*ORIGINAL PAPER*

# RISK MINING ACTIVITIES ON ENVIRONMENT AND SOCIO-ECONOMIC EVOLUTION OF ARIES RIVER UPPER BASIN AREA USING SPPS STATISTICAL ANALYSIS

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***Abstract.*** *This research has as main objective the identification of the potential risks that the mining activity in the upper basin of the Arieş River has on the economic development of this area. The method chosen for this research was the Survey-Based Inquiry in order to know the views of the inhabitants of this area on how economic development and economic welfare was or is affected by mining activity and mine closure.*

***Keywords:*** *chi square test, information analysis software instruments, sample, mining.*

## 1. INTRODUCTION

The geographic area where the questionnaires were applied is located in the Arieş River Basin, which overlaps the historical region known as the *Moţilor Country*. The area is an intensely anthropized one, with a relatively high population density of approximatively 45 inhabitants/km$^2$ (given that the average population density in the mountain area is 25 places/km$^2$) and with a large presence of human settlements. The geological evolution of the region favored the formation of non-ferrous ore resources such as the complex polymethal sulphides from Roşia Poieni and the gold mines of Roşia Montană. Subsoil resources, mainly gold, have been exploited since the Dacian era, and the so-called gold civilization has developed into the area. The polymetallic sulphide resources have begun to be exploited at Roşia Poieni after World War II and their processing was carried out in the town of Zlatna.

After 1990, with the change of the Romanian political regime, the entire activity of exploitation and processing of the mining resources registered a clear decline, culminating in the closure of the exploitation and, implicitly, of the processing plants. Under these circumstances, the interest of international corporations for gold-footer resources, such as Gold Corporation, has also been shown to have caused some discontent among the local population due to the same socio-economic considerations. Mining activity has a strong impact on the environment due to non-certified tailings dumps that pollute the area (cyanide processing has been reported for gold exploitation). Influence on environmental factors begins with the activity of prospering and exploiting the deposits and continues and intensifies with

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the development of productive activities [1]. For the assessment of mining investments it is very important to know the risks associated with the exploitation and exploration of minerals. Mining involves high risks because it requires large capital investment, and for capitalization and depreciation, it is often necessary for long periods of time compared to other areas of activity. It should be emphasized that the liquidation of mining activities will not lead to total elimination but only to the mitigation of the negative consequences on the environment, these regions continue to experience many heavy metal pollution problems, imposing severe restrictions on land use, requiring tremendous financial efforts in mine water treatment, mine preservation and ecology of tailings and waste dumps. On the other hand, the disposal of the mining work force requires finding alternative solutions for its incorporation in other activities, based mainly on the capitalization of local economic resources to ensure sustainable development [2]. To this end, evaluations and decisions are well grounded in advance by an economic assessment and analysis.[3] All these aspects contributed to the present study with the participation of a representative number of inhabitants (160 respondents) from 2 cities (Câmpeni and Abrud) and 19 rural localities (Albac, Roşia Montană, Baia de Arieş, Bistra, Avram Iancu, Scărişoara, Vidra, Abrud, Horea, Vadu Moţilor, Arieşeni, Ponore, Gârda, Lăzăşti, Bucium, Lupşa, Gârda de Sus, Sohodol, Poiana Vadului) covering all age groups and social categories. It is worth mentioning that the respondents were quite reluctant to participate in the survey due to the fact that some press reports and articles (especially the people from Roşia Montană) had been made beforehand, which had a negative impact on the perception of the population local issues in the matter. This has led to a number of negative socio-economic changes in the area, with repercussions on the general state of human society (lack of jobs, massive migration of the young population, lack of investment and infrastructure, accelerated population aging, danger of disappearance very small rural settlements of the "grove" type, etc.).

## 2. ELEMENTS OF THE SURVEY-BASED INQUIRY

Exploring the risks of mining activities on the economic development of the Arieş River Upper Basin Area has as its primary objective to identify the potential risks that the mining activity in the upper Arieş River basin has on the economic development of this area. Activities associated with the mining industry, whether exploitation itself or mine closure, are a major source of risk for both the environment and population [4]. The method chosen to carry out this research was the survey-based inquiry (questionnaire) in order to know the views of the inhabitants of this area on how economic development and economic welfare were or are affected by mining and mine closure. The questionnaire consists of 14 closed-ended questions and 3 open-answer questions. The questionnaire also included items with precoded responses, structured on a 5-step Likert scale, preconfigured as follows: none at all (1), to a small extent (2), neither small nor large (3) to a great extent (4) and to a very great extent (5). To determine the sample size for random sampling, it was taken into account the accuracy level of the estimate given by the error and the confidence interval. It was considered an admitted error level of ± 5% and a confidence level of 95%. According to the distribution table z these values correspond to 1.96. Due to the lack of information on p (the percentage of „YES" respondents), it will be considered as 50%. The size of the sample in percent was determined by the following formula [5]:

$$n = \frac{z^2 \times p \times q}{E^2} \ , q = 1 - p$$

where, $z^2$ - the square of the z-factor corresponding to the confidence level; p - estimate the percentage in case of success; q - estimating the percentage in case of failure; E - the permissible error level expressed as a percentage; n - sample size.

Thus, results: $n = (1.96)^2 * 50 * 50 / 5^2$, n = 384.

Since this research is for teaching purposes and the field data collection was carried out with the help of a team of interviewers from the Geography study program at Valahia University from Târgovişte, the size of the sample will not be respected. The sample used consists of 160 subjects. Under these conditions, the error will be calculated according to the formula [6]:

$$E = z\sqrt{\frac{p*q}{n}}$$

E = 1,96 * √ (50 * 50 / 160);

E = +/- 7,7%

Questionnaire was sent to a total of 160 people whose geography distribution is presented in Fig.1.

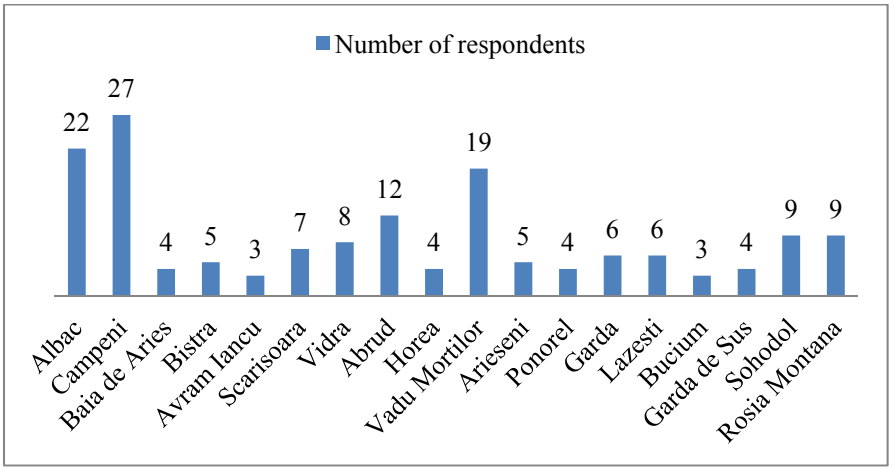


**Figure. 1. Graphical representation of geographic distribution.**

From the previous graph we can see a balanced distribution of the respondents from the localities targeted by the study. As far as the profile of respondents is concerned, they can be classified according to their age, gender and education level (Table 1).

**Table 1. Cross-section analysis of items: age, gender, level of education.**

| Gender/ Suplimentary Information | | | Age | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | under 20 | between 21-30 | between 31-40 | between 41-50 | between 51-60 | Over 60 | |
| M | Education Level | Primary | 1 | 0 | 1 | 4 | 1 | 1 | **8** |
| | | Secondary | 1 | 1 | 3 | 4 | 4 | 2 | **15** |
| | | High-scool | **0** | **4** | **14** | **15** | **15** | **3** | **51** |
| | | Universitary | 0 | 2 | 7 | 4 | 1 | 1 | **15** |
| | | Post-Universitary | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| | **Total** | | 2 | 7 | 25 | 28 | 21 | 7 | **90** |
| F | Education Level | Primary | 0 | 0 | 0 | 0 | 1 | 1 | **2** |
| | | Secondary | 1 | 0 | 2 | 2 | 3 | 0 | **8** |
| | | High-scool | 1 | 2 | 9 | 9 | 2 | 3 | **26** |
| | | Universitary | **1** | **3** | **13** | **12** | **1** | **0** | **30** |
| | | Post-Universitary | 0 | 0 | 2 | 2 | 0 | 0 | **4** |
| | **Total** | | 3 | 5 | 26 | 25 | 7 | 4 | **70** |

**Table 2. Cross-section analysis of items: age, gender, level of education (*continued*).**

| Gender/ Suplimentary Information | | | Age | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | under 20 | between 21-30 | between 31-40 | between 41-50 | between 51-60 | Over 60 | |
| Total | Education Level | Primary | 1 | 0 | 1 | 4 | 2 | 2 | **10** |
| | | Secondary | 2 | 1 | 5 | 6 | 7 | 2 | **23** |
| | | High-scool | 1 | 6 | 23 | 24 | 17 | 6 | **77** |
| | | Universitary | 1 | 5 | 20 | 16 | 2 | 1 | **45** |
| | | Post-Universitary | 0 | 0 | 2 | 3 | 0 | 0 | **5** |
| | **Total** | | **5** | **12** | **51** | **53** | **28** | **11** | **160** |

From the cross-analysis of the three items through the contingency table, it is noted that among the male respondents predominantly is the level of high school education, and among female respondents predominantly is the level of university education.

## 3. SPPS STATISTICAL ANALYSIS

In the study, statistical analysis and graphical representations were carried out with the help of the specialized application SPSS (Statistical Package for Social Sciences). The SPSS method **[7]** is one of the most used in statistical analysis of data. The first version appeared in 1968 and has now reached version 25 and the scope of application has expanded from version to version, along with its operating mode and facilities. The program is used in various fields ranging from marketing, experimental research, education to health, insurance industry, etc. The present study aims to respond to the following research assumptions:

Q1. There is an association between personal experience or the experience of close persons and mining.

Q2. There is a correlation between the actions of a future program of exploitation of mineral resources and the need for such a program

Q3. There are no gender gaps in activities that could support the economic welfare of the area under the closure of mines.

Q4. There are differences of opinion as to the factors that could prevent the mineral resources being exploited in the area.

From statistical reasons hypothesis to be verified (H0) is usually the hypothesis of "equality", i.e. of non additional effect of tested treatment [8]. Thus, the chosen sample consists of people belonging to the same population, which leads to unitary results and confidence in the results of the tests.

### *3.1. RESULTS*

Q1: 52% (84/160) of respondents reported that did not work or did not have people who worked in mining and only 40% (64/160) worked or knew people who have worked in the field of mining. The cross-analysis of the two values highlights that a small percentage (34%, meaning 55/160) of the respondents worked in the gold / copper mining activities.

**Table 3. Crosstable analysis of items related to questions 3 and 4.**

| | **You've worked or had people who worked in the mining industry** | | | |
|---|---|---|---|---|
| **Exploitation type** | **Yes** | **No** | **Don't know** | **Grand Total** |
| No answer | 9 | 73 | 9 | 91 |
| Gold | 29 | 5 | 2 | 36 |
| Copper | 16 | 3 | 1 | 20 |
| Both | 10 | 3 | - | 13 |
| **Grand Total** | **64** | **84** | **12** | **160** |

Q2: A detailed analysis of the answers continues with a contingency table highlighting the actions envisaged by a future program for the exploitation of mineral resources compared to the necessity of a program for the exploitation of the mineral resources. This analysis highlights the fact that respondents consider "to a great extent" the necessity of a mining resource exploitation program which should target the three options in the questionnaire (mine reopening, local and regional mining exploitation, exploitation and creation of a base for transportation and processing of ores).

**Table 4. Crosstable analysis of items related to questions 7 and 8.**

| | **A future program to harness mineral resources should target** | | | |
|---|---|---|---|---|
| To what extent would a mining resource use program be necessary | **Mine reopening** | **Local and regional mining exploitation** | **Exploitation and creation of a mineral transport and processing base** | Grand Total |
| None at all | 2 | 5 | - | 7 |
| To a small extent | 4 | 11 | 10 | 25 |
| Neither small nor large | | 1 | - | 1 |
| To a great extent | 16 | 20 | 7 | 43 |
| Very great extent | 28 | 38 | 18 | 84 |
| **Grand Total** | **50** | **75** | **35** | **160** |

The analysis of the correlation of the two qualitative variables reveals a positive correlation (0.076) doubled by a confidence coefficient of 0.342 which demonstrates that the directions of action targeted by a possible program for exploiting the mineral resources are highly appreciated by the respondents.

**Table 5. Spearman's rank index correlation for questions 7 and 8.**

| | | | To what extent do you consider that a mining resource recovery program for your area would be necessary | A future program to harness mineral resources should target |
|---|---|---|---|---|
| Spearman's | To what extent do you consider that a mining resource recovery program for your area would be necessary | Correlation Coefficient | 1.000 | .076 |
| | | Sig. (2-tailed) | . | .342 |
| | | N | 160 | 160 |
| | A future program to harness mineral resources should target | Correlation Coefficient | .076 | 1.000 |
| | | Sig. (2-tailed) | .342 | . |
| | | N | 160 | 160 |

Q3: Contingency tables [9] applied to multiple-choice questions that wanted to highlight the opinion on the economic welfare of the area and the gender of the respondents. In this context, the following hypothesis was formulated:

H0: There are no differences between women and men in terms of economic welfare of the area under the conditions of mine closure.
H1: There are differences between women and men in terms of economic welfare of the area under the conditions of mine closure:
$H_0$: $O_{ij} = E_{ij}$
$H_1$: $O_{ij} \neq E_{ij}$
Absolute frequencies observed and absolute frequencies expected are shown in the table below:

**Table 6. Crosstable analysis of items related to questions 6 and 13.**

| | | Given the closure of mines, what activities could support economic well-being | | |
|---|---|---|---|---|
| | | I6_ agricultural_activity | I6_tourism | I6_others |
| | | Count | Count | Count |
| Gender | Male | 67 | 62 | 1 |
| | Female | 43 | 53 | 6 |

There are differences between observed frequencies and expected frequencies in all subgroups formed by crossing the two variables.

**Table 7. Chi-Square test applied to independent samples related to questions 6 and 13.**

| | | Given the closure of mines, what activities could support economic well-being |
|---|---|---|
| Gender | Chi-square | 9.899 |
| | df | 3 |
| | Sig. | .019* |
| *. The Chi-square statistic is significant at the .05 level. | | |

As a result of the statistical test, the null hypothesis (H0) according to which "*There are no differences between men and women regarding the economic welfare of the area under the conditions of mine closure*" is invalidated.

Q4: Another possibility to apply a test to the nominal data in the questionnaire is to apply the chi-square test [10] to only one variable. The $\chi^2$ (chi-square) association test is used when we want to test the relationship between two variables, both measured on a category scale. The $\chi^2$ (chi-square) test calculates the difference between the observed and expected frequencies for each of the two crossover table cells of the two variables. If the differences are null, then the two variables are independent, and if the differences are high then the result in the $\chi^2$ test tends to be statistically significant and therefore we could say "*something about the degree of association of the two variables*".

In this example, we want to see if the respondents have formed an opinion on the factors that could prevent the exploitation of mining resources in the area.

The result of applying the test is illustrated in Tables 7 and 8.

**Table 8. Descriptive analysis of the answers to question 9**

| **What factors could prevent mining resources from being exploited in the area** | | | |
|---|---|---|---|
| | Observed N | Expected N | Residual |
| the natural setting | 26 | 26.7 | -.7 |
| the state of the transport infrastructure | 51 | 26.7 | 24.3 |
| competition from other operating centers | 9 | 26.7 | -17.7 |
| indirect costs | 25 | 26.7 | -1.7 |
| inefficient investments in mining | 33 | 26.7 | 6.3 |
| there would be no impediment | 16 | 26.7 | -10.7 |
| Total | 160 | | |

**Table 9. Chi-Square test applied to question 9**

| | What factors could prevent mining resources from being exploited in the area |
|---|---|
| Chi-Square | 39.800[a] |
| df | 5 |
| Asymp. Sig. | .000 |
| a. 0 cells (0.0%) have expected frequencies less than 5. | |
| b. The minimum expected cell frequency is 26.7. | |

The test result reveals that there is a difference of opinion among the respondents as to the factors that could prevent the exploitation of mining resources in the area under analysis. Thus, in the opinion of the respondents, the factor with the highest weight that could prevent the mining resources from being used in the area is *the state of the transport infrastructure (32%)*. As well, *the inefficient investments in mining* is an important factor in the process of valorification of the mining resources thus obtaining a 20% share in the opinion of the respondents.

## 4. CONCLUSIONS

Applying statistical tests to data collected through questionnaires is a safe way to characterize the statistical population.

Over the past 20 years, our country has undergone extensive economic restructuring processes, such as diminishing the production, the operational closure of most mines, activities that have significant consequences for the country's population. The mining activities carried out in the upper basin of the Arieş River have affected this territory from a natural, economic and social point of view.

This paper debated the main problems identified as a result of mining activities in this area. Thus it was observed that the main effects of mine closures in the area are: job losses, population migration in other areas of the country but also to other EU countries, population aging in the area, as well as lower living standards of the population. In addition to these economic and social issues, there has also been a strong impact on the environment. Thus, in the case of mining, uncleaned waste dumps remained, and they continued to pollute, and for the exploitation of gold, cyanide was processed, the harmful effects of which are widely debated at national level.

In order to reconsider and involve the authorities in the economic development of the area in our country, the Mining Strategy of Romania for the period 2017-2035 was adopted, whose main objective is to promote the policies of development and stimulation of a viable system in the operation and management of mineral resources.

From the cross-sectional analysis of the respondents' answers, we can point out that most of the participants in the questionnaire foresee some solutions regarding the economic and social revitalization of the area, provided the reopening of mining activities, the local and regional mining exploitation, transport and processing of minerals, as well as the diversification of the economic activities of the area through the promotion of tourism and the development of agricultural activities, all with the involvement of the authorities through the implementation of viable projects that include infrastructure and involvement of the existing human resources.

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