

Article

## A MCDM Analysis of the Roşia Montană Gold Mining Project

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**Abstract:** The need and estimated utility for a structured analysis of the Roşia Montană gold exploitation project have been palpable in the Romanian public sphere during the last 15 years and there is a vast amount of conflicting information and opinions on the benefits and risks involved. This article provides a comprehensive decision analysis of the Roşia Montană project. Over 100 documents from the past years have been gathered regarding the Roşia Montană mining project, which cover the main official, formal and less formal documents covering the case and produced by a wide range of stakeholders. These were then analyzed while designing a multi-criteria tree including the relevant perspectives under which the most commonly discussed four alternatives were analyzed. The result of this can be translated into a valuable recommendation for the mining company and for the political decision-makers. If these stakeholders want the continuation of the project and its acceptance by civil society, the key challenge is to increase the transparency of the process and improve the credibility and legal aspects; if these aspects cannot be met, the decision-makers need to pay attention to the alternatives available for a sustainable development in the area.

**Keywords:** multi-criteria decision analysis; sustainable socio-economic development; gold mining; cyanide-based exploitations; environmental sustainability; mining activities pollution; multi-stakeholder analysis; Roșia Montană mining; mono-industrial regions

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## 1. Introduction

The Roșia Montană project refers to the plans of exploiting and processing gold and silver minerals from the Roșia Montană area in the Apuseni Mountains, Romania, through open-pit mining and cyanide leaching. The project was proposed to the Romanian Government by the exploitation license holder, S.C. Roșia Montană Gold Corporation S.A. Romanian policy makers are still facing visible setbacks in making a decision regarding the exploitation, while the company is currently pushing for a resolution through “positive dialogue with decision makers” [1]. The main shareholders of the company are the state-owned mining company Comania Națională a Cuprului, Aurului și Fierului “MINVEST” S.A. Deva (former Regia Autonomă a Cuprului Deva, until 1998), with 19.31%, and Gabriel Resources Ltd. based in Canada, with 80.69% shares. Mainly due to a failure to comply with the Romanian legislation on environment issues, the company has not obtained all the permits required to begin exploitation. Ever since the exploitation license was granted in 1999 to the National Copper, Gold and Iron Company “MINVEST” S.A. Deva, and was further transferred to the newly created S.C. Roșia Montană Gold Corporation S.A. (to be referred to as RMGC throughout the paper) in 2000, the project has been promoted by the company through institutional lobby and extensive PR campaigns in the media for its potential economic, social and cultural benefits for the local community and for the Romanian state. After a series of renegotiations of the unprofitable conditions stipulated in the initial license agreement, the Government of Romania estimates a direct benefit of nearly 5.2 billion USD, which includes gold and silver royalties, dividends for the Romanian state as a shareholder, income tax revenues, and social contributions for its employees. However, the environmental risks of cyanide-based explorations, the threat posed to the cultural heritage and to other industries in the area, the forced expropriations, suspicions of corruption and overall lack of transparency of the agreements made citizens and non-governmental organizations mobilize against the project. Legal actions have been taken by several opposing NGOs questioning a number of environmental and archaeological permits given by county institutions and ministries; furthermore, initiatives aiming to raise awareness and civic participation have been taking place both in Roșia Montană and throughout the country, where public debates, art exhibitions and investigations were conducted by universities and research institutes, activists, journalists, and artists. The widespread protests during the fall of 2013 represented the peak of citizen opposition to the project. They were triggered by a draft mining bill advanced by Victor Ponta, Prime-Minister of Romania at the time, and the ruling coalition- the Social-Liberal Union, which would have eased out the legal requirements for the project to be implemented. Due to public pressure, valuable data and previously classified material, such as the 1999 exploitation license, surfaced online and became increasingly visible and discussed.

Nonetheless, the opinions among citizens remained divided. A national referendum was suggested by Traian Băsescu, then President of Romania, but the proposal was rejected by the Parliament. An opinion

poll commanded by a news publication [2] and conducted in September 2013 showed that of the 95% of Romanians that followed the reports on the subject, 52% respondents stated that only through the continuation of the Roşia Montană exploitation could safe jobs be secured for the local community, while 35% believed that the area could develop through tourism, if the project was rejected. The controversy of the project has led the Romanian officials to treat it with caution in the electoral campaigns held in the last decade, their discourse oscillating between reinforcing Romania's need for economic benefits out of its natural resources and stating their disapproval of the cyanide exploitation.

Despite the social, economic and environmental stakes involved in this case, as well as its constant presence on the public and political agenda, we could not find publicly available any structured analyses or weighing of the data on the Roşia Montană project or on the alternatives of development provided by the stakeholders; this lack of a systematic decision-making process, highlighted by the politicization of the decision-making regarding the exploitation, led to repeated delays lasting many years, while the area discussed remained blocked for other economic activities.

The present study, supported by the Stockholm University and by Median Research Center—an independent think-tank based in Bucharest, represents a first attempt to systematize the arguments and concerns of various stakeholders. The authors propose multi-criteria decision-making analysis as the most appropriate methodology for a participative and inclusive assessment of the proposed alternatives of development in the Roşia Montană area, to serve the decision makers both in the present case, and in similar current or future decision processes dealing with complex data.

Below, we will firstly present a short history of the decision process and context in this case, followed by a presentation of the main stakeholders. Further on, we will discuss the multi-criteria decision analysis (referred to as MCDA throughout the paper)—method suitable for this particular case, and the background research, which led to the defined criteria. Lastly, we discuss our results as well as conduct a sensitivity analysis of various scenarios and different weights assigned according to the priorities of stakeholders, as identified in the publicly available documentation and statements.

## 2. The Decision-Making Context

In 2001–2002, RMGC released the first feasibility study for the Roşia Montană exploitation, after four years of geological research and geo-technical drillings in the area; the proposal for exploitation consisted in processing 20 million tons of minerals annually in four open pits from massifs Cetate, Cânic, Jig-Vaidoia and Orlea, with “average contents of 1.46 g/t Au and 6.9 g/t Ag, representing 10.1 million ounces (314 t) Au and 47.6 million ounces (1480 t) Ag—in situ metals” [3]. The technological process would involve blasting the pits, cyanide leaching of the ore in a process plant, and releasing the neutralized sodium cyanide in a tailings management facility, behind a dam made of rock. The area licensed for the company measured 2388 ha, out of which 1346 ha were destined for exploitation and 300 ha for the tailings management facility and dam. The exploitation implied the relocation and displacement of 960 families from three villages—Roşia Montană, Corna and Gura Cornei—as well as of houses and cemeteries, the destruction of four massifs and natural landscapes, buildings and churches [4]. A plan for displacement and relocation was open for public and private debates between the representatives of RMGC and the impacted local families. The project was set out to last from construction to operation and closing phase approximately 20 years.

The first attempt to assess the risks and benefits of the submitted project was in 2003, when a parliamentary Special Committee was appointed to “formulate a unitary viewpoint concerning the economical, social, cultural and environmental aspects implied by the project” [5]. Two months later, the Committee published a report [6] that reinforced the economical benefits for the Romanian state, estimated at 583 million USD, and assured the wider public that no legislation breaches were observed in the license agreement or in the activity of the company up to that point. Despite the positive note of the report and its favorable reception by the local press, two members of the Committee released separate statements, drawing attention to the insufficient data gathered in a short timespan.

Meanwhile, diplomatic meetings between the Romanian and the Hungarian prime-ministers and ministries of environment had the project on their agenda, the Hungarian Ministry of Environment opposing the project and advising the Romanian side to ask for an impact assessment study. Between 2002 and 2006, the company conducted feasibility studies, with the research and consulting services of national and international experts, and released the Environmental Impact Assessment Report (EIA) for the Roșia Montană Project [7]. The documentation was submitted to the Ministry of Environment and opened for public debate. During these procedures, the company purchased properties in the villages to be affected by the implementation of the project and further relocated 125 families to a newly built neighbourhood in the nearby city Alba-Iulia. RMGC took part in 16 public consultations in Romania and Hungary and received 5600 questions from NGOs, researchers and citizens, to which the company responded on the website of the Ministry of Environment.

In 2009, the Ministry of Economy included the project on the agenda of the newly formed government, announcing his intent to accelerate the implementation of the exploitation. The Ministries of Culture and of Environment declared that, given the lack of financial guarantees and of more extensive research, they would not issue the necessary permits. In 2011, conflicting opinions emerged: while the Prime-minister believed that the agreements made between the Romanian state and the company were not in the best interest of the state, the President maintained that the project needed to be done only after a renegotiation of the state benefits and that the government should have the courage to take on the responsibility of giving it a green light. Opposition parties launched their vision for a sustainable development, which included mandatory measures for the Roșia Montană case: declassifying the agreements, independent cost-benefit analyses, identifying the most appropriate technology for the exploitation, taking into consideration the European Parliament anti-cyanide resolution, respecting the villagers’ right to property, assessing the alternatives for the region’s development. In 2012, the newly appointed Prime-minister mentioned three conditions for moving forward with the project: environmental safety guarantees, renegotiating the state shares within RMGC and putting an end to the lobby influencing the political decision. The Ministry of Economy announced the local community that the project is set to start and that a favorable decision would be made by the end of the year. Along with the Parliamentary elections, the Alba county organized a referendum asking the citizens of 35 villages and towns whether they agreed with the company project or not. While 62.45% of the voters said “yes” and 35% voted against the project, the referendum failed to be validated due to a low turnout, with only 43.20% of citizens with a right to vote casting the ballot.

In 2013, there was a turning point in the decisional process, when an acceleration inclining to meet the needs of the investing company was noticeable at governmental level. Following a legislative proposal of a new mining bill and renegotiations of the initial agreement between the Romanian

government and the investors, by which the state shares were raised from 19.31% to 25%, and the royalties from 4% to 6%, previously withheld documentation was made publicly available; a number of relevant documents were made accessible either on the ministries' websites, or through journalistic investigations, making possible a more extensive analysis of the pro and con arguments, considering the socio-economic, environmental and cultural implications of both giving a green light to the project and of rejecting it [8]. One of the main issues of concern stirring negative reactions was the initial illegality surrounding the concession of exploitation rights. An ongoing Special Parliamentary Committee [9] was appointed to hear out the stakeholders' viewpoints and to gather all relevant data leading up to advisory conclusions to be used in the decisional process. Following the hearings, the Committee issued a final report [10] and the draft bill was rejected in Parliament. The final report issued by the Special Committee in November 2013 includes arguments in support of or opposing the project, stated by the main issuers of reports, laws and permits for the Roşia Montană project, serving as a good starting point for a multi-criteria decision analysis that takes into consideration the points of view of different stakeholders. This is particularly relevant to assess since the National Agency for Mineral Resources announced future auctions for other areas containing gold and silver deposits, thus the decision taken in the Roşia Montană case could be a precedent for future negotiations and developments in other mining projects in Romania.

The final decision on the development of the exploitation project by the investing company in Roşia Montană, as well as on weighing it against other development alternatives for this mono-industrial area, belongs to the Romanian Government, through the Ministry of Environment, Waters and Forests, the Ministry of Economy and the Ministry of Culture. Also, given that the Romanian Parliament has been discussing the need for an updated mining law based on the current needs and objectives of the mining sector, the negotiations and decisional process in the case of Roşia Montană will serve as a test bed for future exploitations.

### 3. The Stakeholders

Roşia Montană Gold Corporation S.A. is a joint venture between the main shareholder Gabriel Resources Limited (80.69% shares) and the Romanian state-owned company Minvest S.A. According to the Annual Information Form of Gabriel Resources Ltd. for the year 2013, the company is registered in Yukon, Canada, and operates through its subsidiaries in London, Bucharest, Roşia Montană and Brussels. The company presents itself as having a single focus, namely "permitting and developing its world class Roşia Montană gold and silver project" [11]. Besides the exploitation license for the Roşia Montană gold and silver deposits, the company also owns, through its Romanian subsidiary, an exploration concession for gold, silver and copper deposits in Bucium, within the same county.

The documentation we consulted issued by RMGC includes the Environmental Impact Assessment report, infographics, maps and other summaries of the project available on their website, as well as their hearings in front of the 2013 Special Committee. Also, in order to have more insight on the company's project and on the impacted area of the eventual exploitation, we went to Roşia Montană and were able to speak to the spokesperson of the company, Mr. Cătălin Hosu, who presented the sites in focus and explained the technological process implied by the project, as well as the investments made in the preservation of cultural heritage and in a pilot project of acid waters treatment [12]. The conversation confirmed the information put forward by RMGC in their official data, but it also failed to clarify the

question marks regarding the lack of financial guarantees, formally required for the operator of a waste facility [13], the risks associated with setting the tailings management facility on Corna Valley (which is likely to contain geological faults, according to the former director of the National Institute of Geology [14]), the inherent risks associated with cyanide leaching (even if it is considered BAT—best available technology) and the negotiations with the families refusing to relocate.

**The Romanian state:** Following the accession to the European Union, the Romanian state could no longer subsidize the mining activities of state-owned companies; after the fall of communism, the state was confronted with a typical deindustrialization period, which led to significantly lower production in several industries, including mining. High unemployment rates have had social and economical impacts in the affected areas where mining activities have ceased operation. One of the EU directives Romania had to comply with after its accession in 2007 concerned the rehabilitation and minimization of waste and toxic tailings coming from the state activities in the extractive industries [15]. However, there are still areas that are affected by the toxic waste from mining activities, among them being the Roșia Montană village; the historical pollution of soil and surface waters with heavy metals and their compounds has not yet been handled by the local or national authorities and to the present day, acid water is drained into the Roșia stream from the old mine galleries.

**The local community:** In 2007, a sociological study [16] was conducted in the areas which would be impacted by the Roșia Montană project, namely in the towns Abrud and Câmpeni, and villages Bistra, Bucium, Ciuruleasa, Lupșa, Mogoș and Roșia Montană, and 62.7% of the interviewed had in their families former miners and held positive expectations about the project [16] (p. 86). The standard of living in the areas was perceived as rather poor or very poor in 2009, as most of the respondents declared a monthly income of 300 to 900 RON (between 100 and 300 USD at the time), while 16% of the villagers in Roșia Montană had a daily income of less than 2 USD, coming to a large extent from social security benefits. Another study was conducted in the areas in 2011 [16] (p. 91), looking at the degree of confidence the community had in the revival of surface exploitation mining. Almost 2/3 of the respondents had little or very little confidence in the investors, and 1/3 stated they had strong confidence in the company. The highest degree of confidence in the company was manifested among the villagers from Roșia Montană (52.8% of the respondents living there), as some of them were already working for the company. Some respondents drew attention of the fact that while the people who work for the company have a better standard of living than before, the ones who will not be employed in the mining project, making a living out of agriculture, wood processing, farm animals or tourism, will be severely affected by the project. The jobs that would be created if the project is implemented are the main reasons for the high expectations of the locals. Other expectations for the development of the area consist in potential solutions such as the reopening of underground mines or long-term surface mining, creating strategies for increasing the tourism in the area, as well as investing in dairies and other types of farming.

The inhabitants of the Corna village, which will be the closest to the tailings pond designed within the project, were asked how they feel about the pond being situated in the Corna cut-off [16] (p. 135). Of those asked in 2003 within the study, 9.4% of the respondents said they agreed with the initiative with no sad feelings about it; 28.1% declared they agreed with it, but are, however, sad about it; and 29.7% stated they disagreed with the initiative. Moreover, 31.3% of the respondents believed that the mining project would have a positive impact on the area, while 48.8% believed the contrary. Asked about whether they see any other alternatives besides the RMGC project for the future of the area, 46.9%

of the respondents believed there are other alternatives, while 31.9% believed the project was the only option. In 2013, a series of interviews [16] (p. 149) were conducted with families who have agreed to relocate from Roşia Montană and Corna to the near-by city Alba-Iulia, where RMGC built a new neighborhood from scratch. The questions were aiming to extract people's input on the perceived advantages and disadvantages brought by their decision to agree with the Company's offer. The main advantages stated by the respondents included better access to public services such as health, education, social assistance, better infrastructure such as a sewage system, running water, street lighting and better chances of employment. The disadvantages they mentioned were the higher living expenses in contrast with the low salaries they got in Alba-Iulia, the perception and fear of being marginalized, as well as homesickness.

**Public opinion and civil society:** The local communities are divided in their views on the impact that the project will have on the area. The villagers and property owners who oppose the project have formed in 2002 an NGO—Alburnus Maior, which acted at the forefront of the “Save Roşia Montană” campaign. Several national and international organizations (primarily environmental and cultural), artists [17] and journalists [18] have adhered to Alburnus Maior's campaign and disseminated information on the potential risks of the project both locally and nationally. Through investigative journalism, a multi-art activist festival (FânFest, Roşia Montană, 2004-present), public debates and other awareness actions throughout the country, they have formed a critical mass of citizens opposing the project for a wide variety of reasons. During our visit to Roşia Montană in September 2014, we talked to a representative of the NGO to check if there are any scenarios in which the project would become acceptable, from their point of view; none of the solutions provided by RMGC suited the interests of the NGO members. Irreconcilable aspects included expropriations, the relocation of the cemetery, as well as the interference with the cultural heritage, the threat posed to buildings by explosives use and the cyanide tailings.

Although it was suggested several times, no national referendum was conducted on the matter and the available opinion polls ask inconsistent questions and fail to clarify whether the public supports the RMGC exploitation project or not: three polls conducted in 2013 concluded that a majority of respondents expects authorities to promote the project (Sociopol), agree that natural resources should be exploited in general (INSCOP), but also specifically oppose the RMGC project in Roşia Montană (CURS) [19]. On a larger scale, there is no structured input on citizen preferences. In time, they have been exposed to the stakeholders' discourses, but they lacked the means of participating in the decision-making process. The Chamber of Deputies website features a page dedicated to the project, where few documents issued by RMGC, as well as by independent experts and institutions such as the Romanian Academy, the Academy of Economic Studies, and others are made available, along with a forum for discussion [20]. While users express their views on the project, no interaction between them and a representative from the official host of the forum takes place. The opinions stated on the forum regarding the project are divided, however the most commonly mentioned alternative is tourism. Incidentally, it is on this forum where we have found out about the existence of the extensive study conducted by the National Institute of Research and Development in Tourism on the strategies of sustainable development through tourism in former mining areas [21]. According to its main investigator, Georgeta Maiorescu, with whom we have met in September 2014, the study was presented to the local authorities in Roşia Montană, as well as to the Ministry of Tourism in 2006, but no echoes or follow-ups have taken place ever since. Alburnus Maior has also put forward the alternative of tourism

by supporting and promoting a resource and strategy analysis of sustainable development in Roşia Montană [22]. During the 2013 protests, a wide array of reasons for which people opposed the project have surfaced due to the Facebook community page Uniţi Salvăm [23], with over 50,000 members, as well as to the slogans and posters from the street. These depicted concerns over corporate and political greed, media failure and bias in informing the public, corruption, cyanide infesting waters and soil, sacrificing mountains and landscapes, selling of natural and mineral resources to foreigners, responsibility to future generations, bending legislation to suit corporate purposes, and abusive expropriations.

#### 4. Methodology

Unsupported decision processes, like the current ones in the Roşia Montană case, are usually problematical, both regarding elements such as political or economic agendas and the lack of capacity of the decision-makers. There have in other contexts been several attempts to solve this to some extent by introducing, e.g., computer based methods for risk and decision analysis, but these have generally had some limited success, often due to unrealistic assumptions on the part of decision makers.

Like in so many other cases, there have been a multitude of MCDA methods applied to mining applications from various perspectives. These have covered MCDA techniques for everything from maintaining or improving internal mining processes, such as described in Musingwini [24], to MCDA methods for balancing various factors similar to our approach, *c.f.*, Stralka *et al.* [25], Gelvez *et al.* [26], Esteves [27], Betriea *et al.* [28], and Erzurumlu *et al.* [29]. As usual, there are various advantages and disadvantages with these methods, but generally, they primarily utilize techniques for asserting precise information, often making them quite inadequate for practical purposes. If the expressive power of the analysis method permits fixed numbers only, we normally have severe elicitation problems that might affect the decision quality. Here we have chosen to model the decision problem into some more details than normally is done and utilized a flexible method putting fewer constraints on the decision-makers while allowing for imprecise statements regarding the background information. Imprecision is handled by allowing intervals and comparative statements, while still making this computationally tractable, as shown in Danielson *et al.* [30] and Ding *et al.* [31].

The main model utilized in this study tries to relax some of these requirements by accepting a larger set of user statements and possibilities to aggregate information. It has been used in several large decision problems involving many stakeholders, such as, the design of a flood insurance system for Hungary, the deposition of nuclear fuel, purchasing decisions at the Swedish Rail Administration, investment decision analyses in industry, flood management, emergency management, energy pricing and demining, and many others. It has also been extended to a participatory model more recently [32], further enhanced by studying how groups of political decision-makers desire to express values and priorities. The idea behind the model is that a theoretical decision method (i) should not require substantial formal decision analysis knowledge; (ii) should not be cognitively too demanding by relaxing precision requirements to accommodate unknown parameters; (iii) should not be too time-consuming; (iv) should make use of the information decision-makers are able to supply; and (v) should provide means for aggregating imprecise weight statements from different stakeholders. The main feature of the model used is that it takes imprecise cardinal relation information of the importance of the attribute ranges into account, and interprets the criteria significance input as regions of significance. This rather new approach to decision



analysis lies at the foundations of the DecideIT software, which allows operating with imprecise and uncertain information in the modeling and analysis of a decision problem and carrying out sensitivity analyses, in order to decide which among different decision alternatives is more suitable when considering factors like the stakeholders involved or the values and weights of different criteria.

To get the input to this model, the first step of the analysis consisted in background research of the main official, formal and less formal documents covering the case and produced by a wide range of stakeholders. These documents vary in terms of type and source, from official reports and legislative acts to press articles and social media, from public institutions and RMGC to the civil society at large. The corpus was selected so as to cover all the important stakeholders and their points of view regarding the project, in a balanced way. In the selection of the documents, an important criterion was their credibility; we tried to identify with priority those documents that expressed the official position of the different stakeholders involved, as well as documents that are supported by research. For this reason, most of the corpus consists of studies and reports. In order to facilitate the handling of this large corpus of texts, the NVIVO software for qualitative content analysis was used. The documentation process resembled that of a traditional content analysis, in that it was guided by a scheme of categories and sub-criteria (see Figure 1, which was created through an inductive approach based on the documentation at hand).

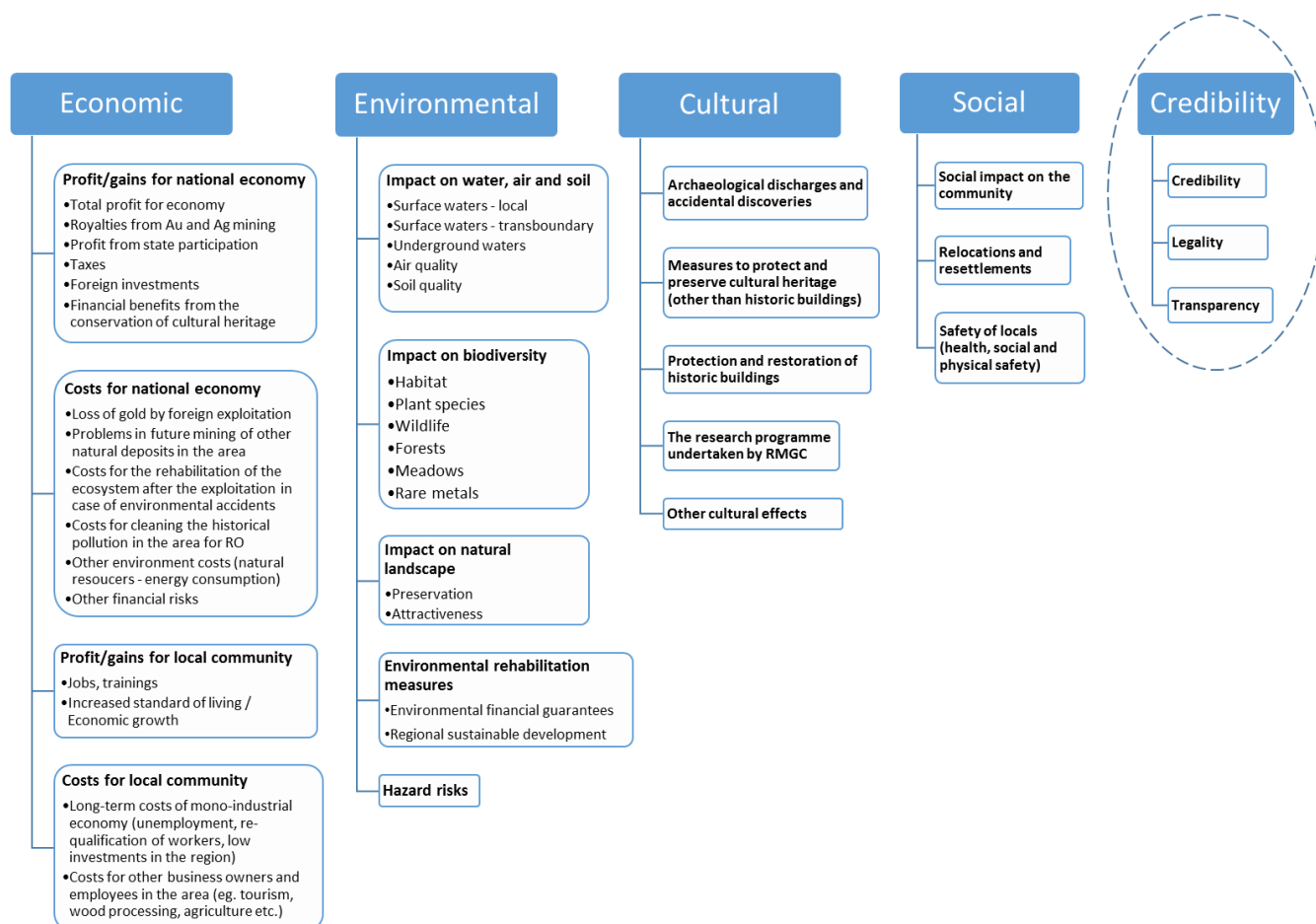


Figure 1. The multi-criteria structure.

An initial multi-criteria tree was designed based on the arguments identified in a previous analysis [8], which was later elaborated upon during the thorough background research phase. The main branches of the multi-criteria tree are: *Economy*, *Environment*, *Social* and *Cultural*, to which we later added the dimension of *Credibility*, considering that the issues regarding the transparency, legality and credibility of the entire development of the Roşia Montană project have played a significant role in the unfolding of the events, especially during the last years. Each of these branches was split in multiple categories and subcategories representing the arguments brought up by the different stakeholders regarding the possible consequences of the exploitation project, as well as of the other identified alternatives for the area.

We went through all the documents previously collected and coded relevant fragments of text under each criterion in the scheme of categories, separating negative from positive evaluations, as well as the different issuers of the respective arguments. This process mapped the stakeholders' attitudes towards the project, as well as the most commonly discussed criteria and arguments by the different parties involved. This information was later used in the process of assigning values to the alternatives and weights to the criteria. While ensuring balance and plurality of stakeholders and perspectives, both negative and positive evaluations for every criterion were identified.

Under the criteria structure, the most commonly discussed four decision alternatives in the debate were analyzed:

**Alternative 1 (Alt. 1).** The updated project with the provisions from the 2013 Agreement between RMGC and the Romanian Government (which was also debated by the Special Parliamentary Committee) [33].

**Alternative 2 (Alt. 2).** The Zero alternative, which implies that the mining project would be dropped, but nothing else would be done instead in Roşia Montană. It is a non-action alternative and it was assessed from a series of documents, among which: the Environmental Impact Assessment for Roşia Montană Project (EIA) documentation submitted by the company [34], the report from the Hungarian Ministry of Environment and Waters [35], following the Convention on Environmental Impact Assessment in a Transboundary Context, a study from the Romanian Academy [36], the Special Committee's Report [37] and other expert studies.

**Alternative 3 (Alt. 3).** The project in its initial form, with the provisions from the 1999 Exploitation License [38] and its additional agreements.

**Alternative 4 (Alt. 4).** The alternative of touristic development in the Roşia Montană area. On the Chamber of Deputies webpage, a forum [20] for debate on the Roşia Montană issues has a thread destined for discussing alternatives other than the RMGC project for the development of the area. The tourism alternative seems to be the most popular among the civil society sector, including among research institutions such as The Academy for Economic Studies or the Romanian Academy. Citizens, local NGOs and the Save Roşia Montană campaign have been promoting this alternative through an annual activist festival in Roşia Montană, lobbying for the inclusion of its cultural heritage on the UNESCO list of protected heritage sites. An ample study [21] on the touristic potential of development of the area was conducted by the National Institute of Research and Development in Tourism during 2004–2006, financed through the Poland and Hungary: Assistance for Restructuring their Economies (PHARE) program and the Ministry of Education and Research. The institute is responsible with elaborating strategies and impact studies for

touristic development throughout Romania, many of their results leading to regional development strategies and financed by the Ministry of Tourism. However, the five volumes report is only accessible at the National Institute of Research and Development in Tourism archives.

Since the background research revealed that the documentation involves mainly projections and scenarios based on rather imprecise or uncertain information, which is often conflicting depending on the source, we used an interval-based method to estimate the values of the criteria, complemented by qualitative estimates (relations between the criteria). We generally used a  $[-1, 1]$  interval. The following informal semantics can give an idea on what is aimed for:

- $[-1, 0]$  most probably negative consequences (or best case none), but the intensity is unknown
- $[0, 1]$  most probably positive consequences (or no consequences), but the intensity is unknown
- 0 neutral
- 1 negative (e.g., environmental costs such as the high amount of energy and other natural resources consumed for the project are a certain negative impact)
- 1 positive, which was never used, taking into consideration that it would also imply a relative consensus among experts
- $[-1, 1]$  where experts are almost equally divided and it is difficult to say whether the consequence would be good or bad; or where we do not have enough reliable data for such predictions.

The process of assigning values, weights and relations is based on the previous systematic documentation, where we tried to cover most of the data available from a broad range of sources covering the topic. As already mentioned, we prioritized official documents and expert studies, due to their higher reliability. The selection of the documentation was made on the principle of balanced representation, our goal being to cover the arguments of all stakeholders involved in a fair manner and not to make assumptions that were not directly supported by data. In addition, we assigned different weights to the criteria and defined equivalence relations between the four alternatives for each criterion (better than, equal and approximately equal to, worse than).

The decision information can be considered as constraints in the space formed by all decision variables, which are collected as linear constraints to the solution sets of the spaces spanned by the weight and value variables, respectively. These constraints may be both range constraints, *i.e.*, constraints involving only one variable such as interval boundaries, and comparative constraints involving two variables. To further aid in the modeling of the problem, the *orthogonal hull* concept is introduced, indicating to the decision-maker which parts of the statements that are consistent with the information given so far. This becomes then the projection of the constrained spaces onto each variable axis, and can thus be seen as the meaningful interval boundaries for the decision situation. The same type of input is used for the components involved, *i.e.*, alternative values  $v$ , and weights  $w_j$ , although the normalization constraints  $\sum w_j = 1$  must not be violated in the weight case.

All input into the Roşia Montană model was subject to consistency checks performed by the DecideIT tool. The calculations are based on the weighted sum of the alternative values under the criteria and sub-criteria aggregated for the entire decision problem. For instance in a three level tree as the current one, this becomes,

$$V(A_s) = \sum w_i \sum w_{ij} \sum w_{ijk} v_{ijk}(A_s)$$

where  $v_{ijk}(A_s)$  is the value of alternative  $A_s$  under sub criteria  $ijk$ .

Given this, we then calculate the *strength* of alternatives as a mean for further discriminating the alternatives. The strength simply denotes the difference in weighted value, *i.e.*, the expression  $V(A_i) - V(A_j)$  for the difference between alternatives  $A_i$  and  $A_j$ . In this way we can readily calculate the maximum and minimum difference between the alternatives. Details on how this is computationally handled in the evaluation are found in [39,40].

An important feature of this process is the *sensitivity analysis*. This analysis attempted to highlight what information was the most critical for the obtained results and must therefore be subject to careful additional consideration. It also points to which of the assessments are too imprecise to be of any assistance in the discrimination of alternatives and thus should be made more accurate, thereby triggering and facilitating iteration in the process. The embedded sensitivity analysis, called the *concept of contraction*, is performed by reducing the widths of the intervals (contraction) for the values and weights in the analysis model of the decision problem. The concept's idea is to shrink the orthogonal hull while studying the stability of the maximum strength at different contraction levels. The level of contraction is indicated as a percentage, so that for a 100% level of contraction all orthogonal hull intervals have been reduced to their respective focal points. The contraction can be seen as cutting the hull from the extreme points (having a lower reliability or a lower degree of belief towards the focal point, increasing the lowest permitted degree of belief. When dealing with interval statements only this is quite simple, and more complicated when comparative constraints are involved. For a formal treatment, see Danielson's paper [41].

## 5. Evaluation and Analysis of Alternatives

Below we go through various scenarios and their consequences for the Roşia Montană exploitation project. The following scenarios were devised according to eight different prioritizations, which led to separate weighing choices of the main criteria: (1) indiscriminate assessment of issues importance; (2) coverage of issue in the consulted data; (3) potential of issue improvement; (4) stakeholder interest—the Romanian state; (5) stakeholder interest—civil society and local opponents; (6) local, national and transboundary interests; (7) stakeholder interest—local community; and (8) transparency and citizen interest. For a more detailed view of the criteria, subcriteria and the assigned weights and relations in DecideIT for every scenario, see the Excel document attached.

### 5.1. Scenario 1

If we give all issuers' views and interests equal importance and refrain from weighing discriminately on account of the expert knowledge available on each category, visibility in the public sphere, local *versus* national agendas, or types of capital at stake, we consider that all main criteria, *economic, environmental, social, cultural* and *credibility* have equal weights. Our evaluation thus relies on the constraints used for each subcriterion and the qualitative relations thereof. Consequently, by using these settings, the expected value of the four alternatives is visible in Figures 2–4. The expected value graph is a representation of an aggregation of the weighed sum for all criteria. The upper and lower graph lines

are the minimum and maximum expected values along the horizontal axis, from 0% to 100% contraction levels. The expected value graphs become as follows:

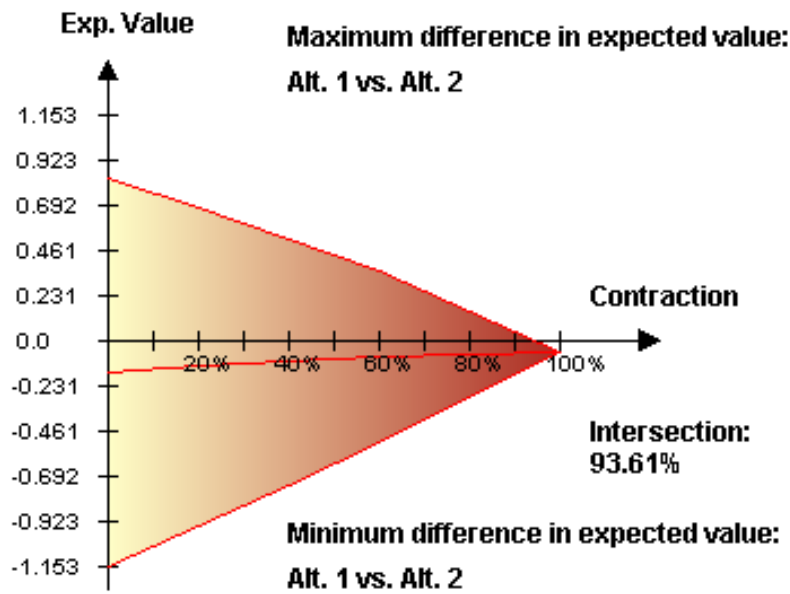


Figure 2. Scenario 1. Evaluation of the four alternatives.

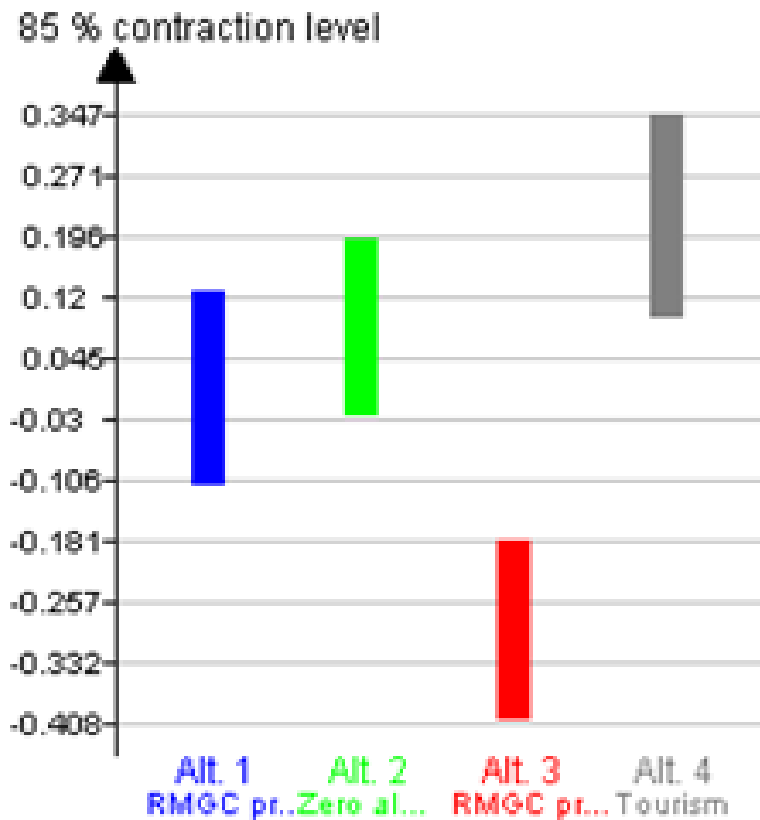
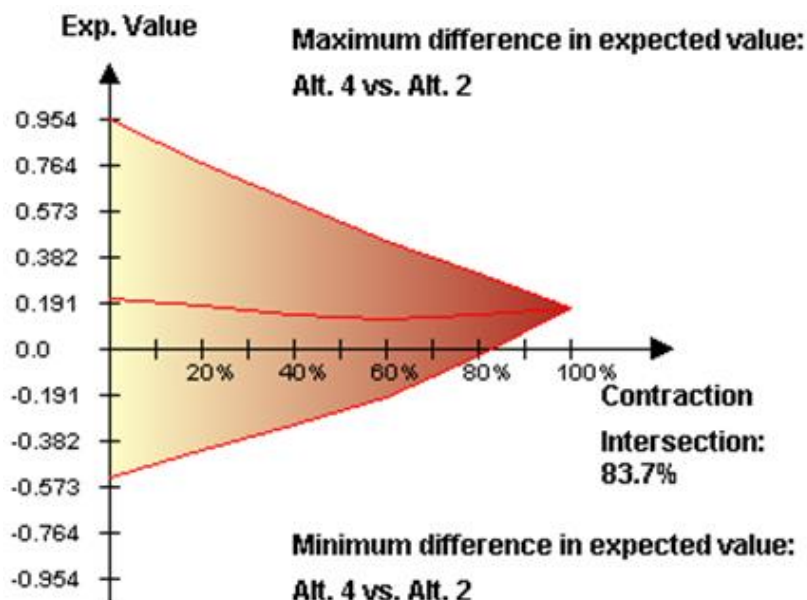


Figure 3. Scenario 1. Comparison Alt. 1 and Alt. 2.



**Figure 4.** Scenario 1. Comparison Alt.2 and Alt.4.

Even though we have worked with imprecise data, the decision analysis model is rather robust, enabling us to evaluate the four alternatives. Based on Figure 2, we can draw three conclusions with a reasonable amount of confidence:

- **Alt. 3** (The project in the initial form, with the provisions from the 1999 license) is the least advantageous of the four, and can be discarded (at a contraction level of 85% there is no overlap with the others, and the values are negative and lowest).
- **Alt. 4** (Tourism) appears to be the optimal decision in this scenario.
- **Alt. 1** (The mining project in its updated form) and **Alt. 2** (No mining project, nothing instead) overlap entirely, which means that in this scenario there is not enough data to differentiate between them, the consequences of each option being rather comparable. Figure 3 confirms that the difference between Alt. 1 and Alt. 2 is insignificant and that more detailed data is needed in order to better comparatively assess the two options.

Figure 4 compares Alt. 4 with Alt. 2 (and implicitly with Alt. 1, due to the overlap between the two) and confirms the conclusion from Figure 3, namely that Alt. 4, a touristic development project, would be the optimal solution.

## 5.2. Sensitivity Analysis

In the sensitivity analysis below we devised different scenarios changing the weights of the main criteria in order to see to what extent the relation between the alternatives alters the results, depending on the various stakeholder views involved. For a detailed indication of the values assigned to these criteria for each option under analysis, see the Excel table attached to the paper.

**Scenario 2:** The second scenario we propose stems from the range of interests dedicated to the categories outlined above throughout the consulted documents and statements. The background research revealed that the most widely discussed issues regarding the project were the *economic* and *environmental* aspects, covered by governmental statements, license agreements, expert reports, national

and international institutes’ positions and others, while *social* and *cultural* issues seemed somewhat secondary in the public debate, gaining visibility mainly through civil society efforts. For this reason, we considered in this scenario that the economic and environmental consequences weigh the same, then social and cultural issues also bear equal weights, but the former categories weigh more than the latter (without specifying how much more, because that is uncertain). We also took into consideration the *credibility* dimension, which we assigned a lower weight than all other four criteria, considering that it has a rather indirect effect on the overall evaluation of the project.

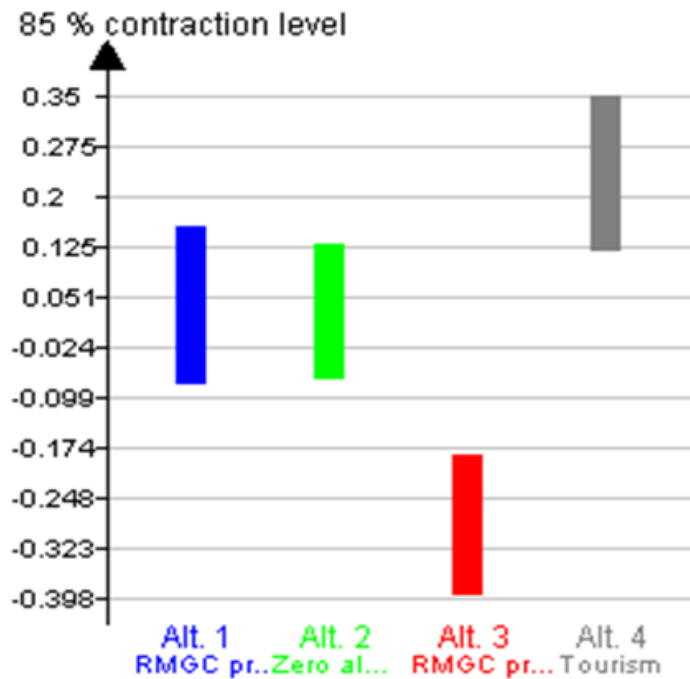


Figure 5. Scenario 2. Evaluation of the 4 alternatives.

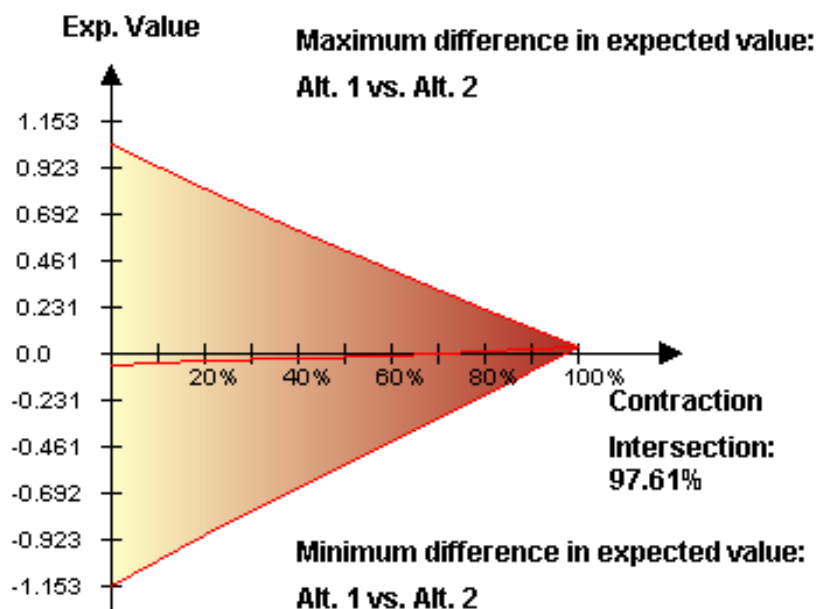


Figure 6. Scenario 2. Comparison Alt. 1 and Alt. 2.

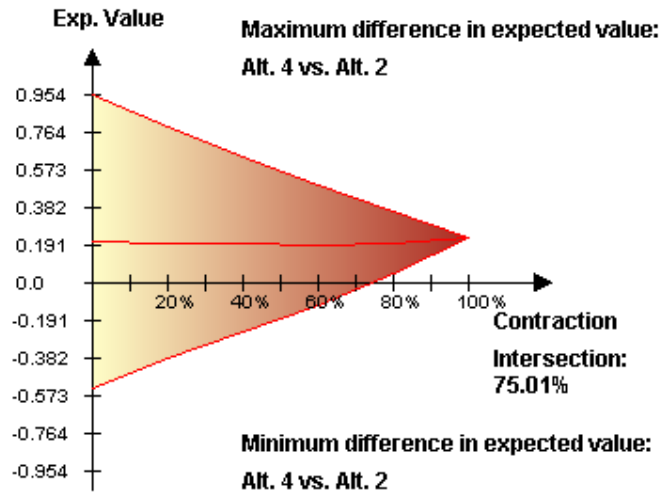


Figure 7. Scenario 2. Comparison Alt. 2 and Alt. 4.

As we can see in Figures 5 and 6, Alt. 2 and Alt.4 are still clearly distinguishable, with the latter being strongly preferred to the former. While Alt. 4 has a higher expected value than Alt. 2, as seen in Figure 7, and Alt.1, more specific data would be necessary in order to differentiate the alternatives with a strong degree of confidence.

**Scenario 3:** For the main scenario, we checked the extent to which the *credibility* issues affect the evaluation of Alt. 1, the RMGC project, in relation to the other alternatives. If the Company and the Romanian Government would improve the transparency of their negotiations, steps and aims regarding the project and would initiate a permanent dialogue on the topic with citizens and the civil society in the decision-making process, *credibility* could be solved and make room for an open democratic discussion on the remaining four criteria. The expected value graphs for scenario 2 where we assigned a weight at most likely point 0 for the credibility criterion can be seen in Figure 8.

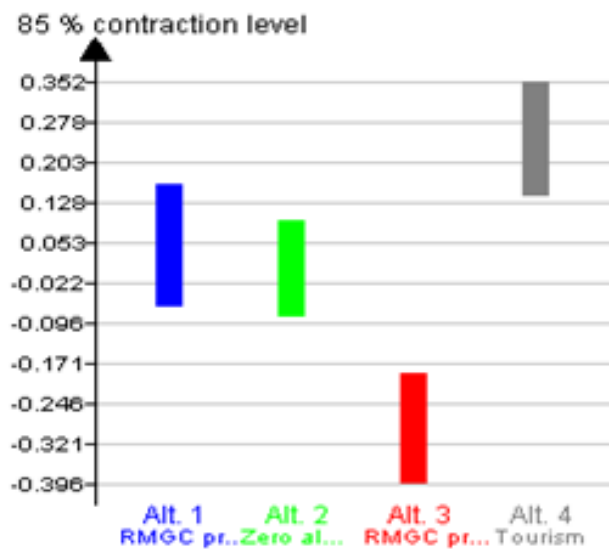
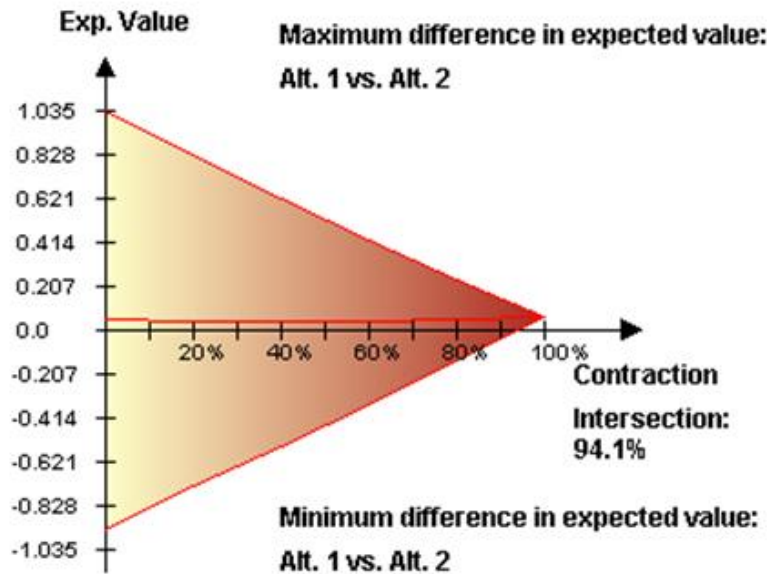


Figure 8. Scenario 3. Evaluation of the 4 alternatives.

According to Figures 8 and 9, if we discard the *credibility* dimension and consider only *economic*, *environment*, *social* and *cultural* issues, the results remain mostly the same: Alt. 3 can be dropped,



Alt. 4 is still the best, and Alt. 1 and Alt. 2 overlap, though the former becomes very slightly better than the Zero Alternative. The same shift between Alt. 1 and Alt. 2, making the former slightly more preferable than the latter is noticed when dropping the *credibility* criterion in scenario 1, as well.



**Figure 9.** Scenario 3. Comparison Alt. 1 and Alt. 2.

In this case, the only position that changes is that of the Alt. 2, which becomes very slightly preferable to Alt.1, the RMGC project. This is due to the increase of the credibility criteria weight, along with its subcriteria legality and transparency. However, the difference between the two is almost insignificant, which means that more data is needed to compare them. Also, the difference between Alt. 4 and Alt. 2 slightly decreases, but remains significant.

**Scenario 4:** Romanian officials have repeatedly stressed the economic potential of the RMGC investment, mainly highlighting the profits derived from royalties and state participation, as well as the potential for creating jobs in the area. The desire to exploit natural resources for the beneficial impact upon the national economy has been expressed by various governments and the former president, being the impetus of maintaining the Company project on the public and political agenda. Below we can look at the value graphs when giving the highest weight to the *economic* aspects, all other criteria having equal weights among themselves, lower than the economic one.

If the economic arguments prevail over all the others, then the results of the decision analysis become somewhat different (Figures 10 and 11). Alt. 1 (the updated mining project) becomes almost as preferable as Alt. 4 (doing tourism), with an overlap of almost 95%, but also overlaps to great extent with the Zero Alternative, which makes it somewhat difficult to distinguish between the three alternatives.

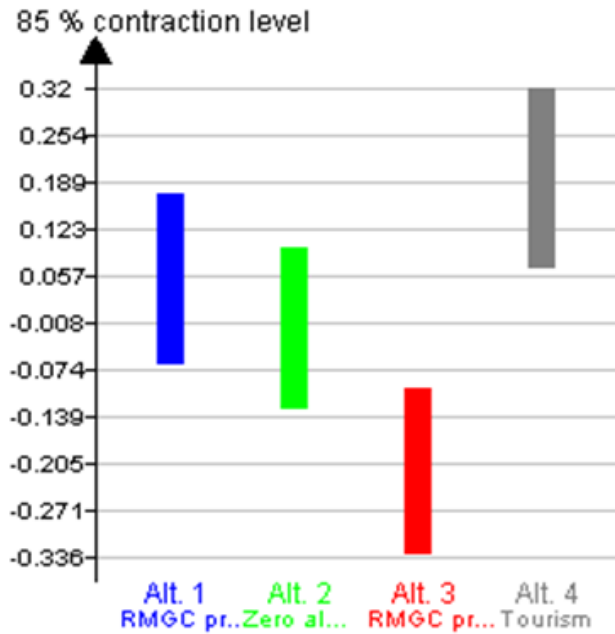


Figure 10. Scenario 4. Evaluation of the 4 alternatives.

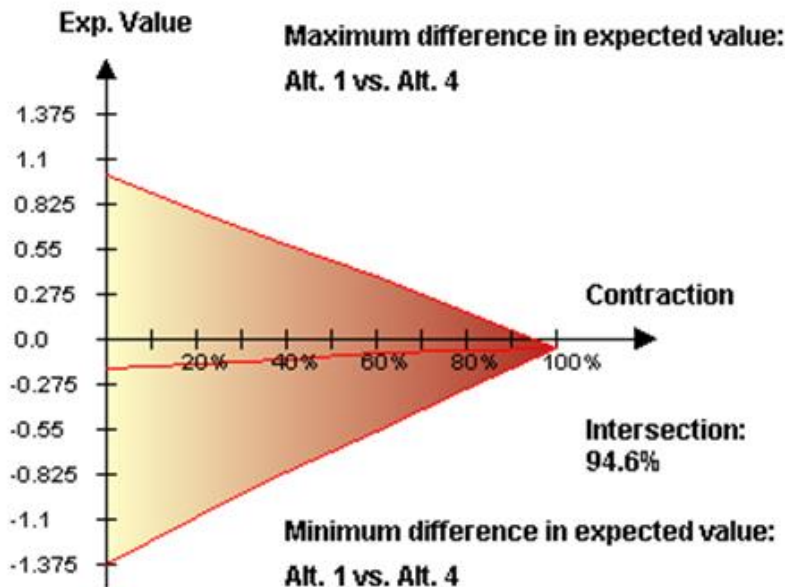
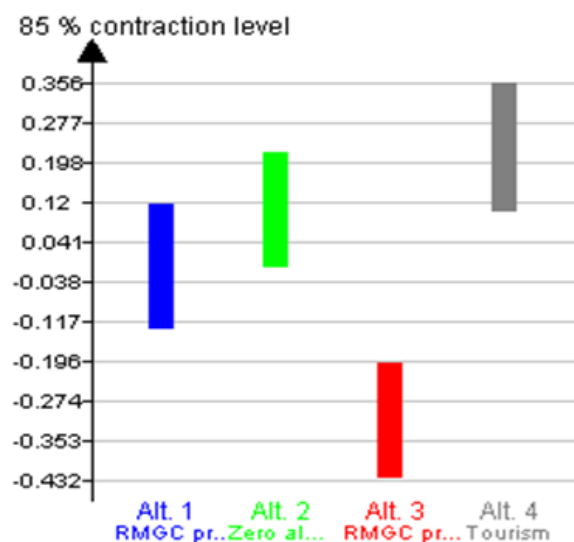
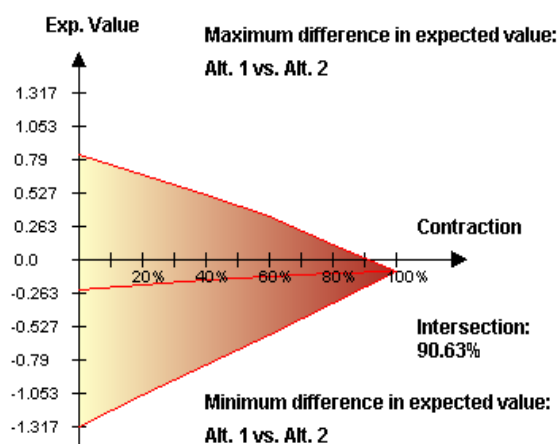


Figure 11. Scenario 4. Comparison Alt.1 and Alt.4.

**Scenario 5:** In this set-up, we prioritize the *social, cultural, environmental* and *credibility* aspects over the *economical* benefits, as demanded by several opposing NGOs including Alburnus Maior and the majority of the protesters. According to critics of the RMGC project, the economical gains derived from the gold and silver exploitation are neither substantial, nor stable enough for a long-term national economic development and better standards of living (the “Dutch disease” of natural resources maintaining instable economies [42]). Moreover, regardless of the economic potential, some opponents consider the social, cultural and environmental risks and impact much more important to consider in the maintenance or future urban planning of the area, being at the same time active watchdogs of the legal process of obtaining local authority and ministry permits.



**Figure 12.** Scenario 5. Evaluation of the 4 alternatives.



**Figure 13.** Scenario 5. Comparison Alt. 1 and Alt. 2.

Again, there is a shift between Alt. 1 and Alt. 2, as the latter (the one favored by the stakeholders who oppose and protest against the project) becomes a better option than the RMGC project for the area.

**Scenario 6:** The highest risk concerns found throughout the available documentation, expressed by experts, citizens and public officials alike, deal with *environmental* aspects. Most countries including Romania require Environmental Impact Assessments for mining projects; RMGC must also submit one in order to get a secure pass from the Ministry of Environment, which has not been granted yet. However, the Romanian side is not the only one having a say in the matter, as the Hungarian government has expressed its call for caution both in diplomatic meetings and expert reports. At the same time, the Romanian state needs to address the rehabilitation and minimization of waste and toxic tailings coming from the state activities in the extractive industries. There are still areas that are affected by the toxic waste from mining activities, among them being the Roșia Montană village. Research shows that the environmental impact of the pollution in the area is significant and the risks associated with it should make pollution mediation a priority on the public decision-making agenda. This scenario weighs the *environmental* issues higher than all other criteria, which have smaller equal weights, and the resulting evaluation graphs being available in Figures 14–16.

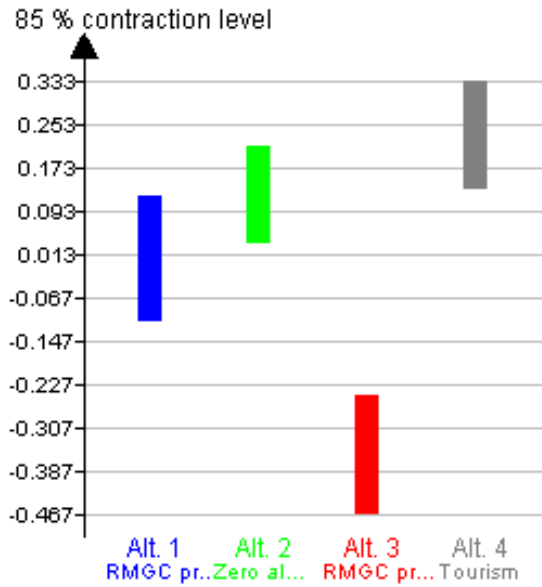


Figure 14. Scenario 6. Evaluation of the 4 alternatives.

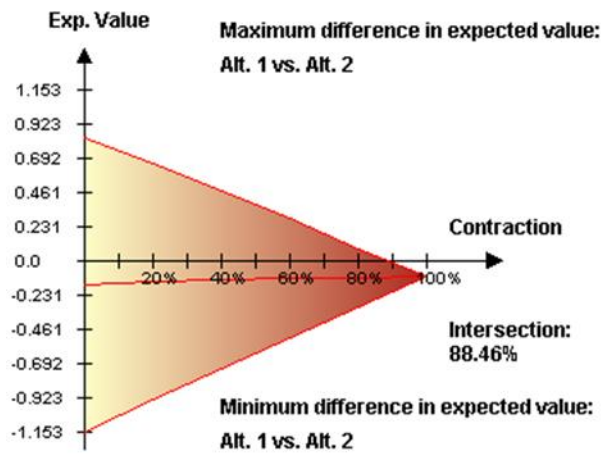


Figure 15. Scenario 6. Comparison Alt. 1 and Alt. 2.

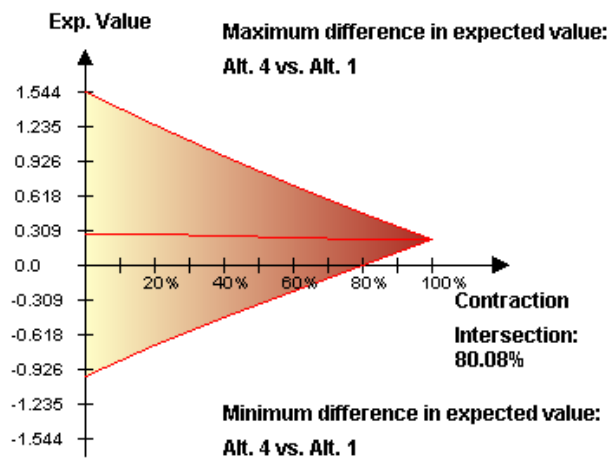


Figure 16. Scenario 6. Comparison Alt. 1 and Alt. 4. (Note: If we prioritize *environment* over *social, economic, cultural and credibility* criteria, then the Zero Alternative becomes the second best after Tourism, which is significantly better than Alt. 1).

**Scenario 7:** The social impact of all alternatives has been taken into account, with the implications of the project—resettlements and relocations, public safety, access to jobs, infrastructure, clean water, and so on. Above, we have discussed in more detail the perceptions of local citizens on the project, on the current state of things and on the possible alternatives. Prioritizing social issues over all the others is a scenario that takes into consideration the directly impacted community in Roșia Montană and the surrounding villages. Thus, the highest weight is given to the *social* criterion and all others have equal smaller weights.

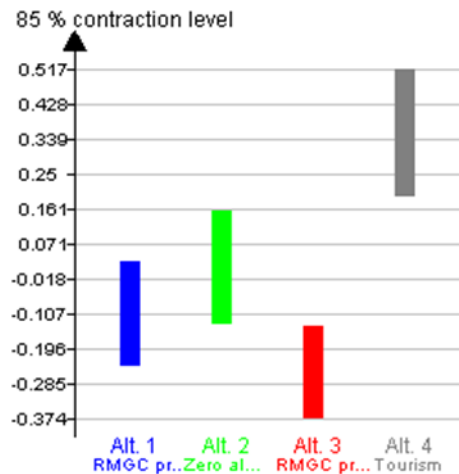


Figure 17. Scenario 7. Evaluation of the 4 alternatives.

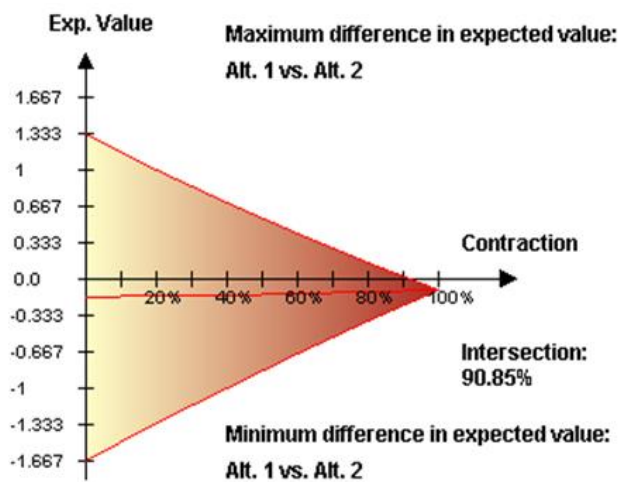
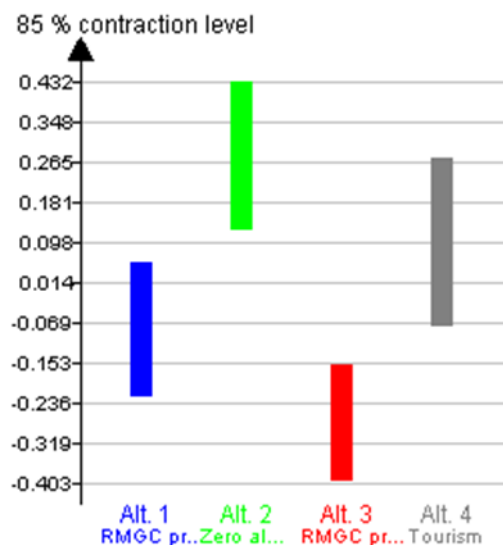


Figure 18. Scenario 7. Comparison Alt. 1 and Alt. 2.

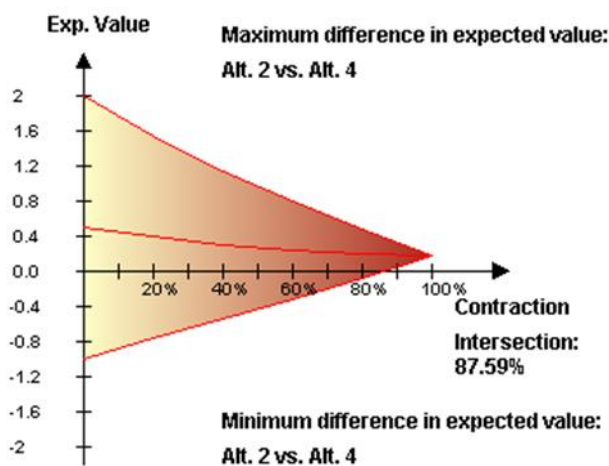
The Zero Alternative becomes slightly preferable to the RMGC project when the local community social issues are given the highest value, while tourism remains the optimal decision for the area.

**Scenario 8:** The legal impediments met by the RMGC project so far have blocked the implementation of the project, but have not yet led to a permanent dismissal of it by the Romanian authorities. Discussions and negotiations behind closed doors have taken place throughout the years, drawing mistrust and criticism from the opponents who fear that legislation can be bent to suit corporate and governmental interests. The lack of transparency and open public debate on parliamentary initiatives and governmental decisions has inflamed the public opinion, making the *credibility* criterion more important

and relevant than any other. By making Roşia Montană a mono-industrial area and, as a consequence, blocking any other enterprise such as tourism to develop, local authorities are as well met with mistrust in choosing the best alternative for the area. Thus, the graphs below show the evaluation of the four alternatives when *credibility* has the highest weight, and all other criteria have smaller equal weights.



**Figure 19.** Scenario 8. Evaluation of the 4 alternatives.



**Figure 20.** Scenario 8. Comparison Alt. 2 and Alt. 4.

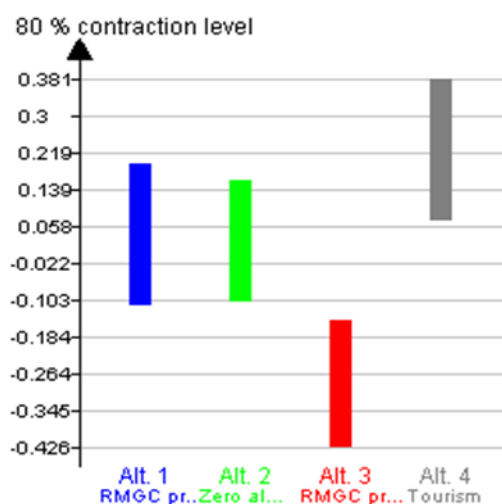
If credibility becomes the main issue, the situation changes to a larger extent. The Zero Alternative becomes preferable, while tourism falls to second place and the RMGC project to third, overlapping with Alt. 3.

### 5.3. Other Scenarios Advanced in the Public Debates:

- i. If a different technology is used in the exploitation, skipping the cyanide leaching process and the toxic tailings raising the environmental concerns, weights would be impossible to estimate within Alt. 1, since Roşia Montană Gold Corporation is not willing to modify the technology. The entire business plan, feasibility and investment studies are built on the present technology. A separate

alternative backed by a feasibility study of alternative exploitations of the deposits should be analyzed by the Romanian state or by other investors.

- ii. If Corna Valley is not used for the construction of the tailings management facility, the risk of toxic tailings permeating the underground waters would considerably diminish, according to the National Institute of Geology. In the multi-criteria tree, the difference would be visible by changing the possible outcomes for the subcriterion Underground waters, within Environment, in the case of the project approval. The interval  $[-1, 0]$  is changed with a most likely point 0. The change does not affect the final cardinal ranking of the alternatives.
- iii. If mining legislation is adopted so as to ease the approval of environmental permits needed for the implementation of Alt. 1, the RMGC project, the risks and benefits of this alternative increase proportionally, as they can be replicated in other similar future projects. Also, taking into consideration the release of new licenses for exploration by the National Agency for Mineral Resources, the precedent of the Roşia Montană project can lead to similar choices to be employed in the future by investors.
- iv. If we consider the documentation provided by the National Institute of Research and Development in Tourism [21] on Alt. 4, we can see that their research and cost-benefit analysis aim at a touristic development of not only the Roşia Montană area, but also of other areas in Apuseni Mountains affected by mining closures after Romania's accession to the European Union. A successful sustainable development through tourism could as well be replicated.



**Figure 21.** Evaluation of the 4 alternatives.

## 6. Research Limitations

The uncertainty of the data and the conflicting evaluations: the inherent problem that we faced was that multiple sources hold conflicting arguments regarding the same issue. Due to the complexity of the issues and to the fact that most of the criteria in question are predictions, the only option for the analysis was to work with rather vague and gross evaluations, which resulted in a lower confidence in the differentiation between the four alternatives. Also, our limited resources did not allow us to organize workshops with the stakeholders involved or other means of obtaining a more precise and direct

assessment of their position on the topic. This implies both that our research was mostly limited to secondary data, and that a rigorous stakeholder analysis was not feasible. However, the current research represents a well-documented starting point for further, more refined decision analyses that would help better differentiate between the alternatives.

This research would not have been possible without the documentation made available with the civil society protests and journalistic investigations, which released the license contracts and made way for a parliamentary public hearing of the main stakeholders.

## 7. Conclusions

Drawing on the sensitivity analysis, we can conclude that the alternative of implementing the project with the old provisions (Alt. 3), dating in the 1999 license, can be dropped, because it is clearly the most disadvantageous of the four options. In addition, in most cases, the Tourism alternative (Alt. 4) turns out to be the optimal one. However, we must take this result with caution because in certain cases the difference from the updated project with the provisions from the 2013 Agreement (Alt. 1) and the Zero alternative (Alt. 2) is not very large, given that the data available for this latter option comes from imprecise and uncertain projections. These precautions are reflected in the 8th Scenario, where Credibility issues are prioritized, and, as a consequence, the best alternative becomes that of not doing anything (Alt. 2), when choosing among the given alternatives. With the current data on Alt. 2, supplied more by RMGC than by the Romanian government, it is difficult to assess whether it is better to launch the project in its updated form (Alt. 1) or to not take any further action (Alt. 2). In most cases, these two alternatives largely overlap, or the differentiations are rather insignificant. There is only one scenario where there is a clear hierarchy between the two options: if we value more the credibility, legality and transparency of the process, the situation shifts and Alt. 2 becomes a wiser decision. This result can be translated in a valuable recommendation for the mining company and for the political decision-makers. If these stakeholders want the continuation of the project and its acceptance by civil society, the key challenge is to increase the transparency of the process and improve the credibility and legal aspects, entering an honest dialogue with the civil society, in order to gain people's trust. If these aspects cannot be met, the decision-makers need to pay attention to the alternatives available for a sustainable development in the area. From these results, there are some future obvious directions of inquiry and action:

- Research in cooperation with other EU member states of alternative technologies leading to environmentally safer mining—see researcher Jack Goldstein's [10] (pp. 17–18) proposed method for Roșia Montană, which uses sodium thiosulfate as the main reactive substance for solubilization; cost-benefits analysis; sustainability; and range of applicability.
- Perform an even more elaborated analysis by expanding the multi-criteria tree with more detailed technical information, leading to a wider number of branches and subcriteria, after gaining more input on: touristic development, local authority plans in case the project is rejected for good, public opinion preferences and perceived risks and needs.
- Introduce more alternatives for sustainable development in areas where state-funded mining was ceased.



The Tourism Alternative, which seems to be a potentially very attractive option, ultimately depends on political will and on how such a project would be implemented. In addition, the 8th Scenario reflects the current situation, where action has been frozen as a result of the massive protests, which were to a great extent due to the lack of transparency, the legality problems and the credibility of the whole process.

Naturally, any decision model faces certain obstacles and limitations regarding firm conclusions, in particular when there are multiple sources that hold conflicting arguments regarding the same issue. This taken together with the complexity of the issues and the fact that most of the criteria in question are predictions with a high level of uncertainty and controversy, as well as the lack of reliable, research-based projections and several other factors, including problems with transparency, complicate the analysis significantly. However, the more intuitive approaches utilized so far have been even more obscure and the current research constitutes a more refined decision analysis and a well-documented starting point for further analysis, which would also help better differentiate between Alt. 1 and Alt. 2, which at the moment are held as the most viable options and which, in our analysis, are hard to prioritize one over the other.

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### **Author Contributions**

Love Ekenberg conceived the methodology and the DecideIT tool for multicriteria analyses and evaluation of alternatives. Adriana Mihai and Adina Marincea conducted the background research of the Roșia Montană case, created the research design for the data analysis and adapted the MCDM methodology for the present case.

### **Conflicts of Interest**

The authors declare no conflict of interest.

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