gross Domestic Product [3]. However, they give rise to negative effects on the side [3]. Also, the weakness of the conversion of this growth into compensation for the losses of communities in these areas, and into rural poverty reduction, is a reality in African countries [3]. For these reasons, questions remain as to whether mining activities improve the livelihoods of local rural populations in these areas and more particularly their agricultural activities, given that mines are an exhaustible resource [3].

According to Musokotware, the effects of mining are numerous, both social and economic, and affect both political leaders, local communities especially those who are living in the vicinity of the sites, the environment and health, etcetera [2]. Nevertheless, in-depth empirical studies relating to the effects of mining on agriculture remain limited, although they are currently emerging [3]. According to Adjei, mining allows for an improvement and increase in agricultural activity among certain households particularly due to the wages of the jobs created and the mining companies' community development programs [4]. Also, mining sites offer a remunerative consumption market for agricultural products, a shorter sales cycle, and a strong attraction for traders [5]. At the same time, there are direct negative effects. These latter are the reduction in time devoted to agricultural activities, as work in the mines is more rapidly profitable than farming; the abandonment of certain crops due to fear of untimely land claims by mining companies; difficult access to active agricultural labor as this is captured by the mines. They are also the loss of family farm labour (especially young people) which is no longer under the control of family heads; 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 depletion of arable land by residential agglomerations around mining sites; the destruction of soil structure; high input prices, and so on [5]. Apart from these direct effects, the impact on agriculture is also indirect. This is the case of reduction in agricultural production that would result from environmental pollution (especially groundwater pollution) [2, 4], although there are no empirical studies to support this, according to the World Bank [3]. The extent of these effects depends on the

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governance of the mining sector, through the structures and processes put in place [4, 6]. These (structures and processes) influence households' ability to access and use available resources [4, 6]. The Department for International Development of United Kingdom (DFID) describes structures as public and private organizations that set and implement policies and laws, deliver services and perform a range of other functions that influence livelihoods [6]. They refer to levels of government and to the private sector. In this case, private sector refers to mining companies. Processes determine how structures and individuals or households' function and interact. They are managed and controlled by structures and refer to policies, laws, institutions and power relations [4, 6]. Policies exert a strong influence on interpersonal relations, in particular on the way different groups of people interact with each other. They grant or deny access to assets, and thus play an important role in household livelihoods [4, 6].

According to Ellis, institutions are formal or informal codes of behavior that also play an important role in access to assets [7]. Adjei cites the institution of land tenure in this regard, which he believes is an institution that influences the ability of affected farmers to maintain their livelihoods, after mining companies claim the land (mining concessions) on which agricultural activities were carried out [4]. Laws refer to mining sector reforms, for example [4]. Power relations refer to relationships that exist between individuals (or households), local political authorities, private organizations - mining companies, and so on [4]. Those relations also exert an important influence on access to assets [4]. Well-functioning structures and processes are, therefore, important, because the opposite is an obstacle to achieving viable and sustainable livelihoods by making access to assets difficult [6].

In Burundi, to deal with the weakness of the economy, the Government has since 2005, decided to diversify its sources of revenue, especially by developing its mining sector as a potential source [8]. 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 [9]. Actual mining began in 2014 [9]. It constitutes the second-largest source of export revenue after coffee and employs, mainly cooperatives, a national workforce estimated at nearly twenty-five (25) thousand people [8, 10]. Also, although its share in state financing is still low as noted in 2019, namely 1% in Gross Domestic Product (GDP), 3% in export earnings and 1.71% in general budget [9], it is still proof that it stimulates the country's growth at the level of its GDP, as has been highlighted elsewhere [3, 11, 12]. Despite this contribution to GDP growth and job creation, questions remain as to whether the presence of mining activities, especially structures and processes put in place for this purpose, also improve the livelihoods of farming households in the vicinity of mining sites, given that a study by

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Nsabimana identified them as causes and amplifiers of soil erosion in Mabayi [13]. Specifically, the purpose of this paper is then to analyze the impact of structures and processes on average agricultural production, average household general income, and hence on their livelihoods, on Gahoma and Ruhororo hills of Mabayi commune, respectively, where the Russian company Tanganyika Mining Burundi-TMB and the local cooperative *Dukorere Hamwe Dusoze Ikivi-DHDI* have both been conducting their activities since December 2018.

MATERIALS AND METHODS

Description and choice of study area

The study was carried out in the Mabayi commune, an agricultural area where bananas are the main crop. Other crops grown by the majority of the population include maize, beans, cassava, sweet potatoes, potatoes and colocases. Rice, coffee, tea, wheat, tomatoes, pineapples, and so on, are also grown by some households. Livestock farming generally involves small livestock due to the very rugged landscape [14]. Animals raised include goats, pigs, sheep, rabbits, chickens, and so on [14]. Small businesses selling a variety of products and services are also common. The other activity practiced is informal gold mining, through which some miners still exploit the richness of the land [8, 9, 13].

The commune has an abrupt relief, with altitude varying between 1,500 and 2,652 m [13]. It has abundant rainfall, often reaching 200 mm per month [13]. These natural features of the area make the land vulnerable to erosion, and thus, more vulnerable to the environmental effects of mining activities. Added to these characteristics, the commune has a high population density of between 500 and 650 inhabitants/km^2 according to the location [14], making access to land more difficult in this commune compared to other mining areas. Furthermore, with a population of approximately 103,623 [15] and a total area of 347.54 km^2 [13], the population density shows that around half of this commune area is not potentially arable. These factors increase the vulnerability of the agricultural sector to the effects of mining activities. Hence, the motivation to choose this commune as a study area.

Sample selection

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 [16]:

$$n = \frac{z^2 p(1-p)}{e^2} * \frac{N}{N + \frac{z^2 p(1-p)}{e^2}}$$

With 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

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characteristic of interest (to be chosen or not) in the population - households, set at 0.50. Based on the adopted 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, all is well [17]. Thus, taking into account the practically similar characteristics of the households, their close location, and the budget and time constraints, almost half of the sample, namely 140 households for the two hills, with 70 households per hill were considered. Seventy households were added for the Buhoro reference hill, making a total of 210 households. Apart from the mining activities that take place on Gahoma and Ruhororo hills, with their related effects, all other features (geographical and socio-economic) developed in the previous point are identical to those of Buhoro hill. The three hills also have the same organizational feature - rural social organization dominated by kinship [18], and had approximately the same quantity of agricultural production before the advent of mining activities. Hence, Buhoro hill, located about 31.9 km and 29.7 km from Gahoma and Ruhororo hills, respectively, was taken as a reference. 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 agricultural production of both categories of households. However, as only 17 households in Ruhororo hill had lost land, they were all included in the sample, along with 53 other households who had not lost land. These households were selected using the interval 4 random sampling method, from lists of households (a list of households that have not lost land, and a list of households that have lost land) provided by the hill chiefs.

Data collection

This paper is based on primary and secondary data. Primary data were collected in July and August 2022. A questionnaire, three interview guides, and observations were used. Two interview guides were individual: one for opinion leaders and another for the communal agronomist, public and community relations officers at TMB company and *DHDI* cooperative. The third interview guide was used for group interviews and focus groups. With the help of three local interviewers, the questionnaire was administered to heads of 210 households in their homes (70 households per hill for the two mining hills Gahoma and Ruhororo, and 70 households for the non-mining Buhoro hill). With this sample, quantitative data on agricultural production before and during mining activities (2017-2018 campaign and 2020-2021 campaign) were collected. For the Gahoma hill, among the 70 households, 35 households had lost land (out of a total of 80 households that had lost land on the entire hill) and other 35 households had not. As for Ruhororo hill, of the 70 households, only 17 households had lost land (out of a total of 17 households that had lost land on the whole hill), and 53 households had not.

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Individual interviews were conducted with opinion leaders (2-one man and one woman/hill), the communal agronomist, and public and community relations officers. Group interviews consisted of gathering and interviewing people with different profiles and interests. With a minimum of six people, they were conducted with miners (for mining hills), students and other household members. The latter were members other than the heads of households, but known by the head of the hill as possessing important information about changes since the advent of the mining company/cooperative's activities or since December 2018. Focus groups consisted of gathering and interviewing people with the same profile, and with the same interest. With a minimum of six people as in group interviews, they 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. At the level of each of the three hills (Gahoma, Ruhororo, Buhoro), students who were interviewed (in group interviews and focus groups) were natives and residents of the hill for at least 18 years. They attended secondary school in local colleges. These conditions reassured on maturity and knowledge about effects of mining activities. They were chosen alone in the focus groups for two reasons: they were among intellectuals with more advanced capacity for analysis than simple peasant farmers, and were the only ones who could be available on site in an interesting number among other categories of intellectuals native to the study area.

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. Natural capital represents stocks of resources that can be used to ensure existence at any time. These are generally natural resources such as land, river (water), forest, atmosphere, biodiversity [23]. Land and environment caught attention on the ground. Human capital represents different aspects of people such as education, skills, knowledge, work capacity, and good health, which together enable them to pursue different strategies to improve their livelihoods [23]. Capacity building of households in agriculture and diseases caused by environmental pollution were cited by interviewees, and observed on the field. Land is both a natural capital and a physical capital [23]. It was taken into account with this double aspect on the field, by the present study. Financial capital represents financial resources that individuals or households use to achieve their livelihood goals. The most common financial sources are credit system, savings, sale of production, remittances, businesses, and wages from jobs [23]. Sale of agricultural production and wages from jobs, especially wages from mining, were mentioned by interviewees for this type of capital (wages

from other jobs, such as, businesses, are also included general household income). Social capital refers, among other things, to relationships between households and institutions, as well as formal and informal groups [23]. The relationships between households and institutions were raised by interviewees in the field, and were of interest to this study. These are all variables that contribute to the general income of rural households as their means of existence, mainly through agricultural production. 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. They also related to the number of household members by level of education, the number of household members who worked in the mines, the remuneration of work in mines, the remuneration of manual agricultural worker before and during mining activities, capacity building in agriculture, non-farm income sources of households, and so on. 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. Animal income and other non-farm income have been included in general income. 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. Products grown by the majority of households in Mabayi (maize, beans, bananas, cassava, sweet potatoes, potatoes and colocase) were taken into account. All survey participants were aged 18 and 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.

Secondary data were collected through papers, books and other documents related to this study. For data relating to agricultural production, the country has a single recognized national institution, responsible for collecting and analyzing data - the “Institut National des Statistiques du Burundi (INSB)”. This institution has only recently been able to disaggregate data down to provincial level. It does not have data at hill level. It was therefore necessary to use primary data, especially quantitative data, for agricultural production.

Data analysis

The research relied on the use of both qualitative and quantitative collection methods. As such, the use of "mixed triangulation" analysis method using both qualitative and quantitative data was the most appropriate. It allows to reason by crossing qualitative and quantitative data, and therefore to have more reliable results (qualitatively and quantitatively verified) [2, 19]. Qualitative data from individual

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interviews, group interviews, focus groups and observations were processed by content analysis [20, 21, 22]. Quantitative data from household agricultural production surveys were processed by descriptive statistics [20, 21, 22]. In addition, since the aim of the analysis was to test improvement or degradation of the livelihoods of farming households (through their general income) by structures and processes that were put in place because of the advent of mining activities, it proved essential to choose a reference group (the non-mining Buhoro hill) that was as similar as possible to the two mining hills (Gahoma and Ruhororo) before the start of mining activities, to be able to distinguish what was attributable to these structures and processes, relative to *DHDI* cooperative or TMB company. Based on data before mining activities, and on data during mining activities in the three communities/three hills, a "difference in differences" or "difference in pairings" strategy, which compares communities/hills with and communities without mining activities, was then used [3]. Indeed, initial differences-pairings (before the start of mining activities or before December 2018: 2017-2018 agricultural campaign) and during differences-pairings (after the start of mining activities or after December 2018: 2020-2021 agricultural campaign) between the two mining communities/hills (Gahoma and Ruhororo) and the non-mining community (Buhoro), were made, as well as differences between these two differences-pairings. These latter differences are attributed to the said structures and processes [3]. They represent the real impacts (of structures and processes), assuming that the trends and needs were the same in the three communities/hills before the advent of mining activities (because the two mining communities/hills and the non-mining community/hill were quite similar in all characteristics: social, economic, political or administrative, and so on) [3]. The attribution of these differences to structures and processes is further supported by the fact that no other confounding source of change was introduced in the three communities/hills [3]. This pairing method is represented in the following diagram:

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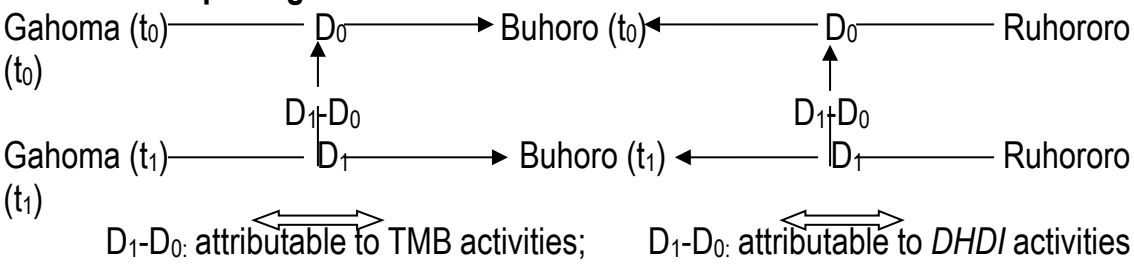
Schematic of pairing method



D_0: pairing 0 (before December 2018); D_1: pairing 1 (after December 2018)
Source: Designed by the author based on World Bank theory [3]

RESULTS AND DISCUSSION

Structures are analyzed in terms of levels of government and private sector - mining company TMB and mining cooperative *DHDI*. Processes are analyzed in terms of laws, policies, institutions, and power relations. These factors that make up structures and processes affect the assets or capitals - physical capital, human capital, financial capital, natural capital, and social capital - corresponding to the livelihoods of rural agricultural households [4, 6, 7, 23]. The results are mixed: Some households have benefited from the presence of mining activities, while others have been victims.

Structures

The Department for International Development-DFID describes structures as public and private organizations that set and implement policies and laws, deliver services and perform all sorts of other functions that influence livelihoods [6]. They refer to levels of government and the private sector. Structures that work well are therefore very important because the opposite is an obstacle to achieving viable and sustainable livelihoods by making access to capital assets difficult [6]. According to Adjei who is interested in mining, levels of government are public organizations that control or influence mining operations and mines in general, including the ministry responsible for mines, local government, and so on, while private sector implies private organizations including mining companies [4]. These latter play an important role in asset access through their demands for concessions occupied by farmers and accompanying issues such as compensation, resettlement of affected households, community capacity building programs, provision of social services and development projects, as well as other alternative livelihood programs (to agriculture) [4]. Similarly, the present study considers levels of government and private sector as structures. For levels of government, the study focused on the Ministry of Hydraulics, Energy and Mines (MHEM), the Ministry of Environment, Agriculture and Livestock (MEAE), and the regional antennas, specifically in its

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research area. It focused on mining company TMB and cooperative *DHDI* concerning the private sector.

Levels of government (public bodies supporting mining sector)

The reality on the ground is one of an almost complete institutional absence of government services. While mining policies and regulations promulgated by the government are generally sound, they are simply not implemented adequately on the ground. For levels of government, the focus is on public organizations that control or influence mining operations and mining in general. These include the Ministry of Hydraulics, Energy and Mines- MHEM through Burundian Office of Mines and Quarries- OBM; the Ministry of Environment, Agriculture and Livestock- MEAE through Burundian Office for Environmental Protection- OBPE and regional (local) antennas. The concerns raised by a large number of household heads (73% on Gahoma hill and 46% on Ruhororo hill) relate to the lack of state intervention in issues related to compensation, the demarcation of mining areas to ensure security of agricultural land, monitoring of the activities of the mining company/cooperative to limit losses and risks related to non-compliance with environmental regulations, as well as support for household livelihoods (especially lack of agricultural subsidies). As for the head of public and community relations at *DHDI* cooperative, his concerns focused on the lack of support that this cooperative should receive from the OBM. Indeed, according to him, this Office is required to provide technical support, if necessary, to ensure sustainable and optimal exploitation of the country's natural resources.

Ministry of Hydraulics, Energy and Mines

The Ministry of Hydraulics, Energy and Mines-MHEM is responsible for developing and administering policies, regulations and laws on mining exploitation and investments, as well as mine safety. In other words, it is responsible for all aspects of the mining sector in Burundian economy, and is the grantor of exploration and mining licenses and leases. It is assisted by the Burundian Office of Mines and Quarries-OBM. The latter was created in 2015 as part of mining sector reforms, in order to minimize bureaucracy [9]. It is a technical organization that must be in regular contact with mining companies and cooperatives. Its responsibility is to ensure geological research and the cadastre of mining areas. It also ensures the control and monitoring of mining, quarrying and hydrocarbon activities. Another role assigned to it is to support the Burundian Revenue Office-OBR concerning collection of revenues, without forgetting technical support for mining cooperatives and companies. In addition to this, the OBM makes recommendations on mining policy and advises the minister on issues that concern the sector.

The establishment of an effective land security system allows households to cultivate crops that can be more productive and can bring high added value [24]. Although

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there are these specifications from the OBM, there is no limit between mining areas and free land that can be safely exploited by households, hence the fear of these households to cultivate long-term crops or perennial plantations, such as bananas (the main crop in the area), and therefore a reduction in their agricultural activities and the quantity of production for some of them. Added to this is the lack of technical support from OBM for *DHDI* cooperative, and monitoring of its activities and those of TMB company, according to information from the public and community relations manager at the cooperative, and from participants in the interviews at Ruhororo and Gahoma respectively. This resulted to negative effects related to environmental degradation such as the onset or amplification of soil erosion, landslides, pollution of marsh water tables, land collapses, water and air pollution leading to various diseases, and so on. These effects carry away, destroy crops and homes or reduce the workforce by affecting the health of household members. This consequently makes households vulnerable to the reduction of their assets or livelihoods. No evidence of compliance with the implementation of environmental regulations by mining operators was found, due to ignorance at TMB; and lack of sufficient knowledge and resources, as well as technical support by the State at *DHDI* cooperative.

Ministry of Environment, Agriculture and Livestock

In regulatory texts, the Ministry of Environment, Agriculture and Livestock (MEAE) collaborates with the Ministry of Hydraulics, Energy and Mines in matters relating solely to the environment (article 135 of 2013 Mining Code). Through Burundian Office for Protection of Environment (OBPE) which is a technical organization in environmental protection, the MEAE tries to maintain a balance between the requirements of economic growth and the need to protect the country's natural resources, the health and well-being of the population, by guaranteeing environmentally friendly resource extraction. It conducts and promotes studies, surveys, research and analyses relating to the improvement of a country's environment and maintenance of a healthy ecological system (Environmental Code 2000). In this context, it provides, among other things, tariffs for the assessment of assets affected by mining operations [9]. It is responsible for managing the country's forests, and is supposed to work with the MHEM on granting mining licenses and leases to better carry out its tasks [9]. However, the defined roles of the various institutions are only statutory, as there are no effective intersectoral links between these institutions. It is very rare for the ministry to be informed about the granting of licenses to mining companies and cooperatives by the MHEM. Furthermore, in the study area, especially in Gahoma, the conflicts observed between households and TMB company, over crops and homes lost due to water pollution and land collapses caused by mining activities, reflect the lack of harmony between these two institutions. Indeed, losses not related to the direct loss of land (mining concession)

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are nowhere mentioned in the texts, to be rewarded. The lack of effective collaboration between these two institutions contributes to environmental problems which negatively affect household livelihoods.

Regional antennas

The OBM mining map locates minerals in two regions: West region, which includes provinces of Bujumbura rural, Bubanza and Cibitoke and East region, which includes provinces of Kayanza, Ngozi, Kirundo, Muyinga, Ruyigi, Rutana, Gitega and Karuzi [8]. Each region has an antenna that is in direct contact with OBM. According to the OBM operations Director, the regional antenna includes a few OBM workers, local administration, and a few influential members of mining communities. According to the same source, it has no control over mining companies or cooperatives, because these work only under orders of OBM central administration. Its role is simply to observe mineral exploitation activities and their illegal trade, the failures of mining companies and cooperatives to meet their commitments, and to inform the central administration of OBM. However, any conflict on the ground between households and mining companies or cooperatives is resolved first in a meeting bringing together the managers of these mining companies or cooperatives and the members of the regional antenna close to the place of the conflict, especially the communal administrator who is most often the legal head of the latter (members of regional antenna) at the time of the meeting. According to information collected in the study area, from opinion leaders, group interviews and focus groups, this administrator negotiates with the managers of TMB company or *DHDI* cooperative without mandate given by households, and forces the latter (households) to sign clauses concluded without their consent, hence, the granting of unfair compensation and the establishment of fictitious lists of beneficiaries (which is linked to the cessation of compensation in Gahoma, according to the communal agronomist). There is no direct framework for negotiation between cooperatives or mining companies and households. In other words, the long chain in the administration of the mining sector leads to a lack of clarity in information, and makes it difficult to establish responsibilities. The difficulties in establishing responsibilities and the absence of direct framework for negotiation between cooperatives or mining companies and households then encourage shenanigans that take place at the level of granting compensation and consequently cause problems especially with access to land by households who lose it to mines and corrupt authorities. Households complain about the communal administrator, while he himself might be in collaboration with his superiors or colleagues in the hierarchy.

Private sector

Private organizations targeted here are Russian mining company TMB and local mining cooperative *DHDI*. The two organizations have different exploitation

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approaches. Indeed, a mining company exploits a site that has already been explored with quantities of ore to be exploited that are already known, while mining cooperative combines both exploration and exploitation phases. However, they have identical programs regarding compensation for household losses and community development projects. Both commit to paying compensation for losses to be incurred before the start of exploration activities, and before the start of actual exploitation activities, and to contribute to the development of local communities, while respecting human rights and environment (articles 11, 40, and 41 of the Convention with the government). For community development projects, company TMB has an agronomist among its employees, while cooperative *DHDI* collaborates with the communal agronomist who sends agronomists from the commune in case of request and possibility.

In Gahoma community, although TMB has initiated projects to improve agriculture, according to the public and community relations officer at TMB company and the communal agronomist, about 73% of household heads surveyed were not satisfied with its operations. Various reasons were given to explain their opinion. Some said they had not received any benefit from the mining company, others said they had benefited from the projects initiated by the company, but lamented that these were destroyed by the lack of follow-ups, others said they lost their land and assets, received unfair compensation, and were forced to travel long distances to access the new land purchased while others said they have not received any compensation at all for losing land and assets. In the latter case, 15 households did not receive compensation, out of 35 households that lost land and were part of the sample. For households that were not affected by land grabbing (among the 73%), their concerns were loss of crops and quantity of agricultural production due to land collapses and water pollution especially of the 'Muhira River', diseases caused by water and air pollution, and possible claims on their land by TMB Company. "*We are losing our crops and production due to pollution of the Muhira River and land collapses. In addition, we are spending a lot of money on health care because diseases related to water and air pollution by TMB Company are more common in our community*," said one of the household heads not affected by land grabbing. For households that were affected (among the 73%), their concerns were mainly about the losses of their crops and homes located on the remaining parts of their former lands, losses that are due to non-compliance with environmental standards, and which for them too, are nowhere mentioned in the texts to be compensated. They also concerned the costs paid for health care of household members due to illnesses caused by environmental pollution. These costs were nowhere mentioned in the texts as being compensated. Other concerns for these households were related to the legal compensations that were not paid for lost land and other assets. Briefly, their concerns were not to improve their livelihoods, but rather to keep them stable. The

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mining company TMB didn't monitor the community development projects (capacity building in agriculture, raising goats and pigs in stables, introducing maize cultivation during growing season B, non-marshy rice cultivation, and managing agricultural microcredits) that it initiated to make them productive. But alongside these projects, it created jobs, according to its public and community relations manager and the communal agronomist. Out of a total of 250 employees, 150 were Burundians under contract. Among the 150 employees, 50 were natives and residents of Gahoma hill. These 50 employees had a monthly salary of BIF 180,000 ($87 USD, $1 = Burundian International Francs-BIF 2,076 in July-August 2022).

In Ruhororo community, although compensations were provided to all 17 households that lost lands and assets, some of these households, as well as some at Gahoma, were concerned about the practice of granting compensations that leave affected farmers with no say in the amount to be received, an amount that often does not take into account market prices of land and assets. This practice damaged the livelihoods of those who were unable to supplement the amount received, for replacing the area of land lost. Overall, the same concerns about environmental degradation at Gahoma were reported by households at Ruhororo, but this time due to erosion (also leading to water pollution by mining residues) and landslides, and with smaller scales compared to Gahoma. Also, all concerns generally affected a smaller number of households at Ruhororo compared to Gahoma, namely approximately 46% of sample households at Ruhororo compared to approximately 73% of sample households at Gahoma. *Dukorere Hamwe Dusoze Ikivi cooperative-DHDI* implemented the same community development projects as Tanganyika Mining Burundi company-TMB, and also created jobs, according to the public and community relations officer at the said cooperative and the communal agronomist. All of its employees were Burundians at the time of the survey. Among 200 direct employees (who had contracts with the mining cooperative) in total, 106 were natives and residents of Ruhororo hill. These 106 employees had a monthly salary of BIF 150,000 ($72 USD). There were also indirect employees (irregular employees without contracts) who mined gold outside the mining concessions, and sold it to TMB company or *DHDI* cooperative. They can earn between BIF 50,000 ($24 USD) and BIF 80,000 ($38 USD)

In Malawi, the agricultural area of households engaged in agriculture decreased from 2.3 ares in 2004 to 1.8 ares in 2010 and 1.4 ares in 2016 [25]. Under these conditions, agricultural transformation (diversification of agricultural systems towards high-value crops that are resistant to climate shocks) and rural transformation (creation of added value through non-agricultural activities) has helped to reduce vulnerability of local farmers [26]. In this present study area (Ruhororo and Gahoma hills) generally, for the 52 households that lost land at

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Gahoma and Ruhororo hills, each household lost an average of 0.2 hectare. *Dukorere Hamwe Dusoze Ikivi* cooperative and Tanganyika Mining Burundi company introduced non-marshy rice cultivation and maize cultivation during growing season B. The first crop has a high added value compared to other food crops, and the second escapes the heavy rainfall of growing season A. This had positive effects at Ruhororo because it helped to reduce food shortage period. It went from 4 or 5 months before mining activities to 3- or 4-months during mining activities. However, at Gahoma, there were no positive effects, because of lack of monitoring by government services and TMB company. Non-agricultural activities were timidly undertaken by some households. But these were not beneficial to all these households, especially those who undertook them thanks to compensation for lost land. Indeed, while there is a need to balance agricultural and non-agricultural activities while awaiting progressive professionalization in the latter [26], the lack of profit among certain households was due to the fact that they abruptly disinvested in part of their agricultural activities by not purchasing replacement land.

Processes

Given that mining activities most often take place within rural communities, mining and agriculture are embedded in a broader political economy that strongly influences the ability of both sectors to develop sustainably and coexist peacefully [27]. Research has found that policies, formal and particularly informal institutions (or social norms), legislation and power relations have a significant impact on farming and mining communities. They can make it easy or difficult for them to maintain their livelihoods, not to mention their prosperity [27]. Processes determine how structures and individuals or households' function and interact. They are managed and controlled by structures and refer to policies, laws, institutions and power relations [6]. They can also include markets, beliefs and social norms and limit individuals or households' opportunities for advancement by framing and limiting their livelihoods [6, 23]. Through markets, for example, individuals or households are able to transform one type of capital into another in an equitable way, in the event of fair processes respected by structures [6, 23]. The study took into account policies, laws, institutions and power relations, specifically to its field of research.

Policies and legislation

A policy is defined as an action plan designed to achieve specific objectives or targets [23]. In 2013, there was a reform of the Burundian mining sector, as part of its macroeconomic policy aimed at diversifying domestic sources of revenue, launched in 2005 [8]. The mining sector was more targeted because it was seen as a potential generator of export revenues. As a result, a new mining code liberalizing the sector to foreign investors was introduced on October 15, 2013, replacing the 1976 code [8, 9]. Indeed, not only was the reform of the sector requested for the

needs of the economy, but was also necessary to draw inspiration from the conditionalities imposed by the World Bank in 1986 as part of the structural adjustment programs (SAP) [9]. The conditionalities relating to the mining sector included the need for a satisfactory degree of management autonomy, and the gradual transfer of mines to private investors [9].

Mining sector reform

In more specific terms, according to World Bank's conditionalities, mining sector policy reform aimed at changes in legislation to make the sector attractive to foreign investment, increased tax relaxation, strengthening and reorienting government institutions supporting the mining sector, privatizing state mining assets, and enacting environmental laws [4]. Thus, to allow sufficient time for reflection on the new mining code of 2013, the country handed over mining operations to individual national private investors in 2005, and the 1976 mining code remained in force. Nonetheless, the results were not satisfactory because these individual investors could easily evade taxes and brought no apparent improvement in the livelihoods of local communities. Indeed, these investors were informally selling the mines outside the country, and declaring false quantities exploited to the Ministry of Energy and Mines [8]. It was then necessary to open the sector to foreign investors, to oblige national investors to work in mining cooperatives, and to prohibit illegal exploitation through Law No. 1/21 of October 15, 2013 relating to the Mining Code of Burundi. This law was followed by the establishment of the technical service-OBM at the Ministry of Hydraulics, Energy and Mines in 2015, a service responsible among other things, for promoting activities of mining companies and cooperatives, and contributing to strengthening their capacities by applying them technically when necessary [9]. In the same year 2015, regional antennas responsible for monitoring mining activities and informing the OBM were set up. In addition, environmental protection was incorporated into the attributions of the Ministry of Agriculture and Livestock by Decree No. 100/087 of July 26, 2018 to involve this ministry in the management of mining activities. The creation of OBM and the involvement of the Ministry of Agriculture and Livestock in the management of mining activities have not had a positive impact on livelihoods in the study area. Indeed, while this ministry has not played its role in enforcing regulations of the environmental code, OBM has never provided support, especially technical, to the *DHDI* cooperative, which nevertheless, needs it so much, according to the public and community relations officer at this cooperative. These shortcomings affect households' access to certain assets such as the stock of healthy human capital following diseases caused by water and air pollution, and that of natural capital following this pollution and the collapses or landslides that destroy and carry away crops and homes. Also, although workers and other ordinary members are an integral part of the cooperative according to obligations of the reform, they do not receive shares of the profits, and

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are excluded from many of the additional benefits that a cooperative model can bring, thus limiting their access to certain assets, particularly financial assets. These benefits are attributed to a small number of shareholders, who at the same time share all the profits of the activities, according to minors during group interviews. In addition, the laws and regulations resulting from this reform do not mention anywhere the settlement of disputes in the event of non-compensation of households in advance, unfair compensation, and failure to comply with environmental standards by mining companies or cooperatives. This encourages irregularities, reduces households' access to natural and human capital as well, especially at Gahoma hill where environmental destruction is large-scale and where 15 households had not yet received their compensation at the time of the survey.

Overall, the reform has made the mining sector profitable for the entire local community by prohibiting illegal artisanal mining by households on their properties, even if some of these households (25.7% and 50% of households surveyed at Ruhororo and at Gahoma, respectively) lamented having lost the more or less stable income from this former illegal exploitation. It is in this logic that some households, those who had mines on their properties and those who did not, were able to improve their access to financial capital thanks to improvement in quantity of agricultural production, work at *DHDI* cooperative or at TMB company, and alternative or complementary activities created, namely 54% and 27% of households surveyed at Ruhororo and at Gahoma respectively, who had reached a general income greater than or equal to national poverty threshold of 2021 (≥ BIF 1,580/day/adult equivalent) at the time of the survey, adding to 21.7% and 20% of households who already had this threshold before the advent of mining activities at Ruhororo and at Gahoma respectively.

Institutions

Land tenure is an institution that affects the ability of affected farming households to maintain their livelihood activities after mines claim lands on which these activities were carried out [4]. In the study area, land scarcity continues to increase as mining expands its operations. This phenomenon results in landowners placing a high value on their lands, and as such, overcharging farming households that need it. The purchase price of one hectare of arable land increased from BIF 20,000,000 ($9,634 USD) before mining activities (before December 2018) to BIF 50,000,000 ($24,085 USD) during mining activities (in August 2022), while rental price of half-hectare for one calendar year, increased from BIF 450,000 ($217 USD) to BIF 480,000 ($231 USD). This land purchase price has become informally institutionalized in the area, and agricultural households that need land, especially those that have lost it, often face unfavorable access conditions (unfair compensation to be able to buy land equivalent to that lost). However, according to the land Code of 2011, all lands

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transfers must be controlled by the government. The latter (government) should therefore intervene to ensure that it is easy for households who are losing lands to mining activities, to acquire others.

Power relations

Power relations are very important in determining access to livelihood assets [4]. Existence of power in a negotiating group, over its interlocutor, can be a facilitator for obtaining these assets [4]. In Ruhororo community, compensation of all households that lost land, construction and rehabilitation of social infrastructure, as well as initiation and monitoring of projects within the framework of the community development program of the local cooperative *DHDI*, were facilitated by the hill chief. According to opinion leaders on the Ruhororo hill, the hill chief was very involved in the negotiation of compensation despite negative interference from the communal administrator, and in the design of projects together with the leaders of the cooperative, because in addition to his function as hill chief, he was a member of the regional antenna and could therefore influence decisions of the cooperative. Also, the hill chief had good relations with the people who lost land and properties because he was one of them.

In Gahoma community, the hill chief allowed himself to be dominated by the communal administrator in the process of granting compensations and implementing community development projects. According to opinion leaders on the Gahoma hill, the said hill chief was disinterested in issues related to mining activities because he had not been chosen to be a member of the regional antenna, and he was not among those who had lost lands and properties. The establishment of priorities on the lists of beneficiaries of compensations or community development projects was then done by the communal administrator according to the relationships he had with the households, and according to his own negotiation with the authorities of TMB company, especially with the head of public and community relations. Indeed, for community projects, popularization of new agricultural improvement techniques is done within associations, with practice among certain households arbitrarily chosen by the communal administrator from among those who have lost lands. Households that are not prioritized on the lists are delayed in the provision of compensations or development projects, or even find themselves eliminated in favor of other households (sometimes non-residents of the hill or having not lost lands) who have good kinship, friendship or financial (corruption) relations with the communal administrator. For these opinion leaders, the communal administrator was a corrupt cheat and should be removed from issues concerning the mines, to promote direct relations between TMB company officials and affected households. An opinion leader at Gahoma spoke out: "*The communal administrator is not trustworthy. He is*

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a cheat and corrupt. The mining company must deal directly with the affected farmers".

In rural areas of developing countries, arable land is the most important asset for ensuring farmers' livelihoods [24, 28, 29]. Indeed, successful productivity growth in agriculture has been at the root of early development, structural transformation and subsequent industrialization in most developed countries [26]. In these developing countries in general, and in Burundi in particular, agricultural operating conditions remain unfavorable to productivity. Agriculture is rainfed, seasonal and subject to climatic hazards. Other negative factors for productivity are lack of chemical fertilizers, lack of phytosanitary products, lack of selected and adapted seeds, lack of adequate agricultural equipment, lack of road infrastructure in good condition, lack of agricultural supervision, illiteracy, demographic pressure which leads to fragmentation of arable land, and so on [25]. In the study area (Ruhororo and Gahoma hills), already with a population density between 500 and 650 inhabitants/km^2 depending on location [14], these factors have been compounded by the advent of mining activities which have taken up an average of 0.2 hectare per household. Land has become increasingly scarce and expensive, making households unable to obtain the same area of lost agricultural land. This is the result of lack of monitoring by state services on the reality happening between the agricultural sector and the mining sector, on the ground. It is also due to poor governance in the mining sector, especially the corruption of authorities which has taken a prominent place there. The lack of monitoring and corruption have led to unfair compensation by TMB company and *DHDI* cooperative, or even the absence of compensation by TMB company. This has contributed to the inability of households to access their former area of agricultural land. But this has not had a negative impact on average agricultural production at Ruhororo, unlike Gahoma, because the hill chief (member of the regional antenna - one of services in charge of managing mining sector) had good relations - power relations - with households. That being, households that lost quantity of agricultural production also lost general income, and consequently livelihoods, both at Ruhororo and at Gahoma.

Negative environmental and social impacts of rural mining can far exceed macroeconomic performance [30]. Withdrawal of households from their former farms, with no or unfair compensation, environmental and air pollution, soil erosion, absence of dialogue framework between State, households and mining companies, and so on, are likely to keep (rural) households in poverty [31]. This is the case in the study area, especially at Gahoma where 53% of surveyed households lost their quantity of agricultural production, their general income and their livelihoods. Indeed, the same factors mentioned above are present at Gahoma and Ruhororo hills, but

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with greater extent at Gahoma. This is also due to absence of state services on the ground, and to poor governance, especially corruption in the mining sector.

Access

Heads of households surveyed in the Ruhororo community (about 54%) admitted that access to assets and livelihood activities, as well as to the use of skills and knowledge, was not a problem at all. In other words, the malfunction of structures and processes was compensated by the negotiation capacity of the hill chief and his good relations with the majority of households in the community, despite the fact that compensations did not correspond to the real value of losses suffered by households due to shenanigans of the communal administrator. It is mainly this hill chief who ensured that access to preferred assets and activities was not greatly limited for a majority of households.

On the other hand, heads of households surveyed in Gahoma community (about 73%) admitted that access to preferred assets and activities was a concern for their existence. In other words, the malfunction of structures and processes has been compounded by the excessive corruption of the communal administrator, and possibly of other authorities including those of TMB company in the process of compensating for losses suffered by households. These irregularities then greatly limited for a majority of households, access to preferred assets and activities. Another problem that was reported by these heads of households in this community is the ban of cutting down trees in household farms without the authorization of the communal environmental technician. According to these household heads, this authorization is time-consuming or often requires bribes, and therefore, limits access to preferred activities such as making and selling charcoal that aided in their quest for survival before the advent of mining activities.

In such functioning of structures and processes, compensations and salaries received were used differently according to the households' choices. The latter were not assisted in their choice of investment neither by State services, nor by TMB company or *DHDI* cooperative. Some households chose to invest their compensations in "agriculture and livestock", especially livestock of goats and pigs. Others chose to invest in "alternative activities" such as the construction of commercial infrastructure (rented houses, rented shops, restaurants and bistros rented or for own business), the purchase of means of commercial transport (vehicles, motorcycles, bicycles) and the engagement in trades (welding, masonry, carpentry). Others chose to invest in "agriculture and livestock and in alternative activities" at the same time. Others chose to invest in “non-income generating activity - purchasing family means of transport” (vehicles) and in “non-directly income generating activity - schooling of children” at the same time. Others chose to invest in “alternative activities and in non-income generating activities” at the same time.

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Households that did not receive compensations at Gahoma hill resorted to selling their animals and working in neighbors' fields for their survival. There are also households among those who did not lose lands, who engaged in small businesses and small trades such as welding, masonry and carpentry, to take advantage of the presence of an additional demand for goods and services in the locality.

In these compensation investments, only households that invested in "agriculture and livestock" or in "agriculture and livestock" with "alternative activities" at the same time (namely 17 households among 20 households that received compensations at Gahoma and 13 households among 17 households that received compensations at Ruhororo), were able to improve or maintain their quantity of agricultural production. They improved their general income or their livelihoods due to this agricultural production and alternative activities. Households that invested their compensations elsewhere (alternative activities only, non-income generating activity and none-directly income generating activity at the same time, alternative activities and non-income generating activities at the same time) than in the last two (namely 3 households at Gahoma and 4 households at Ruhororo) saw their quantity of agricultural production reduced. Their general income decreased and their livelihoods deteriorated due to abrupt disinvestment in part of their agricultural activities. Households that did not receive compensations (15 households at Gahoma) obviously saw their quantity of agricultural production reduced and their livelihoods deteriorated.

Households that did not lose land and that had engaged in alternative activities (16 households out of 35 households that did not lose lands at Gahoma and 40 households out of 53 households that did not lose lands at Ruhororo) were able to improve or maintain their quantity of agricultural production. They improved their general income or livelihoods through this agricultural production and alternative activities. The rest of the households that had not lost land, those that had not engaged in alternative activities (19 households at Gahoma and 13 households at Ruhororo) saw their quantity of agricultural production reduced and their livelihoods deteriorated as a result of effects of environmental destruction by mining activities. Mining wages help households to pay farm workforce, to purchase agricultural inputs and small animals, and to pay for children's schooling.

Overall, under structures and processes which were put in place due to advent of mining activities, average agricultural production decreased by 826 kg/household/year and 136 kg/household/year at Gahoma and Ruhororo hills, respectively. Pairing between experimental hills (Gahoma, Ruhororo) and reference hill (Buhoro) shows a decrease of 673 kg/household/year and an increase of 17 kg/household/year, directly linked to these structures and processes, at Gahoma and at Ruhororo hills, respectively. This pairing also shows an increase in average

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general income of BIF 48,690/household/month and BIF 155,730 /household/month, directly linked to these structures and processes, at Gahoma and Ruhororo hills, respectively (Table 1). Tanganyika Mining Burundi-TMB has a mining area of 86.87 km^2. It uses a lot of chemicals, and produces more ores than *DHDI* cooperative. The latter has 1 km^2 concession that has been exploited since December 2018. It cannot exceed 1 km^2 concession to exploit at the same time, but can request another when it judges that gold ores are exhausted in the first concession. In addition, the study was conducted after only three agricultural campaigns since the start of mining activities. These elements make it prudent to interpret results in terms of addition or loss of quantity of agricultural production. Thus, the addition of 17 kg/household/year at Ruhororo, attributable to functioning of structures and processes that were put in place on this hill with the advent of activities of *DHDI* cooperative, is so insignificant to say that these structures and processes are effective. The latter could in the long-term lead to losses, at a time when *DHDI* cooperative will have exploited a large area and used a lot of chemicals in the same way as TMB company, if attention does not become a priority.

Arable land is both a natural and physical asset. If it is destroyed or taken over and not properly compensated in a timely manner, this constitutes a deprivation of natural asset from which rural farming activity is undertaken as main (and almost sole) means of existence [4]. The 15 households that did not receive compensation from TMB at Gahoma sold almost all of their animals. They survived by working in their neighbors' fields and were in livelihood crisis. Their members were the first to be accused in cases of theft from households or neighbors' fields. This deteriorated social capital, both among the 15 households and among neighboring households, by breaking any form of mutual assistance between the two categories of households.

Ultimately, 47% and 75.7% of households improved their general income and consequently their livelihoods, compared to 53% and 24.3% of households who experienced deterioration, at Gahoma and at Ruhororo hills, respectively. Indeed, compensations for lost land allowed households to reinvest differently according to their own choices. The results are mixed. In other words, households that included purchase of land and small livestock (goats and pigs especially) in their reinvestment (coping strategy) were able to improve their quantity of agricultural production and their general income. Those who reinvested entirely outside agriculture, experienced deterioration in their quantity of agricultural production and their general income. The low wages from mining work help households in schooling children, and in purchasing of chemical fertilizers.

The rate of 75.7% represents households that were able to improve their livelihoods on Ruhororo hill, including 13 households that received land compensations, and

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who included purchase of land and livestock (natural and physical capital) in their adaptation or reinvestment strategy, as well as 40 households that did not lose land, and that invested in complementary activities to agriculture such as small business due to presence of employees of *DHDI* mining cooperative on the hill. Four (04) households that reinvested compensations entirely elsewhere other than agriculture (construction of decent housing, purchase of means of commercial transport such as vehicles and motorcycles, purchase of means of family transport) experienced deterioration in their quantity of agricultural production (physical capital) and their general income (financial capital). Thirteen (13) households that did not lose land, and that did not engage in complementary activities, also experienced deterioration in their quantity of agricultural production and their general income, due to destruction of their land (especially erosion and landslides) by the mining activities of *DHDI* cooperative. The rate of 47% represents households that were able to improve their livelihoods on Gahoma hill, including 17 households that received land compensations, and who included purchase of land and livestock (natural and physical capital) in their adaptation or reinvestment strategy, as well as 16 households that did not lose land, and that invested in complementary activities to agriculture such as small business, to take advantage of the presence of employees of TMB mining company on the hill. The 15 households that did not receive compensations for their loss of land experienced deterioration in their quantity of agricultural production (physical capital) and their general income (financial capital), as well as the three households that reinvested compensations entirely elsewhere other than agriculture. Nineteen (19) households that did not lose land, and that did not engage in complementary activities, also experienced deterioration in their quantity of agricultural production and their general income, due to destruction of their land (especially pollution and landslides) by the mining activities of *TMB* company.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

Livelihoods of rural households in the study communities were influenced by levels of government, TMB company and *DHDI* cooperative with their mining operations, policies and laws, institutions and power relations. The absence of government services on the ground led to non-compliance with environmental regulations (due to ignorance at TMB, and lack of technical support from OBM at *DHDI*), absence of assistance to households in their choice of compensation investment, and informal rise in land prices. Corruption, for its part, led to absence of compensations for some households at Gahoma, unfair and lump sum compensations. Bureaucratic burden in the administration of the mining sector made it difficult to establish responsibilities and encouraged corruption especially at Gahoma where the hill chief was disinterested in conflicts between households and mining company TMB. As he was

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not a member of regional antenna, this hill chief had no negotiating power with TMB and played no advocacy role for households. For this reason, irregularities at Gahoma were of great magnitude, so much so that 73% of households said that access to preferred assets and activities was limited. On the other hand, the Ruhororo hill chief had negotiating power with *DHDI*, and played well his advocacy role. Thus, irregularities at Ruhororo were of low magnitude, so much so that 54% of households reported that access to preferred assets and activities was not limited.

From the above, although the reform of the mining sector has made it potentially beneficial to the whole community, the overall functioning of structures and processes (governance) is under question, especially at Gahoma where mining company TMB operates. Indeed, if this functioning does not change, it raises questions about the long-term future of agriculture and livelihoods on this hill. This is because it has already caused a significant loss of average quantity of agricultural production (673 kg/household/year) and livelihoods, for a significant number of households (53%). It is true that it has allowed an improvement in average general income compared to the reference year (+ BIF 48,690/household/month). But this concerns a small number of households (47%). At the same time, for Ruhororo hill, the long-term effectiveness of the functioning of structures and processes (including *DHDI* cooperative) is to be feared. This is because its contribution to the average quantity of agricultural production is too low, although positive. However, its improvement in average general income, and therefore in livelihoods, is relatively consistent (+ BIF 155,730/household/month) and concerns many households (75.7%).

Briefly, structures and processes including the mining company TMB deteriorated household livelihoods in general on Gahoma hill (53% of households experienced deterioration, compared to 47% who experienced improvement). Those including the mining cooperative *DHDI* improved household livelihoods in general on Ruhororo hill (75.7% of households experienced improvement, compared to 24.3% who experienced deterioration).

The government must develop a mining policy that balances the expectations, needs and wishes of all stakeholders involved in mining (State, mining companies/cooperatives and households). Revenues from mining through various fiscal instruments such as royalties and taxes must enable reasonable and healthy economic growth, and sustainable development [32, 33]. Its positive involvement in household compensation process from start to finish, in the implementation of community development programs by the mining company/cooperative, and in choice of compensation investment, would improve household livelihoods. Its technical support to *DHDI* cooperative and its regular monitoring of mining activities in general would help to maintain a healthy environment favorable to agricultural

production. This would contribute to a diversification of national income sources, by promoting both mining and agricultural activities. Compliance with commitments by the mining company/cooperative would also do as much. Households should be encouraged and supported, both in promotion of agricultural activities and in that of alternative activities.

The study was not able to analyze evolution of agricultural production over all the 3 agricultural campaigns since the start of mining activities, due to the lack of availability of secondary data. The National Institute of Statistics of Burundi (INSB) should make those data available. Thus, future similar studies in all provinces with mining activities (Bujumbura rural, Bubanza, Cibitoke, Kayanza, Ngozi, Kirundo, Muyinga, Ruyigi, Karuzi, Gitega and Rutana) would benefit from the presence of secondary data, and would allow a generalization of positive and/or negative impacts on agriculture and livelihoods of rural households.

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Table 1: Comparison of agricultural production and income with control (reference hill)

	Gahoma	Buhoro (reference hill)	Ruhororo	Horizontal differences % control	
	Average agricultural quantity (in kg/household/ year)	Average agricultural quantity (in kg/household/ year)	Average agricultural quantity (in kg/household/ year)	Gahoma/Buhoro	Ruhororo/ Buhoro
2017-2018	2,648	2,230	2,933	Pairing before mining activities	
				418	703
2020-2021	1,822	2,077	2,797	Pairing during mining activities	
				-255	720
Vertical differences	-826	-153	-136	Difference between pairings	
				-673kg /household/ year	**+17kg /household/year**
	Average agricultural income (in BIF/household /month)	Average agricultural income (in BIF/household/ month)	Average agricultural income (in BIF/household/ month)	Gahoma/ Buhoro	Ruhororo/ Buhoro
2017-2018	162,330	135,420	179,850	Pairing before mining activities	
				26,910	44,430
2020-2021	197,400	200,250	303,030	Pairing during mining activities	
				-2,850	102,780
Vertical differences	35,070	64,830	123,180	Difference between pairings	
				-29,760	**+58,350**
	Average general income (in BIF /household/ month)	Average general income (in BIF /household/ month)	Average general income (in BIF /household/ month)	Gahoma/ Buhoro	Ruhororo/ Buhoro
2017-2018	204,570	159,390	223,290	Pairing before mining activities	
				45,180	63,900
2020-2021	330,300	236,430	456,060	Pairing during mining activities	
				93,870	219,630
Vertical differences	125,730	77,040	232,770	Difference between pairings	
				+48,690	**+155,730**

Source: Table designed from field data 1$ USD = 2076 BIF (July-August 2022)

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