

IMPACT OF ARTISANAL MINING ON IMPROVING THE SOCIO-ECONOMIC CONDITIONS OF ARTISANAL MINERS

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ABSTRACT

Since 2013, the Burundian mining sector has seen several initiatives aimed at integrating this sector into the development engine. Legal and policy reforms have allowed artisanal mining to develop by formalising it. It is with this in mind that this article measures the level of wages and satisfaction with the standard of living of artisanal miners. It presents artisanal miners' perceptions of the level of income derived from artisanal mining and presents a statistical analysis of wages and the number of women artisanal miners.

Keywords: Artisanal miners, cassiterite, coltan, wolframite, 3T minerals, gold.

1.0 INTRODUCTION

Burundi has significant mining potential including: nickel mineralisation, gold, tungsten (wolfram), tin, Nb-Ta (coltan), rare earths, vanadium and industrial minerals such as phosphates, limestone and kaolin [1][2][3]. Until 2013, the mining sector was governed by Decree-Law n°1/138 of 17 July 1976 on the mining and petroleum code of the Republic of Burundi and Decree n°100/130 of 14 December 1982 setting out the implementing measures for Decree-Law n° 1/138 of 17 July 1976 [2]. As discussed in Midende (2010) and the study by Ndikumana and Mbonicuye (2019), this legislative framework revealed gaps. It was thus promulgated the law n°1/21 of 15 October 2013 on the mining code to adapt it to new imperatives. Since then, the government of Burundi has implemented initiatives aimed at the possibilities of integrating the mining sector into the challenges of sustainable development in order to make this sector the engine of sustainable development and fight against poverty [4]. To this end, promising new legislative and regulatory provisions (mining policy, Burundi Mining Code, mining regulations) have been promulgated and state institutions (OBM and OBPE) have been created. Burundi has also adopted international transparency standards (ITIE, Dodd Frank Act, OECD Guide, iTSCi) to ensure good governance in the management of the mining sector [2][5].

Mining is dominated by artisanal exploitation, with gold and the 3T minerals (Tantalum, Tin, Tungsten) [5][6]: columbite-tantalite (coltan), cassiterite and wolframite; of which wolframite accounts for the largest share of production (38%) and tantalite accounts for a third (30%) of production [3].

According to the World Bank (2016), artisanal mining employs 6,000 to 7,000 men and women in mines producing the 3Ts, and between 14,000 and 27,000 in gold mines.

The mining industry continues to fuel certain economies in sub-Saharan Africa and is now a driver of socio-economic development [7]. Therefore, in Burundi, actions have been taken to achieve development objectives and the place of the artisanal miner can be a framework for reflection to measure his satisfaction and assess the contribution of the mining sector in improving his standard of living.

It is with this in mind that this article measures the level of wages and satisfaction with the standard of living of artisanal miners. It aims to contribute to the knowledge of the level of appreciation of the contribution of artisanal mining to the fight against poverty.

The remainder of this paper is divided into eight parts: in section 2, the materials and methods used are presented and the mathematical formulation of the problem is given in section 3. 4 the wage modelling is done. Section 5 presents the statistical grouping of artisanal miners by wage and in section 6 the modelling of the number of female artisanal miners is discussed. The discussion of the results is presented in section 7 and a conclusion is drawn in section 8.

2.0 MATERIALS AND METHODS

2.1 Sample selection and size

A combination of methods was used to carry out the present work. The initial desk research was complemented by data collection at 19 mining sites through individual and group interviews, and direct observation. The study targeted artisanal miners and site managers in the North and West regions containing five provinces, namely Kayanza, Kirundo, Ngozi, Bubanza and Cibitoke, taking into account sites artisanally mining gold and 3T minerals, and having valid mining permits. These regions were chosen because of their significant artisanal mining.

The voluntary sampling method was used in the selection of artisanal miners and a sample of 96 artisans was surveyed out of the calculated sample of 100 artisanal miners chosen using P. Ardilly's formula [8].

2.2 Study variables

In the wage study, we constructed a categorical dependent variable of weekly wage bands (=1 if wage < 5,000, 2 if between 5,000 - 10,000, 3 if between 10,000 - 20,000, 4 if between 20,000 - 50,000, 5 if between 50,000 - 100,000, 6 if between 100,000 - 150,000, 7 if between 150,000 - 200,000, 8 if >= 200,000). Among the independent variables we included site-specific factors such as the type of artisanal mining (underground, small-scale open pit, large-scale open pit), minerals mined at the site (1=Cassiterite, 2=Coltan, 3=Gold, 4=Wolframite, 5=Mixed concentrate), number of shareholders (1,2, ...), age of the site and province (1=Kayanza, 2=Kirundo, 4=Ngozi, 6=Cibitoke, 9=Bubanza) The socio-demographic factors of the artisanal miner selected were gender (1=Male, 2=Female), age (1=Under 18, 2=18 to 24, 3=25 to 29, 4=30 to 39, 5=40 to 49, 6=50 to 60, 7=over 60), marital status (1=Single, 2=Married, 3=Common law, 4=Divorced, 5=Widowed), level of education (1=Primary/Fundamental, 2=Secondary/Post-Fundamental, 3=University, 4=None), length of time as a craftsperson

(0=Less than 5 years, 1=5 to 10 years, 2=11 to 15 years, 3=16 to 20 years, 4=21 years and over), category of worker (1= Supervisor, 2=Digger, 3=Daily), and status of payment (monthly, daily, per production).

For the study of the number of women in the mining sector, the dependent variable : number of women in the employees of the site was chosen (0,1,2, ...). An attempt will be made to discuss the hiring conditions for women and the difficulties faced by women artisanal miners.

The potential factors for the number of women retained are : type of minerals mined at the site, type of artisanal mining, region (1=North, 2=West), province, length of time at the site, total number of employees at the site (1=0 to 5years, 2=6 to 10years, 3=11 to 15years, 4=15years and above), number of permanent employees (0.1, ...), total number of shareholders (0.1, ...) and number of female shareholders (0.1, ...).

3.0 MATHEMATICAL FORMULATION OF THE PROBLEM

Given that our study variable, wage, which is qualitative with ordered modalities, we conducted an ordered logit regression model to further analyze and identify the explanatory factors and their mechanisms of action on the wage level. This model estimates the relationship between an ordinal dependent variable and several explanatory variables. It estimates a given score (S_j) as a linear function of the independent variables and a series of intersection points (K_i). To use this model, the modalities of the dependent variable must have an order relationship with each other, be ranked in a given order. Also, the number of modalities must be greater than two. The explanatory variables can be either quantitative or qualitative. The formula for estimating the probability of occurrence of event (modality) i of the dependent variable for an individual with modality j of the independent variable is provided by the mathematical expression (Franklin B, 2005 [9]) :

$$\Pr(j = i) = \frac{1}{1 + e^{-(K_i - S_{ji})}} - \frac{1}{1 + e^{-(K_{i-1} - S_{ji})}}$$

As mentioned by R. Bourbonnais (2015) [10], the model thus consists in finding a model to predict the wage class from the proposed explanatory factors (x_i), by modelling a latent variable:

$$Y_i^* = a_0 + a_1 x_i + a_2 x_i + \dots + a_n x_n \quad (1)$$

The values taken by the variable y_i correspond to intervals (c_i) in which y_i^* is found, thus defining the following decision model with $M + 1$ modalities:

$$\begin{cases} y_i = 0 & \text{si } y_i^* \leq c_1 \\ y_i = 1 & \text{si } c_1 < y_i^* \leq c_2 \\ y_i = 2 & \text{si } c_2 < y_i^* \leq c_3 \\ & \vdots \\ y_i = M & \text{si } c_M < y_i^* \end{cases} \quad (2)$$

The values of the coefficients (a_i) of this model are not directly interpretable in terms of marginal propensity, only the signs of the coefficients indicate whether the variable acts positively or negatively on the latent variable.

To model the number of women, the poisson model modified in zero was used. In the presence of a variable to be explained which is a count variable, which is our case, poisson models are used. Indeed, the poisson law being a discrete law and taking only positive values is well suited for counts [11]. When processing the count data, it is important to check for over-dispersion and the number of zeros. If there is over-dispersion, the negative binomial model is preferred to the poisson model. And, if the number of zeros is high, the zero-inflated models should be used [12]. The vuong test tests the preference between the standard poisson models and the zero-inflated models [13]. In our case, the vuong test proves that the latter is preferred; indeed, in our variable we encounter an excess of zeros. The equation of our model will therefore be of the form:

$$\log(Y) = a_0 + a_1x_1 + \dots + a_nx_n \quad (3)$$

This implies

$$Y = \exp(a_0 + a_1x_1 + \dots + a_nx_n)$$
$$\Leftrightarrow Y = \exp(a_0) \times \exp(a_1x_1) \times \dots \times \exp(a_nx_n) \quad (4)$$

With:

Y variable to be explained

x_i explanatory variable

a_i coefficients

The variable is considered to explain the number of women if it is statistically significant, i.e. with a p-value of less than 0.05.

4.0 ORDERED LOGISTIC MODELLING OF ARTISANAL MINERS' WAGES

According to the labour code [14], wages are the counterpart of the work done. The diggers are paid a sum for the quantity of ore produced at a fixed price per kilo and the supervisors receive a monthly sum. The day labourers receive either a daily sum fixed in advance or a sum according to the work done. In some sites, diggers and supervisors receive benefits such as meals on duty. Only the monetary wage was the subject of our study and was evaluated weekly.

Most artisanal miners have a weekly wage ranging from 10,000 to 150,000. Indeed, the wage brackets 10,000 to 20,000 and 20,001 to 50,000 have the highest proportion (26.04%) followed by the brackets 100,001 to 150,000 and 50,001 to 100,000 (15.63% and 14.58% respectively). The under 5,000 bracket is the least represented with 3.13%.

Site managers told us that, on average, a mining artisan can have a maximum weekly wage of 196,500 (which can average up to 345,000). In most sites, the minimum wage is less than 32,000.

Table 1: Distribution of artisanal miners by weekly wage

Salary (in bif)	n	Frequency
Less than 5 000	3	3.13
5 001 to 10 000	4	4.17
10 001 to 20 000	25	26.04
20 001 to 50 000	25	26.04
50 001 to 100 000	14	14.58
100 001 to 150 000	15	15.63
150 001 to 200 000	4	4.17
More than 200 000	6	6.25

This disparity led us to assess the possibility of the existence of the relationship between wages and the potential factors selected.

It was found that in large open pit mines, about 70% of employees have a weekly wage of less than 50,000 while in underground mines 45.9% have more than 50,000. This is due to the fact that in the open pit mines there are many day labourers and the production in both types of operation is not the same. A high concentration of artisanal miners with a salary of more than 200,000 bif was noted in the cassiterite mines (26.32%); the low salary is much more noticeable in the coltan mines where about 93% have a weekly salary of less than 50,000 bif.

The artisanal miner category has a statistically significant relationship to wages. Day labourers receive a low salary compared to the other categories, with 80% earning less than 5,000 to 20,000 per week. Framers come second with a salary that varies between 10,000 and 50,000 (85.72% of framers). 75% of diggers earn a salary ranging from 20,000 to more than 200,000, which makes them the best paid category.

Wages also differ from province to province. The province of Kirundo comes first where 100% of the artisanal miners interviewed said that they often had a weekly salary of more than 100,000. The provinces of Kayanza and Cibitoke come second and third respectively, with 43.77% and 36.37% of the workers declaring that they often have a salary of more than 50 000. This is followed by the province of Ngozi with 23.81% of workers having more than 50,000 and finally the province of Bubanza with a proportion of 10%. This diversity of wages is mainly

due to the nature of the ore present in each province, the type of artisanal mining and its productivity.

In terms of the length of time the sites have been operating, it can be seen that artisanal sites are generally young, with less than 10 years of service. In sites with less than 5 years, wages are low compared to sites with 6 to 10 years.

4.1 Modelisation

To explain the wage, we chose eleven independent variables. The following table summarises the results of the ordered logistic regression performed.

Table 2: Recapitulation of the results of the ordered logistic regression

Salary	Coeff	P> z
Type of artisanal mining		
Large mine in the open	Ref	
Underground mine	1.4013	0.348
Minerals mined at the site		
Cassiterite	Ref	
Coltan	-4.500**	0.038
Wolframite	0.3490	0.876
Gold	0.2281	0.927
Concentrated-Mixed	0.0078	0.993
Number of shareholders		
1 to 5	Ref	
6 to 10	2.0457	0.126
11 to 15	-0.8186	0.583
16 to 20	-0.4713	0.857
21 to 25	4.8969**	0.043
26 to 30	1.6220	0.443

Age of the site		
0 to 5 years	Ref	
6 to 10 years	0.0161	0.990
Employee seniority		
Less than 5 years	Ref	
5 to 10 years	-1.1025	0.100
11 to 15 years	-0.0923	0.911
16 to 20 years	-1.8547**	0.049
21 years and over	-3.7512***	0.001
Gender		
Male	Ref	
Female	0.7236	0.667
Age		
Under 18s	Ref	
18 to 25 years	2.2089	0.324
26 to 30 years	4.6957*	0.056
31 to 40 years	6.2866	0.012
40 to 50 years	4.1248	0.121
51 to 60 years	7.5358***	0.008
Marital status		
Single	Ref	
Married	-2.4812***	0.002
Level of education		
Primary/Fundamental	Ref	

Secondary/Post Fundamental	-0.9259	0.505
Without instruction	-1.2544*	0.073
Category		
Framer	Ref	
Digger	-0.5772	0.505
Daily	-4.1396***	0.004
Province		
Kayanza	Ref	
Kirundo	5.2871***	0.001
Ngozi	-2.3749	0.085
Cibitoke	-0.8169	0.797

From these results, it appears that the factors that significantly explain (at the 5% threshold) the salary of a mining artisan are : worker seniority, age, category, province, type of ore mined, number of shareholders and marital status.

Compared to artisanal miners with less than five years' seniority, those with more than 15 years in the sector are likely to have low wages. Indeed, those with 21 years or more are 7.57% more likely to have a salary of 10,000 to 20,000 bif, while they are 3.07% and 3.62% less likely to have a salary of 50,000 to 100,000 and 100,000 to 150,000 bif respectively (at the 10% threshold).

The fact that a mining artisan is older increases the chances of being paid a higher wage than artisans under 18. Indeed, the older the age, the less likely one is to be paid between 10,000 and 20,000 bif (8.54%) and the more likely one is to be paid between 100,000 and 150,000 bif (4.09%) at the 10% threshold.

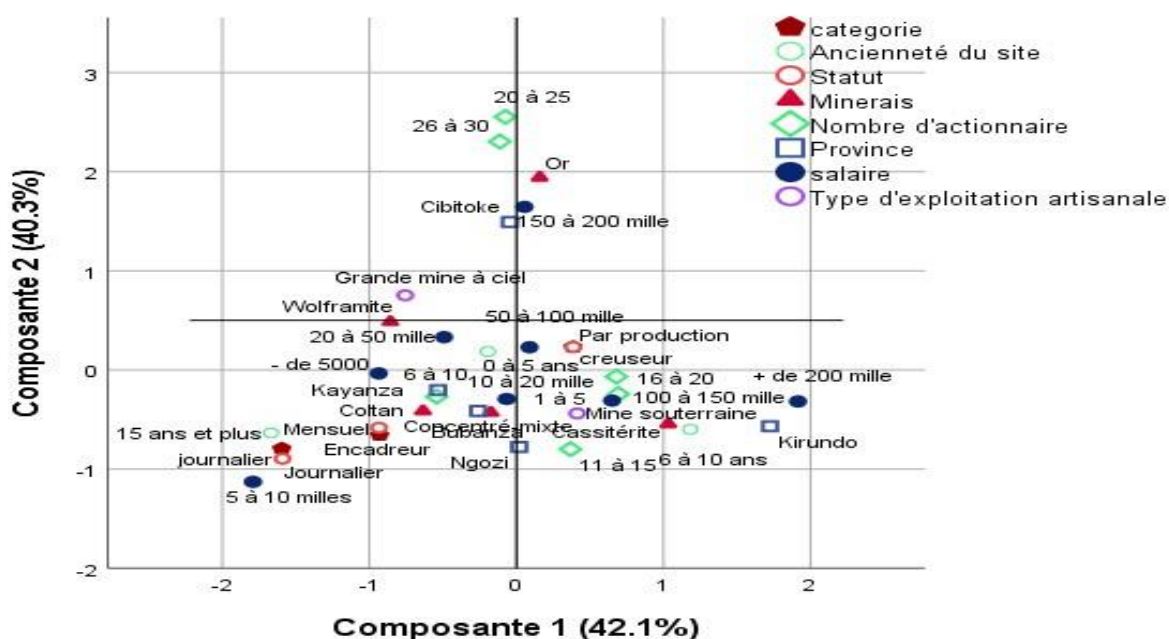
In terms of category, day labourers are less likely to have a high wage than supervisors.

5.0 STATISTICAL GROUPING OF ARTISANAL MINERS

In this paragraph, we will describe the salary according to the variables that can be associated with it. The factorial analysis of multiple correspondences was carried out and enabled us to identify two groups of artisanal miners with regard to their salary. The first two axes were retained, representing 82.3% of inertia, with 42.1% and 40.3% respectively for the first and second axes.

The first axis opposes the diggers to the supervisors and day labourers. The variables category, status and salary are well represented (inertia greater than 50%), this axis is an indicator of the characteristics of the categories of artisanal miners. The diggers are characterised by a salary varying from 50 thousand to more than 200 thousand and are paid according to their production. Day labourers and supervisors have a salary of less than 50 thousand.

The second axis contrasts Gold with the 3T minerals. The type of ore, province and number of shareholders are the variables that are best represented (around 70%).



This is an axis of mineral characterisation. On the one hand, the artisanal miners of the gold sites, based in the province of Cibitoke, are characterised by a salary varying from 150 to 200 thousand. The cooperatives working in the gold mines are characterised by a large number of shareholders, varying between 20 and 30. On the other hand, those in the 3Ts are characterised by a salary ranging from less than 5,000 to more than 200,000. This result shows that in the gold mines the category of day labourers, characterised by a low salary, is not much noticed in contrast to the 3T sites.

– The multivariate analysis by AFM allowed us to distinguish two groups of artisanal miners with respect to wages: Artisanal miners with a good salary. They are in the category of diggers and are characterised by a weekly salary of between 50,000 and over 200,000. These wage brackets are most common in Kirundo province and on the sites where cassiterite and gold are mined.

– Artisanal miners with a rather low salary of less than 5,000 to 50,000. This group includes supervisors and day labourers; it is most common in the provinces of Bubanza and Kayanza and, at most, in the Coltan and mixed concentrate mines.

6.0 STATISTICAL MODELLING OF THE NUMBER OF WOMEN ARTISANAL MINERS

6.1 Indicators of women in the artisanal mining sector

Women are present in the activities on the 19 mining sites visited, among the 1181 artisanal miners declared in this study, women represent 14.39%. Half of the sites employ women at less than 10.51% of their workers. On average, a site with 65 employees employs 2 to 17 women. This proportion is statistically the same depending on the province, the type of minerals mined on the site and the type of artisanal mining. All these women are in the category of artisanal day labourers and therefore do not participate in the extraction of minerals. They are mainly involved in transporting the minerals and other tasks. The fact that they only work in processing activities means that they earn little; indeed, the weekly wage varies between 5,000 and 20,000 bif for the day labourers, while it varies between 50,000 and 150,000 bif for the diggers.

The women artisanal miners surveyed all felt that they were facilitated in their daily activities and 80% were generally satisfied with their work.

The main reasons reported for the low number of women in the mining sector include that mining work requires a lot of strength and that women underestimate themselves and fear sexual abuse in the mines. Another reason reported is that they are often involved in housework and farming.

For women artisanal miners, working in the mines is a secondary activity after farming, allowing them to supplement their income from agriculture. Nevertheless, 20% of the women interviewed are not satisfied with their work and deplore the low wages.

When hiring, gender comes fourth among the criteria evaluated by the site managers. In fact, to recruit, the following are evaluated: seniority (63.16%), age (57.89), physical strength (42.11%), gender (21.05%) and level of education (2.78%). The conditions of gender and physical strength exclude women among the artisanal miners sought especially in the category of diggers; women are only recruited for day labour.

6.2 Zero inflated poisson model on the number of women artisanal miners

From the table below, we can see that the factors explaining the number of women at a site are: total number of employees, number of permanent employees, region, province and type of artisanal mining.

Table 3: Summary of the results of the zero modified poisson regression

Variable	Coeff	dy/dx
Type of minerals	0.1987*	1.8961
Type of artisanal exploitation	0.3730**	3.558*
Region	1.7180***	16.387**
Province	-0.5359 ***	-5.11**

Age of the site	0.8161	7.7846
Total number of employees	0.057***	0.5353**
Number of permanent employees	-0.0636***	-0.6064**
Number of shareholders	-0.0366	-0.34
Number of women shareholders	0.1161	1.1078
cons	-1.4713	

The number of employees significantly explains the number of women on a site. Indeed, for sites willing to employ women, if the number of employees increases, the number of women increases by 5.7%. However, if the number of permanent employees increases, the number of women decreases by 6.36%. According to the type of artisanal mining, the sites that employ women, large open pit mines have 37.30% more women than underground mines. The same is true for the region, where the West has 16.39 more women than the North.

Regarding the provinces, the sites in all provinces willing to employ women have 5 fewer women than Kayanza province.

7.0 DISCUSSION

The work in the mining sites satisfies the artisanal miners. Most of them (70.8%) report a better standard of living than farmers and some (34.38%) report a higher standard of living than government officials in their community. The category of diggers is the most satisfied. It can therefore be seen that this sector brings a large number of positive contributions (Midende, 2010) [1] to the artisans.

7 out of 10 artisanal miners have a weekly salary of between 20,000 and 150,000. It varies according to the category of artisanal miners; the diggers being the best paid, followed by the supervisors and finally the day labourers. This disparity is mainly due to the fact that the main workers in a mining site are the diggers and the other two categories do support activities for them. In addition, their remuneration is based on the production of the ore and at a rather affordable price.

In this study we notice that the salary varies from province to province. The high wage brackets are most noticeable in Kirundo province and the low brackets are most noticeable in Bubanza. This proves the province specificity in a mineral, the low wage in coltan mining sites in Bubanza and a likely high mineral productivity in Kirundo. Most of the low-paid artisanal miners are present in Kayanza, which would indicate either the massive use of day labour in this province or the low pay in the sites in this province.

Seniority has also been identified as a factor in wages. Workers with high seniority are most likely to have low wages. As mining work requires a lot of physical strength and is paid according to production, exhaustion would be a factor in this lower wage depending on seniority.

Age affects salary levels. Artisanal mining attracts many young people (Ndikumana J.B and Mbonicuye D, 2019), with most (82.29%) of the employees we met being under 40 years old. The mining sector is helping to disgorge the agricultural sector, which is becoming less and less profitable due to overpopulation and increasingly scarce cultivable land. Artisanal miners under 18 years of age encountered in this study are likely to have lower wages than their adult counterparts. This result shows that mining sites are making children work (Midende 2010) and paying them less, which is characteristic of child labour (Unicef, 1997) [16].

Unlike in the neighbouring country DRC, where women are involved in collection activities (women diggers) [17], or in Uganda [18], Burundian women artisanal miners are only involved in supplying the site and/or transporting the minerals. They come to work in mining to supplement their agricultural income and support their families. The fact that they only work in support activities means that women are paid less than men, as they are only allocated to the lower paid activities (Doris Buss et al, 2017). The explanatory analysis shows that the number of women differs from one site to another, according to the type of artisanal exploitation, and from one region to another. Indeed, the Western region has a larger number of women artisanal miners than the Northern region, with Kayanza province coming out on top. Women in the Northern region are most interested in agricultural work, unlike their counterparts in the Western region, who turn to other sectors.

The low number of women in the mining sector is partly due to the stereotype that digging is a job for men, and partly due to the double workload of women. Indeed, women are considered to be primarily responsible for household and agricultural tasks, which means that they spend less time on other activities.

From these results, it can be seen that efforts need to be made to raise women's awareness in order to encourage them to participate significantly in the various mining activities, and to encourage them to group together and organise themselves in order to strengthen their position within the sites. Efforts would be much greater in the provinces of the northern region, with the exception of Kayanza province, where the number of women artisanal miners is low. It is also up to the male artisanal miners to trust the women and hire them and thus help to combat gender discrimination in the employability of miners. Finally, women artisanal miners should be supported to be role models and to develop their economic empowerment; and thus encourage other women to take an interest in the mining sector.

8.0 CONCLUSION

Artisanal mining contributes enormously to the development of artisanal miners. In general, artisanal miners, most of whom are young people, are satisfied with their work and are able to satisfy their primary need. As seen in different countries such as Mali (Seydou, 2001 [19]) and DRC (Mukotanyi, 2018 [20]), this paper shows that artisanal mining contributes enormously to the fight against poverty through the reduction of unemployment and increases the standard of living of Burundian artisanal miners.

On the mining sites, women are present and perform various activities apart from mineral extraction; as a result they are paid less by the mining sector. In this study it was shown that although the proportion of child labour is low (2.08%), child labour is noted. There is a need to sensitise the sites on the disadvantages of child labour. As the study focused on formal sites, future studies should survey as many artisanal miners as possible and take into account non-formal sites in order to clarify the proportions of children in the sector. In view of the low number of educated artisanal miners encountered and the fact that the level of education is not verified in the allocation of work, it would be necessary to raise the awareness of the population surrounding the mining areas to prevent mining from having a negative influence on the schooling of children.

Given that mining is an activity in a world with limited resources, the exploitation of mineral resources does not continue to increase; it would be essential to invite artisanal miners to invest in other areas and thus address the problem of frequent cessation of activities. An accompanying policy is essential. Most artisanal miners deplore the fact that they do not have access to bank credit services; orienting the policy of creating mining micro-credits will contribute to the development of artisanal miners. Artisanal mining could thus be the bearer of economic growth and reduce the number of idle youth.

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