

SOCIOECONOMIC IMPACT OF BERYL EXPLOITATION IN THE NORTH OF THE ANKAZOBE DISTRICT (MADAGASCAR)

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ABSTRACT

Numerous beryl deposits associated with pegmatites have been exploited in the north of the Ankazobe District since the 1950s. Currently, exploitation is essentially artisanal and on a small scale. The promotion of this beryl exploitation, even artisanal, could contribute to improving the socioeconomic conditions of the inhabitants of this area. To this end, the existence of reliable and up-to-date socioeconomic data is essential. A socioeconomic survey was carried out on a sample of the population of the commune of Andranomiely -Sud in order to obtain information on 81 parameters grouped within 7 socioeconomic factors: socio-cultural, education, eating habits, health, housing conditions, work and standard of living of residents. In this study, the socioeconomic impact was assessed by comparing miner and non-miner groups. For each parameter, a statistical test was applied, and conclusions were drawn based on significant differences between the two groups. In addition, information relating to the exploitation of beryl was collected in order to complete the study. The significant differences observed on the education factor, housing condition and standard of living of households; as well as information on beryl exploitation shows that non-mining households have a higher socioeconomic level than mining households, and the positive impact on operators is low. Furthermore, the study showed that education and the establishment of good market regulation are crucial for the promotion of the sector.

Key words: *socioeconomic, exploitation, beryl, Ankazobe, Madagascar.*

1. INTRODUCTION

Madagascar is considered a country rich in mineral resources. However, these mineral resources are underexploited as they represent only 5.27% of the national GDP [1], and precious stones represent only 5% of

mining revenues. The delay in the development of the Malagasy mining sector is partly linked to the lack of knowledge about the country's potential resources and the absence of an adequate regulatory framework [2].

The extractive sector is a pillar of the economy of resource-rich countries, and the macroeconomic impact of extractive sector operations is significant and generally, if not uniformly, positive [3]. It can generate direct and indirect employment, income, foreign exchange earnings, and tax revenues, but it is also associated with social and environmental challenges [4][5]. Thus, there are many socioeconomic factors to consider in understanding the impact of the extractive sector. The existence of reliable and up-to-date socioeconomic data is therefore essential in order to promote the gemstone mining sector.

This is why we proposed to conduct a socioeconomic survey to determine the impact of beryl mining at the household level in the north of the Ankazobe district. Our hypothesis is that beryl mining has a socioeconomic impact at the household level in the north of the Ankazobe district.

2. MATERIALS AND METHODS

In order to understand the impact of beryl mining on the population, socioeconomic data were collected during a survey conducted from August 4 to 11, 2024. They cover different parameters grouped into seven socioeconomic factors: the socio-cultural aspect, education, eating habits, health status, employment, housing conditions and the standard of living of households in the commune of Andranomiely. The survey was carried out by five investigators previously trained in the questionnaire and survey techniques. The main data collection tool was a structured questionnaire. The survey was conducted in the 6 fokontany of the commune: Andranomiely Sud, Andranomiely Nord, Antsakay Nord, Analamirafy, Bevony and Sambotsy Mangarivotra.

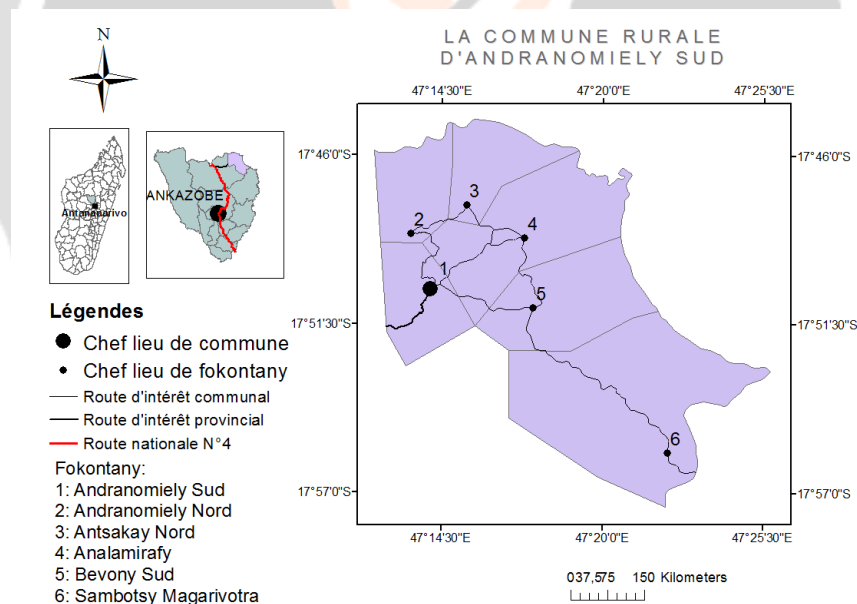


Figure 1. Location of the Rural Commune of Andranomiely Sud

The minimum sample size \sqrt{n} (113 households) was calculated using the normal distribution formula [6] with a 95% confidence level and a 9% margin of error.

Although the required number of households is 113, we collected data on 123 households. The households visited were randomly selected and their number is proportional to the total number of households that make up each fokontany. In this study, the term "mining household" describes a household in which at least one family member is a beryl miner. Thus, the data of mining and non-mining households, forming independent series, were

compared on the basis of frequencies or averages of socioeconomic indicator values. Then, statistical tests were applied to determine whether the observed differences are significant or due to sampling fluctuations. For the frequencies of categorical variables, a homogeneity test χ^2 was conducted in the case where all the frequencies of the categories for mining and non-mining households were greater than 5; otherwise the Fisher test was used. The Student t-test was done on the averages of numerical variables (with a normality test of the variables beforehand). In all the tests carried out, we pose as null hypothesis that the values in both groups are equal. Subsequently, the socioeconomic indicators with a significant difference were counted and if the indicators of which those of the miners are superior are more numerous, our hypothesis is confirmed. In addition, questions relating to the exploitation of beryls were asked to the mining households for additional information.

Data entry was done by four data entry workers and raw data was stored and pre-analyzed using the relational database software PostgreSQL (version 12). Contingency tables, hypothesis tests and graphical representations were performed using the R programming language (version 3.6.3). Since the parameters are numerous (each question corresponds to a parameter), PostgreSQL is convenient for identifying relationships between data and filtering the data before sending them to R. Similarly, hypothesis testing for each question is made easy thanks to the dedicated statistical language R.

3. RESULTS

In this survey, 39 mining households (~32%) and 84 non-mining households (~68%) were visited. There were 173 family members of the mining households and 392 of the non-mining households. Of the 81 parameters measured on both groups, statistically significant results deserve special attention. Therefore, the results presented here will focus on these parameters; they belong to the Education, Housing conditions, Work and Standard of living factor. Information on beryl mining will be presented in section 3.5.

3.1. Education

Regarding the level of education, 11% of individuals have never been to school, including 9% from non-mining households and 15% from mining households. Individuals who are not of school age or are in preschool represent 56% of the sample. Few have reached secondary school (7%), high school (3%) or university (1%) levels. Generally speaking, the number of people who have attended school is higher for non-mining households than for non-mining households.

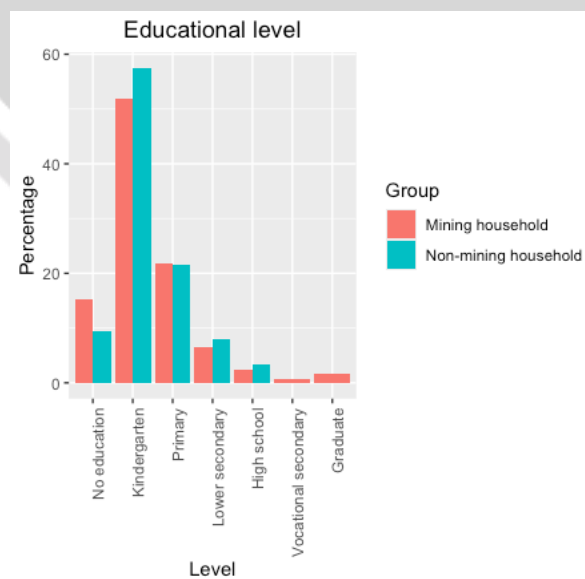


Chart 1. Educational levels of household members

households tend to send their children to school at a later age (average = 5.74) compared to mining households (average = 5.54). Overall, the number of students decreases progressively from class Grade1 to class Grade12. Only about 1% of children admitted to Grade1 reach the higher education level. Furthermore, it is noted that the percentage of students enrolled in Grade5 for the preparation of the CEPE (primary school certificate) is higher for non-mining households (12%) than for mining households (6%).



Chart 2. Distribution of households by grades

28% of individuals under 18 years of age were not attending school at the time of the survey. Furthermore, it appears that there are more children not in school among mining households (41%) than among non-mining households (23%). In addition, the proportion of children (under or equal to 18 years of age) in school is higher among non-mining households (77%) than among mining households (52%).

Table 1. Distribution of children (<=18 years) currently at school

Children currently in school	Mining households		Non-mining households		Total	
	N	%	N	%	N	%
Yes	24	52	87	77	111	70
No	19	41	26	23	45	28
Other	3	7	0	0	3	2
Total	46	100	113	100	159	100

Several reasons were given by mothers. The most common of which was: busy with daily work and household chores (22%) (Chart 3). The proportion of children who do not attend school because of their busyness with daily work is much higher among mining households (38%) than among non-mining households (10%).

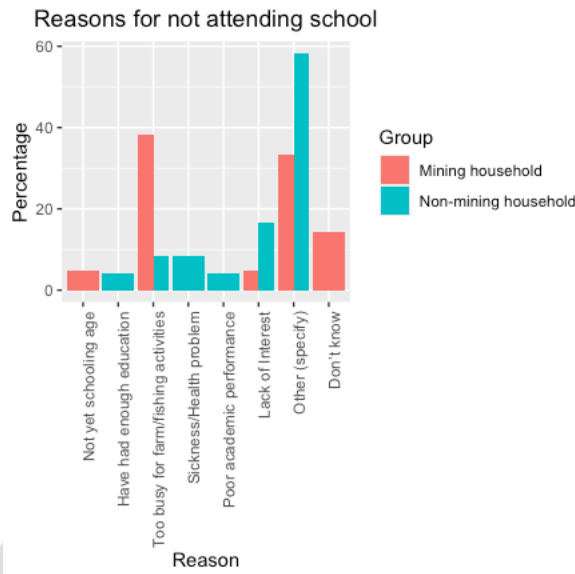


Chart 3.Reasons for not attending school

3.2. Housing conditions of the families surveyed

None of the mining households and 10% of the non-mining households have an electrical installation. In addition, for 118 households (97%), the water source is

functional throughout the year (Chart 4). This category includes 35 households (90%) for mining households and 83 households (100%) for non-mining households. For the other households, water is most lacking from October to December.

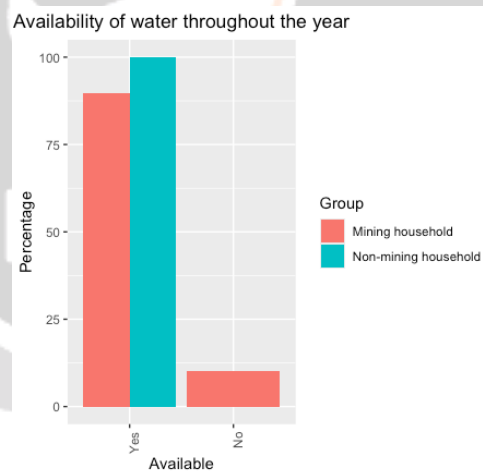


Chart 4. Distribution of households according to water availability throughout the year

3.3. Work

Regarding work, only 27.64% of households (33.33% for mining households and 25% for non-miners) had members who had been employed in the twelve months preceding the survey. To this end, their work sectors are essentially: education/training (24%), and agriculture/forestry/aquaculture (55%). There are more people from mining households working in the agricultural sector, and non-miner households seem to be more oriented towards the Education/Training and Trade sectors (Chart 5); the gaps are significant for the above-mentioned sectors.

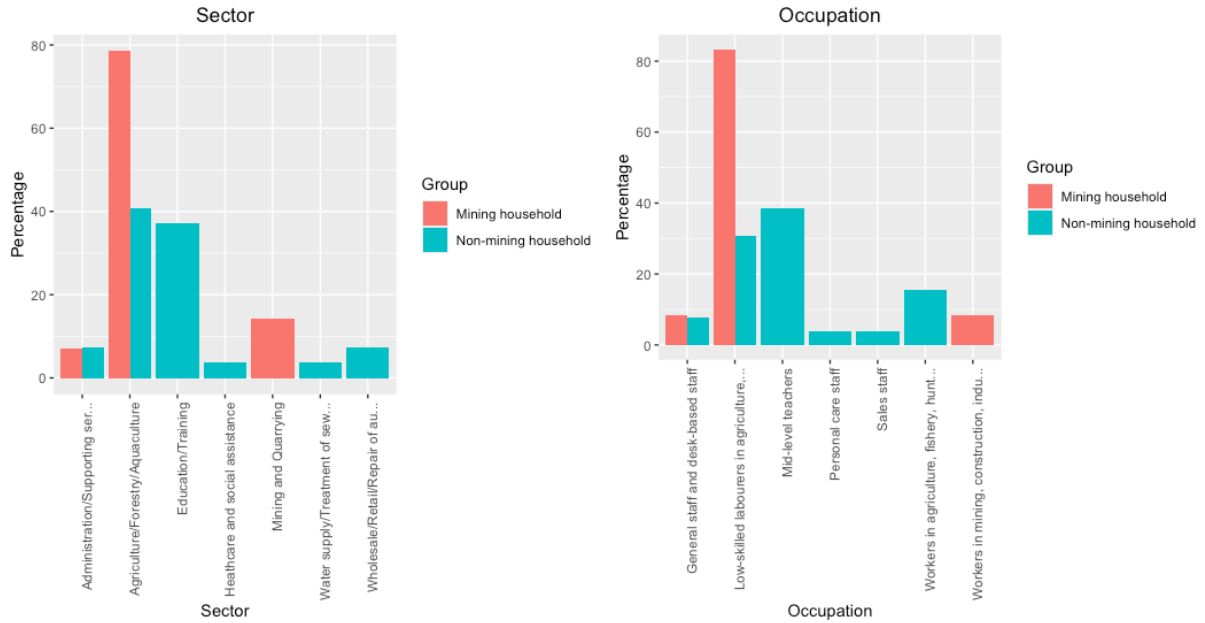


Chart 5. Distribution of employment sector and occupation of household members

Chart 5 also shows the different jobs held by the members of the families we visited. They are mainly: basic level workers in agriculture (57%), intermediate level teachers (26%) and personnel service workers (8%). During the 12 months preceding the survey, on average, they worked 15.00 days for mining households and 17.18 days for non-mining households. In addition, people are often reluctant to answer questions about their cash earnings. Their answers were therefore very approximate. Thus, during this survey, they declared having earned, in the last 12 months, up to 1.8 million Ariary for mining households and 12 million Ariary for non-mining households. The average earnings per individual were 587916.7 Ariary for mining households and 1972352.9 Ariary for non-mining households. In addition, for the vast majority of families (97% of mining households and 88% of non-mining households), some members exercise a liberal professional activity. They are mainly involved in agriculture and livestock (82%) (

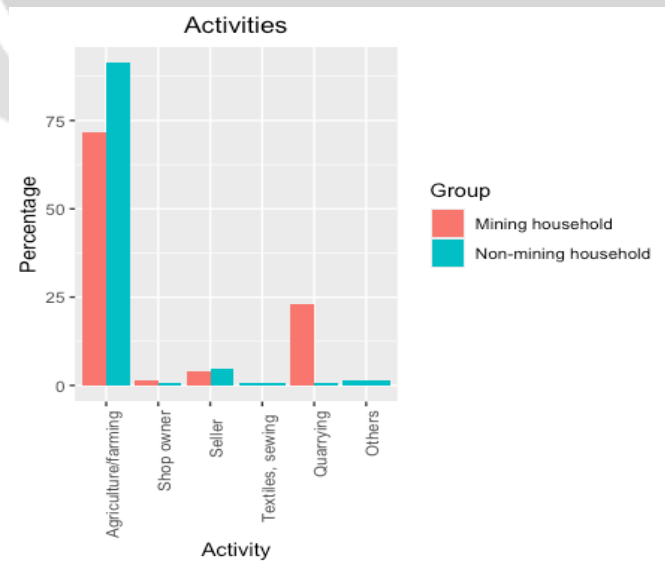


Chart 6).

Chart 6. Distribution of activities for self-employed household members

3.4. Standard of living

The existing goods and other structures give us a reflection of the standard of living of the households visited. The goods available at the level of most households are: radio, generator/battery, electricity and mobile phone (Chart 7). These are agricultural communes, but only 8% of the sample have a car. There are no major gaps between the proportions of the two groups. However, it should be noted that the possession of a radio and a watch is much higher among non-mining households while the possession of a bicycle is higher for mining households.

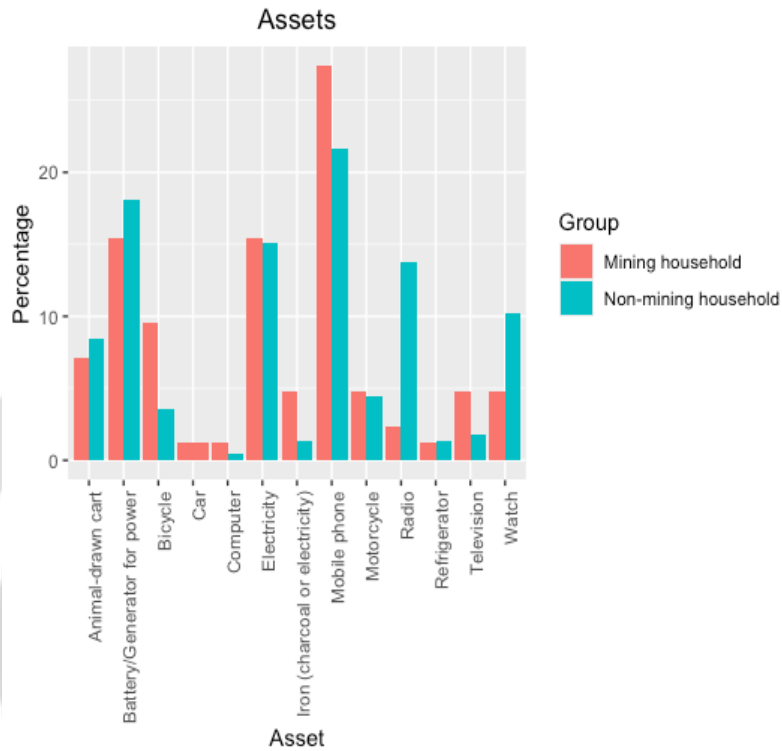


Chart 7. Distribution of households according to the assets present in the household

3.5. Information about beryl mining

Among the households surveyed, the majority of families that exploit the mines exploit mainly beryl (~ 48%) and columbite (~ 35%) as liberal work, that is to say without a boss who finances the exploitation (~ 93%). In addition, the most exploited quality of beryl is beryllium (58.18%). Apart from that, during the 12 months preceding the survey, on the households that declared their beryl income, the income from beryl exploitation contributed from 1 to 100% of the family budget; the average being 25%.

For the majority of beryl operators (64.70%), this liberal activity is seen as a secondary source of income (Chart 8).

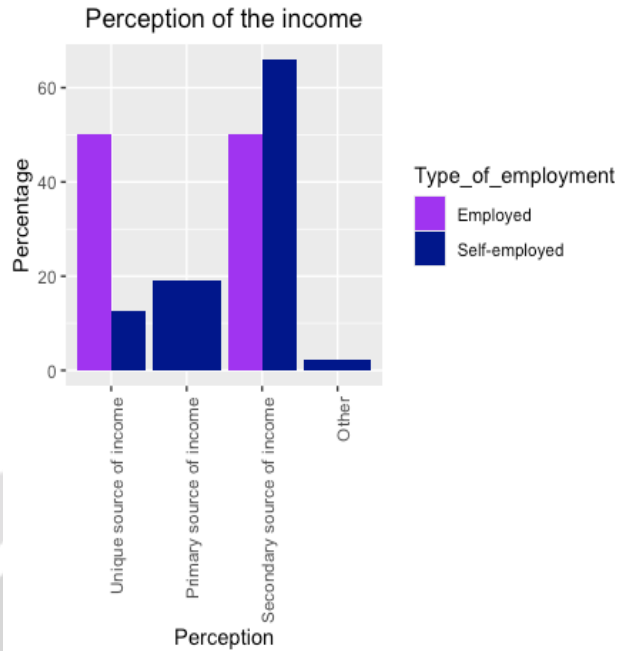


Chart 8. Distribution of households according to perception of beryl income

When asked how they spent the money earned from beryl mining, the majority (50%) of miners said they used it for household expenses.

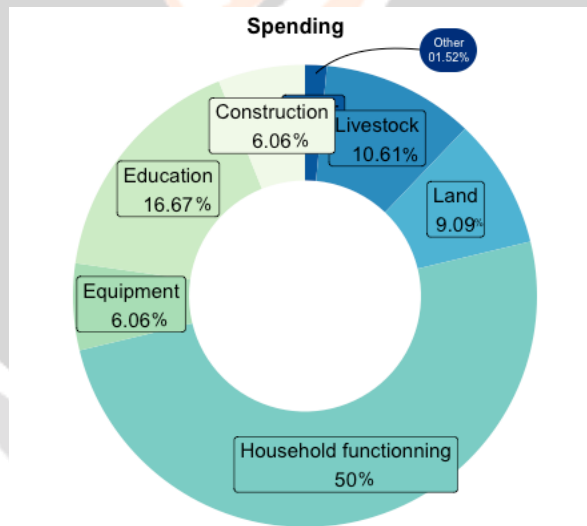


Chart 9. Spending of beryl income

The main difficulties encountered by operators are the lack of equipment (36.6%) and the price of products being too low (34.1%). The difficulty related to prospecting, the regularization of the activity and security each account for a little less than 10% of the problems. Thus, the lack of financing and other problems was mentioned by 5% of respondents (Chart 10).

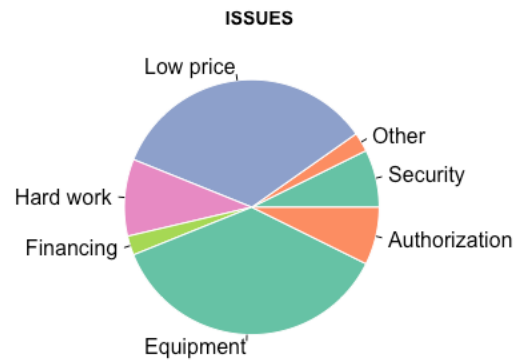


Chart 10. Problems encountered in the exploitation of beryl

In addition, "non-mining households" were asked about the impact of beryl mining on their activity. Thus, 50 households (76.92%) stated that there is a positive impact, 11 (16.92%) responded that they perceive no impact and 4 (0.61%) stated that there is a negative impact.

4. DISCUSSION

In the education factor, the number of people who have attended school is higher among non-mining households. This can be explained by the fact that work in the beryl deposits of the study area does not require a high level of education. Indeed, work in the mines is done in an artisanal manner. Apart from this, although non-mining households tend to send their children to school at a later age (mean = 5.74) compared to mining households (mean = 5.54), the gap is not very large. In addition, the study shows that there are more schooled children from non-mining households than children from mining households. This situation is probably due to the lack of awareness about the role of education in the cognitive development of the individual. Moreover, as there are fewer individuals who have attended school among mining households, they are less willing to send their children to school. Generally speaking, children do not attend school, particularly because they are busy with household chores (Chart 3). However, this situation weighs more heavily on mining households. In other words, the beryl mining activity does not allow these households to send their children to school. This situation is not unique to the case of the north of the Ankazone district ; several authors have shown that mining activity has an impact on school dropout in developing countries [7], [8]. Furthermore, a compilation of 43 articles on the causes of early school leaving in different regions of Africa and Asia shows that the most common causes of early school leaving are lack of income, parents' education level and employment status, living in a single-parent household, being an illegitimate child, age, region of residence and academic performance [9]. It can be said that, from an educational perspective, non-mining households have a higher socioeconomic level.

Access to water is an important socioeconomic factor. Indeed, a study has shown that improving water supply, sanitation and hygiene is the most cost-effective way to prevent most of the devastating burden of water-related diseases, and it also plays a direct role in ensuring the right to an adequate standard of living and increasing the standard of living of the population [10]. All non-mining households surveyed benefit from a functional water source throughout the year compared to 90% of mining households. As water is a basic need, this lack of access is due to insufficient financial resources or willingness to address this problem. Furthermore, there is a significant difference in the number of weekly trips taken by the two groups to fetch water from the source (19.84 trips for mining households versus 13.16 trips for non-mining households). Efficiency in water transport can improve the time taken to fetch water. Furthermore, a socioeconomic study on inequalities in access to drinking water conducted in South Africa [11] showed that there is a correlation between socioeconomic level and water access conditions such as the use or not of pipes, the time taken to fetch water, the distance etc. Therefore, considering access to water, it can be concluded that non-mining households have a higher socioeconomic level.

Wage earners from mining households work in the primary sector such as agriculture while those from non-mining households work in the service sector such as education and trade (Chart 5). Furthermore, more than half of

the individuals (54%) are in the basic worker category. However, there are more individuals from mining households in this category (84%) than individuals from non-mining households (31%). This difference is probably due to the differences in education level mentioned in section. Furthermore, though the difference in average annual income between wage earners from mining and non-mining households is not significant ($p = 0.0808$), we considered interesting to mention this difference since p is not very far from the significance level of 0.05. The results show that non-miners earn more than double the wages of miners. This is probably due to the lack of qualification, which is attributable to the lack of education among the miners. As for liberal work, the field of activity is dominated by agriculture/livestock (82%), followed by extraction (10%). Thus, 90% of non-mining households and 66% of mining households practice agriculture or livestock. 27% of mining households are in the field of extraction (other than beryl), and only 1% of non-mining households (

Chart 6). These differences are explained by the fact that the beryl vein is hard, and therefore requires a lot of working time. Thus, mining households are forced to devote themselves entirely to it, by subcontracting or abandoning agricultural work. They maximize their income by diversifying the mining products they exploit. In addition, non-mining households appear to work more days (mean = 19.31) than mining households (mean = 18.80). Indeed, mining work does not extend over a year. Typically, miners do not work during the rainy season, i.e. from November to April, because the galleries are fragile at this time of year. The average annual income of the households surveyed is higher for non-operators. However, as the difference is not significant ($p = 0.509$), no conclusion can be drawn. In short, salaried work reflects a higher socioeconomic level among non-mining households. For independent work, no conclusion can be drawn based on the comparison between the two groups. Nevertheless, the financial impact of beryl mining, only at the level of mining households, is discussed in the section concerning information on beryl mining.

The inventory of some goods and other structures existing in the household shows that the possession of a radio and a watch is more frequent in non-mining households while the possession of a bicycle is more frequent in mining households (Chart 7). A possible explanation is that the work equipment for beryl extraction is heavier (Angady, crowbar, hammer) compared to that of agriculture. In addition, the deposits are often located in remote areas, and it is necessary to bring food, therefore, miners use light means of transport such as the bicycles. The possession of a radio reflects the openness of non-mining households to learning and to the world around them. This trend confirms the observations on Education. In addition, the possession of a watch reveals that they value their time, and this is explained by the fact that these households work more in the service sector such as education or trade. However, it is difficult to conclude on the socioeconomic level of the two groups based on the possession of material goods. Indeed, one must consider not only the financial value of the good, but also the socioeconomic impact that this good could generate. Indeed, in our case, a bicycle is more valuable than a watch and a radio, but the socioeconomic impacts of owning these goods deserve further investigation. However, the study also showed that there are more non-mining households with electricity than mining households. Electricity, especially clean energy, benefits women by improving their capabilities, health, education and income, as well as other benefits [12]. Based on these considerations, it can then be concluded that non-mining households have a better socioeconomic condition.

mining products in the area are mainly beryl and columbite, and miners operate without external funding. For the majority of households, this activity is seen as a secondary source of income (Chart 8) and constitutes on average 25% of the family budget during the 12-month period preceding the survey. In addition, the profit generated by mining is generally used for household expenses (Chart 9). The main problems encountered by miners are the lack of equipment, the purchase price of products considered unreasonable and the difficulty of prospecting (Chart 10). Nevertheless, approximately 77% of non-mining households have a positive perception of the impact of mining on their daily lives. They cite in particular an improvement in their commercial activity. These observations show that beryl mining is still underdeveloped in our study area. This is due, on the one hand, to a lack of financial education, and on the other hand, to the absence of a prospecting guide. Indeed, the lack of financing and materials; and the use of the profit generated entirely in daily expenses form a vicious circle. Financial education based on savings and investment could reverse the trend to form a virtuous circle. Training on marketing and prospecting of deposits is also necessary. In any case, these results show that the socioeconomic impact of beryl mining on mining households is less and that it is non-mining households that benefit from it, in the long term.

A study on the socioeconomic impacts of artisanal and small-scale mining was conducted in 2015 by an independent international research group (IIED) in three African countries: Ghana [13], Tanzania [14] and Madagascar [15]. It would appear that the three countries were exposed to the same challenges, such as poverty of

the population, limited access to markets, finance and investments; inadequate equipment and data and a complex regulatory environment. Actions were then taken to address these issues such as organizing dialogues within mining areas between representatives of the state, civil society and operators. In addition, local officials were trained in financial administration related to mines. In addition, miners were trained in basic gemmology and sensitized on the benefits of organizing themselves into associations. In 2018, another socioeconomic study on Artisanal Small-Scale Mining was conducted in Ghana, but coupled with a water quality study [16]. It appeared that artisanal and small-scale mining has proven to be an important source of income for many people living in rural areas with few other employment opportunities in Ghana. However, adverse effects such as school dropout, child labor, early pregnancy, and environmental degradation have been observed. In the case of Madagascar, the number of people working in the small-scale artisanal mining sector is about 1 million, and the major problem is the dependence of small-scale miners on an unregulated market dictated by external interests. This national problem seems to be intact, as it is confirmed by 34.14% of the miners in our study area (Chart 10). In addition, this situation is aggravated by the insecurity that reigns in most of the areas rich in mineral resources in Madagascar such as Ankazobe. Although one of the objectives of Law 2023-007 on the overhaul of the mining code is the professionalization of artisanal miners, much remains to be done. The reason that would explain these differences in results is that in Ghana, there is a joint effort by the State, civil society and foreign partners in the promotion of small-scale artisanal mining. The number of individuals dependent on this sector is estimated at 4.4 million. Organized into associations, they receive technical and administrative training. In addition, the state has decided to issue a permit for small-scale artisanal operations, and to make them a national priority [13].

The main factor limiting our study is the security aspect. Indeed, shortly before our investigation work, the population of this area had been the target of kidnappings and other acts of banditry. This situation made the investigation difficult because some families are reluctant to provide the real amount of their earnings from beryl mining. Indeed, they fear that the investigators will give information to the bandits, and that this could put their lives in danger. In addition, our movements in this area were limited, because we could not leave one fokontany to join another after a certain time. Apart from that, we could not stay in the field for more than a week, at the risk of being noticed by malicious people. Furthermore, although the commune of Andranomiely is indicated for this impact study of beryl mining, due to its proximity to the Vohambohitra granite massif, the ideal would be to extend the study to all the communes in the northern zone of the Ankazobe District. These are the communes "sitting" on the geological formation of the Andriamena unit.

5. CONCLUSION

This study compared the socioeconomic parameters of beryl mining households and non-mining households. 81 parameters grouped into seven socioeconomic factors including socio-cultural aspect, education, eating habits, health, housing conditions, work and standard of living were studied. There are significant differences between eleven parameters belonging to the factors: education, housing conditions, work and standard of living. Among these parameters, there are eight where the socioeconomic level of non-miners is higher and three where no conclusion can be drawn. In addition, questions relating to the beryl mining activity revealed that it is still underdeveloped and contributes little to the household economy. In addition, the non-miners, who are more educated, benefit more from beryl mining. Based on these considerations, it can be concluded, within the limits of our study, that beryl mining has no socioeconomic impact on the inhabitants of our study area. The education factor seems to play a major role in improving the situation. Indeed, according to the results, the main difficulties of the miners are linked to the lack of training in the administrative, financial and technical fields. In addition, this study can be improved by extending the survey to all the municipalities in the northern zone of the Ankazobe District. With more time and resources, and in an adequate security environment, the results could be more refined and new perspectives could emerge.

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