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Is There Sustainable Development after Mining? A Case Study of Three Mining Areas in the Apuseni Region (Romania)

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Abstract: The cessation or downsizing of mining activities induced complex challenges for entire regions in Romania, leading to depopulation, poverty, and pollution. Resource-dependency locked these regions in a mono-industry setting where it was difficult for new development paths to emerge. This paper presents a historical overview of a well-known Romanian mining region and identifies promising recovery opportunities that could shift the trajectory of its mining communities towards new sustainable paths. The research was based on official statistical data for the period 1965/1966–2018, complemented by qualitative data extracted from 39 semi-structured interviews with residents from the study area. The results revealed that the concentration of employment in the mining sector, together with other concurring factors, made it difficult for the communities to find sustainable ways of development while, at the same time, highlighting some possible revitalization and recovery opportunities. The findings contribute to a better understanding of mining communities, which will support the creation of tailored policies and planning strategies aimed towards their sustainable redevelopment.

Keywords: sustainable development; mine closure; downsizing; mining communities; Apuseni Mountains

1. Introduction

For centuries, mining has been a major activity that has created economic prosperity, technological development, and social welfare [1,2]. However, this economic growth is mostly associated with numerous negative social and environmental consequences, which include, but are not limited to soil, water, and air pollution; loss of biodiversity; visual impact on the landscape; abandoned mine sites; community displacement; and negative impacts on human health [3,4]. Unfortunately, some of these impacts remain, even after mine closure [5].

Sustainable development (SD), as a concept, was introduced at the end of the 20th century, being defined as "development that meets the needs of the present generations without compromising the

ability of future generations to meet their own needs" [6]. It is a concept that describes a permanent change for a future situation [7,8]. The three pillars of sustainable development (society, economy, and the environment) are strongly interconnected and should be simultaneously applied [2,8,9]. The Earth Summit in Rio de Janeiro in 1992 emphasized the relation between human development and environmental protection, with sustainable development becoming a guiding principle [8,10].

In 2001, the UN adopted a set of eight goals, called the Millennium Development Goals (MDGs), which were succeeded by the Sustainable Development Goals (SDGs). They were agreed upon in 2015 in order to end poverty, protect the planet, and ensure prosperity. The 17 SDGs are part of an Agenda to be achieved by 2030 and may be applied to any economic/industrial activity, including the mining sector, which is a major improvement because, in 1992, the goals of sustainable development were barely discussed in relation to the mining sector [11].

The concerns related to the impact of the mining industry on the environment and society forced the largest mining companies to launch, in 1998, the Global Mining Initiative (GMI) to clearly define what sustainable development should mean to the industry and how it could be put into practice [12].

Mine closure directly impacts the economy and the employment opportunities in the surrounding area, social and economic development also being the pillars of SD. Maintaining an equilibrium among these pillars, depending on the interests of individuals, politicians, and companies, is important for the sustainability of mining projects at different life cycles [12].

It is important for the stakeholders to regain the abandoned land and to restore its ecologic, economic, and aesthetic values, while at the same time considering sustainable development [13]. In recent years, mining companies have been required to apply SD principles to their long-term post-mining strategies in an attempt to restore the mining environment to an acceptable state [14]. It is both a moral and a legal obligation; the strong ties local communities had with the mining sites, together with the society's concerns, were transposed into legislation that required the companies to protect the environment both during and post closure. Several intervention methods are discussed in the scientific literature [15–17], while several successful cases are being recorded around the world. Three terms are mostly used regarding post-mining land use: restoration, reclamation, and rehabilitation [13,14]. However, there are also former mining areas that are unique habitats, as they are considered to be cultural heritage monuments and are therefore protected [18]. Furthermore, some of the wastes have high metal contents and are re-considered for use [19]. This paper intends to provide new insights into how new development paths can be achieved following the decommissioning or downsizing of mines.

The main aim of this paper is to investigate the development of three mining areas in the Apuseni Mountains—an important mining region of Romania—over a five-decade period and to identify opportunities for future development. The specific objectives were to identify the critical junctures that determined the particular trajectories of these areas and analyze their evolution over a period of five decades, highlighting the fluctuations generated at each juncture. Another specific objective was to highlight the potential of new development paths and the extent to which these new paths originate from the old ones. The analysis is based on archival statistical data and qualitative data gathered from interviews with the residents of the three mining areas. The interviews captured the individual perceptions of the changes that occurred and the way these changes affected their communities.

The investigations pursued the answers to the following research questions:

RQ1. How can new sustainable development paths originate and evolve in this historical context?
RQ2. To what extent does the creation of these sustainable development paths relate to the old ones?
RQ3. How do individuals from the communities perceive the changes induced by the critical junctures?

To establish the context, a description of the methodology and a case study in the Apuseni mining region (Alba County) are provided before exploring how the critical junctures in the history of the area shaped the communities' opportunities for creating new sustainable development paths.

2. Materials and Methods

2.1. Study Area

The study comprises three mining areas in one of the most intensely mined regions of Romania, the Apuseni Mountains, situated in the northwestern region of the country (Figure 1).

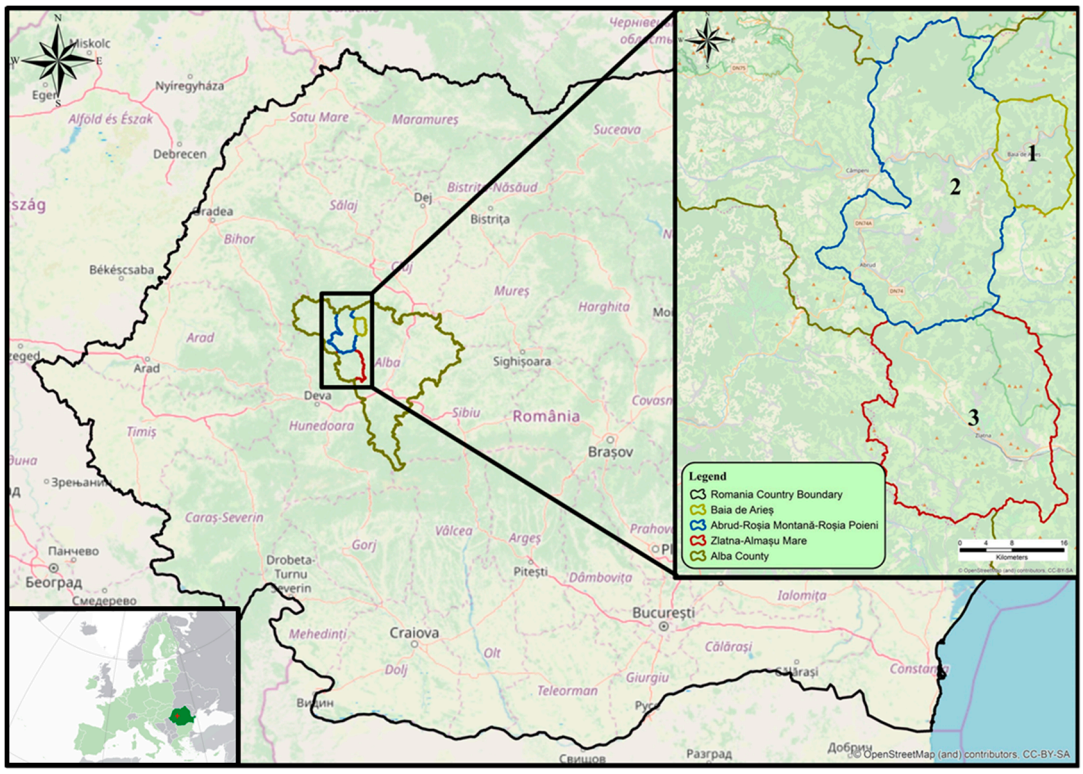

Figure 1. The location of the three mining areas.

Mining activities have been conducted here for millennia, since Roman times. The three mining areas, today comprising a population of 30,499 inhabitants (spread across 859.38 km^2), belong to the so-called "Golden Quadrilateral", whose name comes from the rich gold and silver ores of the region. Beside the silver and gold ores, complex ores (Cu, Pb, and Zn) were also mined in the area, and copper is still mined today in one of the three mining areas (Table 1).

Mining underwent several periods of more intense activities, dating back to the Roman period. Another interval of significant development in mining was the communist period, when many ore processing plants and tailing dams were built. The mining strategy during that period did not follow the sustainable development principles, to say the least. In its pursuit of industrialization, the communist regime considered neither the amount of necessary subsidies, nor the costs related to human resources or environmental rehabilitation. Once intensely industrialized, especially during the communist era, the region is nowadays on the edge of subsistence, with poor industrial and economic activity and an aged population.

There were two turning points that marked the history of this region, which are analyzed throughout this research:

1. The political regime change in December 1989, when Romania turned from a communist country to a democratic one;
2. The closure of the mines in 2004–2006.

These two critical junctures, the first of a political nature and the second one of a socio-economic nature, impacted the three mining areas to various extents. The first juncture—the collapse of the centrally

planned economy in socialist Romania—was a major turning point for Romania's economy. Interestingly, however, the mining industry survived for almost a decade, until 1997, when a right-leaning government decided to terminate the subsidies for the so-called loss-making mining enterprises [20,21]. Because mining is a capital-intensive industry, the withdrawal of state support for mining amounted to an abrupt/no-transition change in the local economy, which resulted dramatically in the second critical juncture—mine closures.

Table 1. Study area profile.

	Mining Area (MA)		
	MA 1 Baia de Aries	**MA 2 Abrud—Rosia Montana—Rosia Poieni (Still Active)**	**MA 3 Zlatna—Almasu Mare**
Territorial administrative units	1 town: Baia de Aries	1 town: Abrud 4 communes: Bistra, Bucium, Lupsa, Rosia Montana	1 town: Zlatna 1 commune: Almasu Mare
Population (and density in inh./km^2) in 1 July 2018 (The value at national level is 79.88 inh./km^2)	3922 (47.74)	17,433 (42.06)	9144 (25.20)
Population change in the 52 year period 1966–2018	−23.3	−26.1	−35.9
Median age of population in 2018 (The value at national level is 40.5 years)	45.5	43.5	44.0
Percentage of population aged 65 years or over (The value at national level is 16.4%)	17.6	17.7	19.4
Mining Area surface in km^2	82.14	414.45	362.79
Currently operating mines	None	S.C. Cupru Min S.A. Abrud (copper)	None
Closed mines	Ariesmin Baia de Aries (non-ferrous ores)	Rosiamin Rosia Montana (non-ferrous ores)	S.C. Ampelum S.A. Zlatna (processing plant)

Sources: Population and economic data from the National Statistics Institute of Romania.

2.2. Research Methodology

The methodological approach employed in this study was threefold, combining both qualitative and quantitative research.

Step 1: The most relevant social, economic, and environmental driving factors of sustainable development were considered, in line with the 17 goals of the 2030 Sustainable Development Agenda. The 2030 Agenda for Sustainable Development was adopted by all United Nations member states in 2015, with the purpose of achieving a more global sustainable future. The 17 goals are broad and interdependent and cover global challenges such as poverty, water and sanitation, industry and growth, climate change, environmental degradation, inequality, peace, and justice. The indicators analyzed in this paper include demographic dynamics, healthcare facilities, housing, infrastructure, economic sectors trends (extractive industry, agriculture, and tourism), and the quality of the environment. These were selected based on the available statistical data.

Step 2: A qualitative research method was used (i.e., in-depth, semi-structured interviews) to further explore historical evolution from the locals' perspective. Questions on this topic were embedded within a larger interview that also explored place attachment in the studied communities.

Step 3: After analyzing the statistical data and the local population perspective, the third and last step of the methodology focused on the local development initiatives that have the capacity of creating new development paths for the declining mining areas.

These three methodological steps enabled us to frame the current state of affairs of the region within a wider context of temporal change and to support it by testimonials of the residents in the three mining areas.

2.3. Data Collection

In order to describe the evolutionary trends of the mining communities in the three study areas, the social, economic, and environmental driving factors of sustainable development were explored over a 52-year time span. This period of time was chosen because the published literature [22] has shown that the life span of mines also influenced the degree of social and economic problems that will be analyzed in this paper.

Step 1: For this methodological phase, statistical data was gathered in order to identify the trend of the studied sustainable development indicators. The socio-demographic data was compiled for the period 1965/1966–2018 at the Administrative Territorial Unit (ATU) level in the study region.

The data was centralized from two main sources:

1. Data from 1965/1966 to 1995 retrieved from the country's statistical data archives;
2. More recent data, beginning in 1990, was extracted from TEMPO-Online—the free access statistical information database of the Romanian National Institute of Statistics.

During data collection, some inconsistencies were observed. For some indicators, data was only available until 2014, while in other cases information was missing for certain years. However, the available data and the long time span taken into account have enabled us to understand the past and current transformations that have shaped the path of these mining areas.

Step 2: Data for the second step of the methodology was gathered using an interview designed to obtain information on the local communities from respondents who were actively involved in the public life and/or were affiliated with mining activities from the study area. Therefore, thirty-nine (39) interviews were conducted between April and May, 2019, the interview respondents being selected from among local authorities (mayors, deputy mayors, head of the emergency department), local public institutions (doctors, teachers), local entrepreneurs (shopkeepers, touristic venue owners, and lawyers), the mining industry (former miners, employees/former employees of the mining companies), and mining opposition groups (environmental activists) from the region. Additionally, further interview participants were selected using the snowball-sampling method in order to represent maximum variation in the responses. The interviews lasted between 30 and 90 min each, and they were audio-recorded and transcribed. The interview protocol included questions regarding the residents' opinion on risk sources in the area, their perception of the pollution of the local physical environment, and their perception of the present situation as compared to the past. Their place attachment was also assessed. The analyses of the resulted interviews focused mainly on understanding how individuals from the communities perceived the changes that occurred in the mining area and how these changes affected their lives.

Step 3: The necessary data was gathered during field campaigns, from mayor's office websites, and from representatives of the local administration. The interpretation of these data, combined with the data from the previous two methodology stages, would lead to answers to the research questions raised by the paper.

3. Results and Discussions

To get a historic overview of these mining communities, the relevant sustainable development indicators were analyzed over five decades. This long period of time was useful for achieving a comprehensive understanding of the current state of these mining communities, considering the fact that mining communities that evolved over several generations are more likely to be affected by severe social problems caused by mine closure than those where mining activities were started or emerged more recently [22].

3.1. Industry

Driven by the resources of the area, the imprint of mining activities on the evolution of the other development indicators is unquestionable and it is therefore addressed first in the analysis. During

the analyzed period, the extractive industry had been mostly the only industrial sector gathering a workforce and generating industrial production in the area. Two indicators were analyzed: (1) the total global industrial production and (2) the global industrial production of non-ferrous metallurgy (including the non-ferrous extractive industry), and they were expressed in ROL (former Romanian currency). The first indicator was traced back to 1965, in Abrud, being 17.6 M ROL (~2.9 M USD at that time), a value that had multiplied thirteen times by 1985 (the last available data for Abrud).

The most productive town in the study area was Zlatna, with a total global industrial production of 292 M ROL (~48.6 M USD) in 1968, going as high as 2.65 B ROL (~635 M USD) in 1989 and 10 B ROL (~232 M USD due to inflation) in 1992. For the other localities, the growth trend of the production is proportional to those previously described. An exception was identified in Lupsa, a commune hosting the Rosia Poieni copper quarry, the largest in Romania and the second largest in Europe, where the growth was much more significant, given that the values increased twenty-five times until 1989 (see Supplementary Material—Table S1). In regard to the second indicator, i.e., the global industrial production of non-ferrous metallurgy, the figures also have an increasing trend from the 1960s or 1970s up to the 1990s (see Supplementary Material—Table S2).

The evolution of the three mining regions under study was marked by social and political turmoil in 1989, when Romania turned from a socialist republic to a democratic country. However, the change was not for the better regarding the extractive industry, as most of the mines were not considered cost-effective and, therefore, this industrial sector underwent an intense and harsh restructuring process. Eriksson and Hane-Weijman (2017) [23] state that specialized regions such as this one, which are dependent on a single resource and therefore are more vulnerable, might be more affected by an economic shock. The same idea is supported by other authors; the mono-industrial nature of these areas, together with the one and only management of the state, led to the lack of communities' capacity to adapt to the present crisis situation affecting the region [24]. The situation of this mining region was not singular. The same scenario developed in other countries as well [25,26] and all over Romania, especially after the fall of the communist regime, when the state was no longer capable of supporting the mining industry. The restructuring process of the Romanian mining sector started in September 1997 and consisted of mine closures and massive layoffs of people working in the extractive industry over a short period of time. With Romania's adherence to the EU in 2007, the mining activities were once more reconsidered, this time also from an environmental impact point of view. In 2007, the closure of 550 mines and quarries was approved, and approximately 370 towns and villages from 22 counties were socially and economically affected [27].

In line with the restructuring process at the national level, the Apuseni region also underwent the restructuring process, with all the subsequent effects on the socio-economic and natural environment. The mining activities in the study area ceased around the period 2004–2006. From the three state-owned mining companies operating before in the areas, nowadays only one is active—Rosia Poieni (S.C. Cupru Min S.A. Abrud), which has only 540 employees left from the 2900 that it used to have [28].

The intense industrial activity during the most productive years of the mine is deeply regretted by the locals: "*(The miners) . . . worked in four shifts, six hours per shift*" remembers one of the teachers. Regardless of their opinion of the past, the people in the study areas agree on the present 'decline' state: "*Everything is destroyed, all industry, the one that was polluting and the one that wasn't*" (former miner).

The average number of employees (all the persons with a valid working contract) experienced an ascending trend starting from 1975 (9856 employees), with small annual fluctuations, until 1989 (the year recorded as the peak, totaling 18,332 employees). After 1989, the trend was descending, with 4442 employees in 2018, decreasing by more than 75% (Figure 2).

The most dramatic decreases in the average number of employees were recorded in 1993 (from 16,274 in 1992 to 14,441 in 1993) and in 1991 (from 17,722 in 1990 to 16,109 in 1991). A professor spoke about the losses in the number of jobs over the final years: "*The mono-industrial town of Baia de Aries had, in the '80s, approximately 3000 miners, including administrative staff, and now it subsists on . . . let's say two institutions: the school, with approximately 60 employees, and the private sector, the clothing industry,*

which also reduced its number of employees from 2000 to 150". Overall, the respondents confirmed the lack of industry in the region, with a small number of employment opportunities for people. As a result, these people preferred to leave the region for better jobs and wages. Currently, there are two trends in the study area: (1) young people leave their homes, sending their incomes back in the community; (2) others choose traditional activities, such as agriculture, farming, timber harvesting, or tourism, that maintain low income levels.

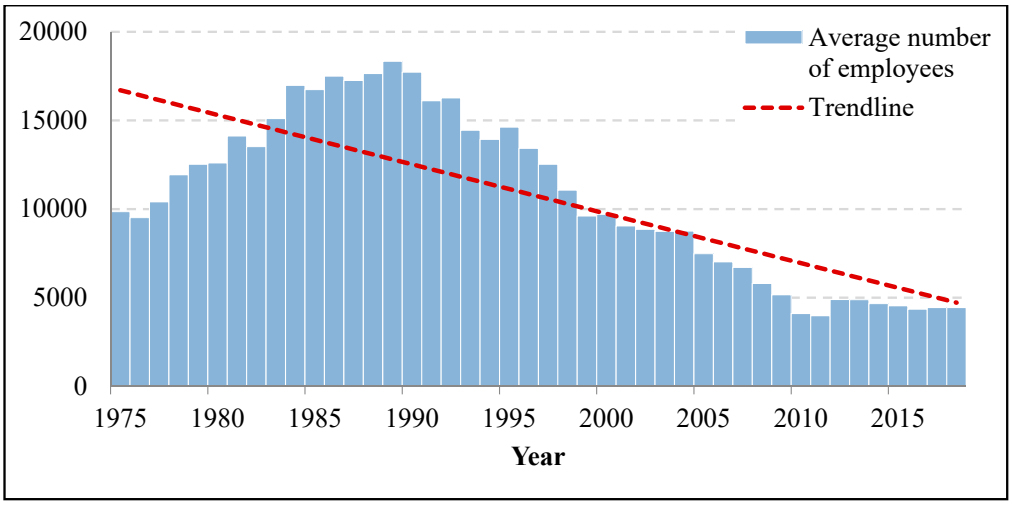

Figure 2. Average number of employees in the study area.

However abrupt the political regime change may have been, its impact on the mining industry was rather slow and manifested itself more abruptly only a decade later, in 1997, when the state ended the support for this industrial sector. This marked the start of the restructuring process of mining, which eventually led to the second critical juncture—the closure of the mines (except Rosia Poieni) in the three analyzed mining areas.

The lack of planning and investment in the local economy created a situation of indefinite conservation, with no transition period, and made it difficult for these mining areas to change their trajectories towards new development paths. Although these mining regions may have had a long prosperous period, as was the case in our study, the limited heterogeneity in resources is considered by scholars to affect their capacity to initiate new activities, which inhibits change and novelty [29]. However, even in the case of former or present mining regions, with mono-industrial activity, their long mono-industrial evolution does not necessarily have to create lock-in type trajectories, as new paths can derive from the old ones, which can lead to renewal and rejuvenation [30,31]. To conclude, the old path of industrial development (1965–1989) was based on a broadly shared purpose [21]. After 1990, and most clearly in 1997, this common purpose began to dissipate and the industrial basis of the regional economy followed a descending path.

3.2. Demographic Profile

The demographic dynamics were undoubtedly influenced by the booms and busts of the mining industry. The permanent resident population of the study area in 2018 was 30,499 persons (56.4% in urban areas and 43.6% in rural areas), recording a continuous decrease. The population has decreased dramatically, by 29%, over the last 52 years. The major demographic collapse must be highlighted: −28.6% in 2018 as compared to 1970 and −29.0% in 2018 as compared to 1966 (See Supplementary Material—Table S3).

The closing of industrial facilities, including the ones in the mining sector, caused a negative evolution of the number of residents in other areas of Romania as well, such as Banat [32] or Cavnic [33]. However, Borsa, in the northern part of Romania, followed a different demographic trend; the population here

increased by approximately 900 residents, from 29,017 in 1996 to 29,921 in 2017 [33]. This different trend is due to the particularity of the town of Borsa, where a large proportion of its workforce migrates abroad temporarily or permanently, even though they are counted among the town's permanent residents.

The population dynamics were more profound in rural areas, registering a decline of 40.6% over the last 52 years. In urban areas, the population has also decreased over the last 30 years by 9.5% in 2018 as compared to 2009 and by 16.5% in 2018 as compared to 1970. Regarding the gender distribution, there is a balance between the male and female population, with an average value of 50.5% and 49.5%, respectively, in 2018.

Over the last 50 years, the population dynamics in towns and villages underwent frequent fluctuations, with the total population decreasing or increasing. Thus, the highest rates of increase/decrease over the last five decades were +6.0% in Abrud and −68.6% in Almasu Mare (See Supplementary Material—Figure S1).

Figure S1 illustrates not only the variation rates over the five analyzed decades, but also the rates over relevant time periods, such as economic growth (before 1989), post-communist transition (1989–1999), mine closure and restructuring (1999–2009), and the present (2009–2018).

Figure 3 shows age group dynamics over the last decade. The most significant decrease (−29.3%) was experienced by the 0–14 age group, while the 65 years and over age group increased.

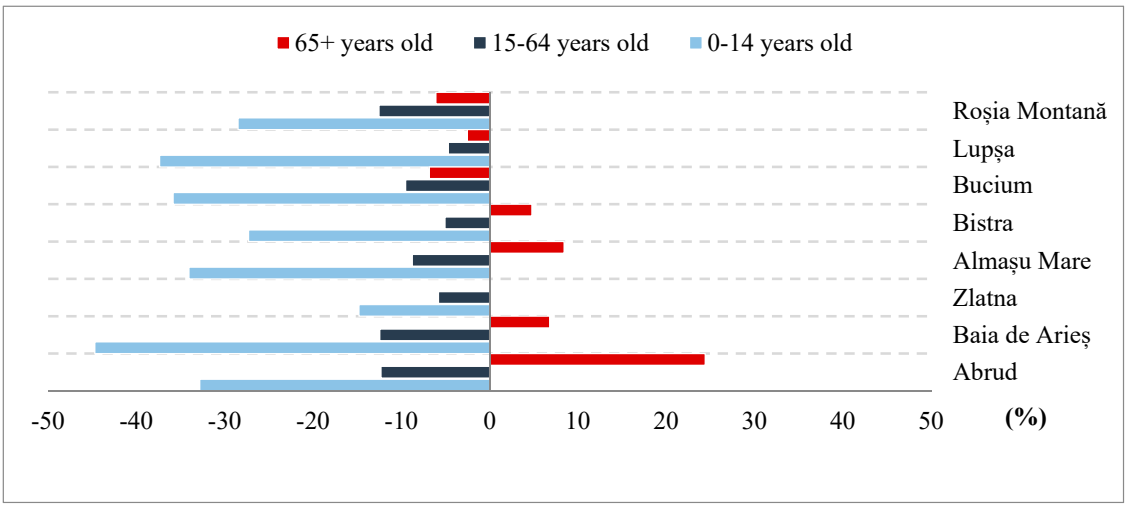

Figure 3. Population growth rate by large age groups over the last decade in the study area (%).

The demographic dependency ratio ranged in, 2018, from 34% to 54% in the study area. In the last decade, the demographic dependency ratio of youths decreased slightly in all the towns and villages in the study area, while the demographic dependency ratio for elderly recorded a general increasing trend. In 2018, the ageing index was 127 in Rosia Montana and 332 in Bucium, values that are visibly higher than the values in 2009; i.e., 85 in Abrud and 229 in Bucium. The ageing trend of the population was also recorded at the level of the Apuseni Mountains [24] and at the national level [34].

The rate of natural increase recorded a sinusoidal decreasing trend in the 52-year analyzed interval. As such, two distinct stages can be noticed:

1. The 1966–2000 period, with positive values (the highest value recorded +16.9‰ in 1970);
2. The 2001–2018 period, with negative values (the lowest value −20.4‰ in 2004).

Figure 4 shows the average rate of natural increase for all the administrative territorial units (ATUs) in the study area during the analyzed period.

This sinusoidal trend was also experienced by other mining settlements in Romania; for example, in 1992, the natural birth rate had positive values (Cacica = 15.9‰; Carlibaba = 15.9‰; Iacobeni = 15.4‰, Fundu Moldovei = 12.9‰) while, in 2002, this rate registered a negative increase (−6‰ = Iacobeni, −4.7‰ = Fundu Moldovei) [35].

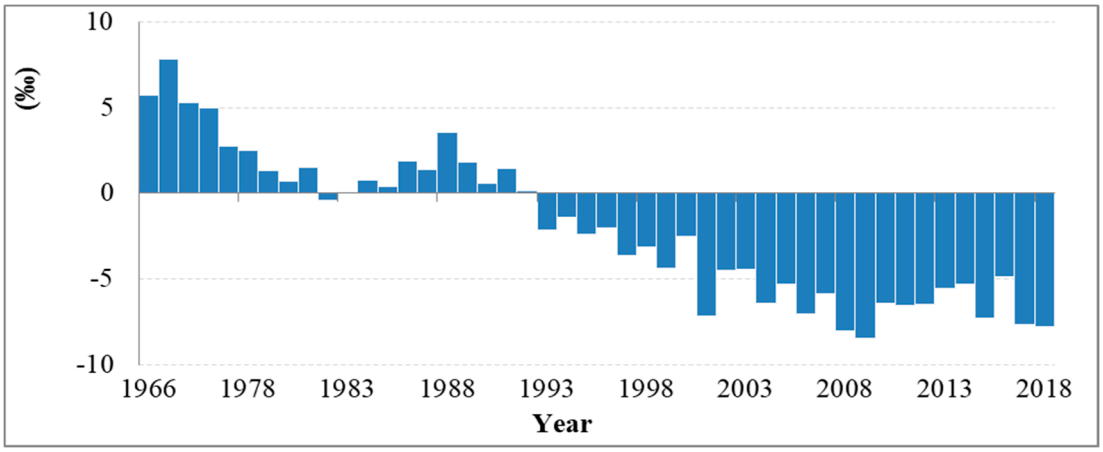

Figure 4. Average rate of natural increase (‰).

According to [22], the mining areas where the population is relatively older are more vulnerable to severe social problems generated by the closure of mines. In our study area, the decrease of young age groups and the ageing index over the last 10 years demonstrates the highest increase of the number of old people per 100 young people, especially in rural localities but also in some urban localities, such as Abrud. The increasing trend of the demographic dependency ratio for elderly, both in rural areas and in urban areas, coupled with the other social and economic issues in the study area have a negative impact on the social pillar of sustainable development. In the same way in which the booming industry of the 1960s–1980s period attracted a large workforce to the three mining areas, the path of industrial decline was paralleled by demographic contraction due to out-migration and population aging.

3.3. Education

Education is usually seen as a resource for sustainable development [26], but its effects are mediated by the economic opportunities. In the study area, the school population enrolled in the national education system (including kindergarten, primary and secondary school, and high school) followed the population trend. Indeed, the upward trend started in 1965 (6237 children enrolled in the education system) and continued until 1978, when it reached its peak of 11,296 pupils, which coincided with an ascending development path. This increase was further enhanced by Decree 770, issued by the communist regime in 1966, which was aimed at an accelerated increase of the Romanian population by restricting abortion and contraception. Afterwards, the trend decreased constantly until 2018, when the total school population was 3273, mainly due to a decrease in the total number of residents. The respondents also perceived the decrease of the school population as a dramatic social effect of the economic recession. A history professor said: "*Currently, there are fewer children; we now have only two grades, in the past we used to have four grades and children came from a larger area*".

The number of education facilities had a similar trend; starting with 54 school units in 1965, their number increased, reaching a peak in 1979, and then decreased until 2018. The period 1977–1980 was one of development; the number of kindergartens and schools was the highest and the high schools in Abrud and Baia de Aries were built. Since 1999, there have been only three high schools in the three towns in the study area.

The decreasing trend in both the number of pupils and teachers identified in the study area is a relevant indicator because it is more difficult for uneducated people to have better employment options and therefore the chances of having a low standard of living are higher. While [36] promote the creative class as the main development factor in any region and [26] propose that, in such areas, authorities should attract more secondary schools or universities and their branch establishments as a factor of human development, in the mining areas analyzed in this research, due to the decreasing number of children, the development of new secondary schools or university programs is not feasible.

The steeply declining demographic trend thus prevents the sustainable development potential of education from unfolding and generating new paths. In response to Research Question 3, this situation is thus generally perceived as a drawback by some local stakeholders.

3.4. Healthcare Facilities

Access to healthcare is an important factor in sustainable development. Out of the three hospitals in the three towns that were open in 1968, only the one in Abrud was still operational in 2018. The hospitals in Baia de Aries and Zlatna were closed in 2011. As for the healthcare capacity, the number of hospital beds in the region followed the population trend; from 1968 to 1977, the number of beds available in the three hospitals increased from 300 to 529. The most prominent increase was recorded in Baia de Aries, where, from 1968 to 1977, the reported bed count increased by 278%. After that, the number of hospital beds remained relatively steady until 1991, when a major decrease occurred; in just one year, the bed count in the three towns fell from 550 to 375. This trend kept on, and only 190 beds were available in hospitals in 2010. Two out of the three hospitals closed down in 2011. From 2011 to 2018, the bed count in the hospital in Abrud remained constant: 85 (See Supplementary Material—Figure S2).

The decline of specialized health capacities in the region was mostly felt in Baia de Aries, mainly due to its geographical position and bad road infrastructure. In this regard, one public official noted that if somebody from Baia de Aries needed urgent medical care, it could take hours until the patient would get specialized medical help: "*From here (Baia de Aries) to the neurosurgery intensive care unit from Cluj-Napoca, the roads are really bad, there are many serpentines, it takes one and a half hour for the ambulance to get here*".

The number of medical offices also changed; the number of medical dispensaries increased gradually from 10 in 1968 to 16 in 1997. In 1998, the number of dispensaries dropped to 12, and from 1999 on there is no data available. In 2002, the Romanian healthcare system was restructured and the medical dispensaries became medical offices, mostly for family medical practitioners. The number of medical practices increased from 9 (2003) to 13 (2018). However, while in some towns/villages the number increased (Zlatna, Bistra, and Lupsa), it declined in others (Abrud and Baia de Aries). Additionally, a local doctor noted that not every rural settlement from the region has easy access to these health facilities: "*There are many elderly people who cannot come to the medical office. Once a week, I change location to be more accessible for the elderly living in more remote regions*".

The number of doctors increased from 27 in 1965 to 80 in 1988. After 1988, a decreasing trend in the number of doctors was recorded, from 80 in 1988 to 48 in 2018. A significant decrease in the number of doctors occurred in 2011, most probably attributed to the closure of two hospitals in Zlatna and Baia de Aries. Afterwards, the number of doctors began to increase once again.

The decline of healthcare capacities also took a toll on the sustainable development of the three mining areas. The steep decrease in the number of healthcare services and healthcare workers made access to healthcare, especially emergency care, really difficult in some regions. In recent years, the number of medical offices and doctors is on the rise and there are also plans to open new medical facilities. However, more remote communities are still struggling to access healthcare services. The poor health conditions of the individuals living in mining communities impair their ability to find stable work, thus deepening their poverty level and stunting local initiatives and potentially new paths. The poor health conditions, lack of employment, lower earnings, and the resultant high malnutrition can increase the risk of disability among the people living in the mining communities, who could already be battling with visual impairments, mine-pit injuries, and respiratory diseases [37,38]. In order to sustain the development of the area, it is recommended to build hospitals or other healthcare facilities, which are beneficial infrastructures for the entire community.

3.5. Housing

Following the analysis of the number of dwellings recorded at the end of the year, a general upward trend can be noticed up to the level of 1990, followed by a sharp decrease (See Supplementary

Material—Figure S6). It is well known that during the communist period the authorities were actively involved in housing development, hence the rising trend before 1989. In the 1990–2000 period, the trend is rather linear; major differences in the dynamics of the number of houses are recorded after the year 2000. Analyzing the dynamics of the number of dwellings in the towns of Abrud and Zlatna, an inverse proportionality relation can be observed in the 2001–2011 interval. This trend can be explained by a change in the polarizing character of these two towns. In the case of Rosia Montana, beside the marked decrease from 1989, the statistics reveal another prolonged downward trend, starting with the year 2002, when a mining company that was interested in investing in the area bought a number of houses from the villagers.

Generally, the situation in the real estate sector during the intense activity in mining was affected by the decisions made by the authorities regarding the construction of complex mining objectives such as tailing ponds. According to a local ecologist, following the construction of such objectives, entire communities were relocated: " . . . *Where the village of Geamana was in the 80's, there were hundreds of houses*". For the most part, relocations were also made in other localities in the study area, with very few people leaving the area. This fact meant that these variations were not covered in the available statistical data.

Regarding the total inhabitable area at the end of the year, a constant increase was noticed in almost all cases. This fact may be due to the rising standards and necessities of living as a national trend.

Analyzing the indicator regarding the number of houses completed during each year since 1975, a strong decreasing trend is noticed. Most of the interviewees not born in the study area said that they moved to the area in the late 1970s–early 1980s period. The main reason for their relocation to the area is related to the newly-created jobs available in the area due to mining. To accommodate the large number of people employed in the mining sector or associated sectors, the authorities built a very large number of dwellings in a rather short timeframe (1975–1985). This fact is narrated by one of the residents during the interview: "*A miner from Baia de Aries was earning at that time as much as a minister . . . houses were built here overnight, which I think will not be done here in the next 30 years.*" This situation is not singular because housing development was a top priority for the state or the mining company in the case of new mines or mine expansion, to respond to the urgent need of housing the miners [39]. However, this approach to create "open" mining towns and to use homeownership as a tenure option for housing programs is a failure because it does not consider the long-term implications of both mining and town development [40].

Statistics show that the number of dwellings completed by the end of the year is, broadly speaking, proportional to the total number of dwellings, regardless of whether the analyzed locality is a town or a village (See Supplementary Material—Figure S3). This proportionality has not been that obvious over the last two decades due to the small number of dwellings completed by the end of the year in the entire area. The low number of newly built homes in recent years is linked to issues related to economic profitability, as a former trade union leader mentions: "*I honestly tell you that I'm sorry that I built a house here and I have a house that cost me 200,000 Euros. And I'm sorry that I made the investment here, because I don't think I'll even get 100 (thousand Euros) if I sell everything I have here*".

The statistical analysis of data related to housing infrastructure showed that the influence of the political climate on development directions at the local level is very strong. The year 1989 (the end of the communist regime) represented the maximum point of development in the study area from this point of view. Both the forced urbanization process and the emergence of jobs in the mining field (an area that proved unsustainable with Romania's accession to the market economy) initially caused the increase of the housing fund, but as soon as the mining companies were no longer subsidized by the state and they went bankrupt, neither the people nor the authorities invested any more in maintaining or developing the housing infrastructure. Meanwhile, the older real estate stock began to deteriorate as its inhabitants (the aged population in the entire mining area) grew older and lacked the necessary resources to invest in it. This real estate, which is in rather bad condition, could be restored and converted into tourist accommodation, while former public buildings (miners' canteen and locker

rooms) could be transformed into exhibition spaces, being ideal starting points for thematic tours of the mining and other heritage sites in the region [41].

3.6. Infrastructure

The total length of roads in the study area in the three towns, Abrud, Baia de Aries, and Zlatna, varied slightly from 116 km in 1976 (the first year with available data for all towns) to 104 km in 2018. However, the situation of rehabilitated roads is different, as the total length of rehabilitated roads almost doubled from 24 km in 1976 to 51 km (half of the total road length) in 2018. This increase may be explained by the fact that the existing built roads have all been rehabilitated over the last decades.

The total length of the drinking water distribution system increased in the three towns from 11 km in 1968 to 44 km in 2018. Major increases occurred after the fall of the communist regime and around the year 2010 (with the peak in 2014). The interviews showed that there are currently households with no water infrastructure, but efforts have been made to implement and to develop the drinking water system using European funding. This is also supported by the opinion of an administration official, who declared: *"Zlatna comprises 18 villages, which are all modern, with gas system and water and sewage systems, where possible . . . . We were able to bring electrical power and water supplies to all remote villages"*. Similarly, the total length of the sewage system in the three towns (Abrud, Baia de Aries, and Zlatna) tripled in the 1965–2018 period.

The availability of infrastructure in the three study areas poses several problems that directly reflect on the people's quality of life and community development. All factors related to infrastructure (roads, water supply, and sewage system) have an equal contribution to obstructing the sustainable development of the study area. Although the local authorities struggle to develop these areas, there is little administrative capacity for strategy building, planning, and control in such small and medium sized towns and, unfortunately, the political agenda pays little attention to this type of mining region [26]. However, of crucial importance in promoting post-mining development paths is the valorization of artefacts (buildings, infrastructure, landscape sceneries, etc.) and traditions left behind by the mining past [26]. The sustainable transformation of mining regions is not a utopian project, and this is proved by successful examples like the Ruhr District in Germany where no less than 89 projects were realized with extensive state support [26,42,43]. There is a great need for significant financial and political backing by the state and for the identification of potentials in such regions to facilitate their integration in holistic urban and regional development concepts [26].

3.7. Tourism

One of the new paths emerging from the old mining tradition is tourism related to mining objectives. In term of tourism, three indicators were considered. The first is the number of tourist establishments in each village/town. In the period 1970 to 1983, there was only one tourist establishment in the town of Abrud. Then, starting in 1984, another touristic establishment was opened in Zlatna and, after 1985, two others were opened in Lupsa and Rosia Montana. In 2019, there were tourist facilities in all towns and villages in the study area. The second indicator was the capacity of tourist accommodation establishments calculated as the number of accommodation places multiplied by the number of days the touristic establishments were open. This indicator started from 47 places-days in Abrud in 1970 and reached 18,436 places-days in 2018, with high numbers in all the other villages and towns. The third and last indicator related to tourism was annual occupancy (arrivals and nights spent by tourists), which rose from 7 in Abrud in 1970 to 693 in 2018, with values ranging between 68 (Almasu Mare) and 924 (Baia de Aries).

The opinions of the residents on tourism development are divided: some support the idea of tourism as an alternative to mining, while others consider that tourism is not an option and mining is still the easiest way to develop the region. Those supporting tourism even have ideas such as developing ski slopes and agritourism or opening mining galleries or specific mining landforms—"gropane" for tourists (mayor), setting up touristic attraction sites like Detunata rock in Bucium (Geography

professor), or even artisanal mining as a leisure activity for tourists (former miner). However, all of them agree on the deplorable state of the roads and infrastructure, improvements to which are necessary for tourism: "*In the upstream area, tourism is an alternative, but the roads, . . . I tell you, pothole near pothole*" (entrepreneur).

Some authors [26,44] argue for the contribution of tourism as an economic indicator that translates into economic development at the local level. In their opinion, the key factor is not the number of tourists, but the profits of the local economy from tourism-related services [44]. In the three mining areas of the Apuseni Mountains, tourism services have only been developed locally, as will be discussed later, and only by individual initiatives and not as a part of the strategic planning of the mining areas. Moreover, the tourism development initiatives are sometimes hindered by the uncertain status of some mining areas, such as Rosia Montana, where there are several perspectives on sight [45]. Overall, however, tourism seems to be able to foster the development of localized secondary paths, which sometimes run counter to the overall economic decline. Some local stakeholders have eagerly seized this opportunity and are optimistic about the future.

3.8. Agriculture

In Romania, data concerning land use is available from 1968 up until 2014, when new data entries are blocked on the national level and will continue to be so until the national cadaster is updated. In this period, the agricultural land area decreased by 19%, from 38.888 ha in 1968 to 31,479 ha in 2014 (See Supplementary Material—Figure S4). In 2014, the highest percentage of agricultural land surface out of the total land surface was recorded in Mining Area (MA) 2 (41%), followed by MA 1 (39%) and MA 3 (36%). Among the three analyzed mining areas, MA 3 recorded the most pronounced agricultural land loss over the years, with 30% of the agricultural land used for other purposes by 2014. A similar trend was recorded in MA 2, while in MA 1 the surface of agricultural land remained fairly steady, with only 3.7% of the agricultural land repurposed by 2014.

The reasons behind agricultural land loss are twofold: it is either due to land degradation or the land is converted for other purposes [46]. In Romania, comprehensive statistical data regarding the use of non-agricultural land is available from 2010 onwards, and includes degraded land, built environment, forest vegetation, and water bodies. According to data on land degradation, 6206 ha from the total surface area (8%) is unproductive land; 14% of the surface of unproductive land can be directly attributed to mining—878 ha of the land surface is covered by tailing dams or waste heaps. MA 2 has the highest share of land degraded by mining activities; 750 ha of its surface are covered by mining waste [47]. As for the distribution of unproductive land area among the three MAs, the trend is in line with the agricultural land loss; 58% of the unproductive land surface is in MA 3 and 40% is in MA 2, while just 2% is in MA 1. When it comes to land productivity, the opinions of the interview participants are contradictory. One former employee of a mining company argued that the soil in the region was fertile and not polluted "*Because potato production is really good. And fruit trees never yielded such a bountiful harvest as last year*". Meanwhile, others reported a decrease in land productivity as compared to the past. Among them, a public official declared that, in the 1970s and 1980s, the agricultural production was more diverse and that "*At present, for example, we can no longer cultivate cucumbers or tomatoes unless they are planted in solariums or if they are sprayed with pesticides*". The reasons behind the decline of land productivity were perceived differently, some of the participants mentioning pollution, acid rains, and climate change as the main factors, while others argued that the soil quality was poor in the region, given its geographic location.

Agricultural land use function also underwent some changes. The surface of arable land and pastures changed most prominently over time. From 1988 to 2014, the surface of arable land decreased by 63%, with the largest area loss in MA 3, while the surface of pasture increased by almost 20%.

The post-mining landscapes are very different from the traditional rural landscapes characterized by agriculture and forestry [26], especially when it comes to open-pit mining. The situation in this

study area was not similar to that of other former mining regions, where a disproportionately high share of agricultural reclamation was enforced by state authorities in the 1970s and 1980s [48].

The agricultural land functions changed considerably over the years, indicating that, at present, agricultural practices are mostly limited to small-scale farming and animal husbandry. Access to such agricultural assets can contribute to sustainable development, especially at the household level. However, while agricultural activities are preserved by some as a tradition at the moment, lack of workforce due to population ageing or decreased land productivity due to pollution and climate change may jeopardize these practices in the future. Therefore, to ensure the profitability of agriculture in the region, (Government) funding schemes are important to stimulate agricultural activities. Additionally, as an alternative, mining land could help reduce the pressure on agriculture if used for biomass production, where contaminated land cannot be used for food production [26]. However, the three areas are not particularly rich agricultural areas, therefore agriculture in itself could at most develop into a subsistence economic sector.

3.9. Quality of the Physical Environment

The quality of the physical environment in the study area was determined mainly by the technologies used in the extractive and processing industry, by the measures taken to protect the environment, and by the quality of the mine closure and conservation work. During the intensive mining operations during the period 1970–1989, the environmental quality was not a priority for the communist regime, which was more concerned with increasing production and profit. For example, regarding the air pollution in Zlatna, during the time of intense metallurgical processing, the annual emissions were 150,450 tons of SO2 and 3498 tons of dust with Pb, Zn, Cu, Cd, Sb, Bi, and As [49]. This is supported also by testimonies of residents: " *. . . They did not use filters, everything came out into the air and we felt it when breathing and the nature felt it*" (economist).

Whereas the air quality has greatly improved after the closure of the mines and the processing plants, the soil and water pollution still persist in the study area. Acid mine drainage (AMD) is a serious threat to the quality of underground and surface waters. Hence, in the Rosia Montana-Rosia Poieni area, the mine waters flowing from the old galleries bear high concentrations of Al, Fe, Cd, and As, whose toxicity increases because of the low pH; e.g., <3 in Rosia Poieni [50,51]. The Abrud creek and the Aries River are also polluted by waste water leakages and levigation of waste rocks by rain waters from the tailing dams [52–54].

Soil pollution is also ongoing in areas where the rehabilitation and revegetation of the waste heaps and tailing dams failed. The population is also aware of the pollution and the failure of the mine closure process: "*Mine conservation was conducted superficially*" (retired teacher). "*Mine waters and surface waters, indirectly, . . . are polluted with heavy metals, cadmium, iron ores, copper, and whatever is there. This is why the acidity is very high, with a three–four pH value. . . . The soils are also affected, especially in the area of the open pits and the tailing dams, the same components affecting the waters. As you know, the soil needs a very long period of time to recover*" (Geography professor).

Another threat is posed by the poor stability of the tailing dams, especially the operational one at Valea Sesei, with recent and frequent accidental discharges [55] and water quality indicators often exceeded [56]. This is also perceived as a high risk by the people in the area: "*Since the storage capacity is exceeded, risks and accidents can happen. It happened two or three years ago, when a pipe that pumped the tailings into the dam broke. Huge amounts of water and sludge reached the main course of the Aries River. It impacted the aquatic ecosystem and not only that.*" (university professor). Far from having a reduced environmental footprint, mining has created new landscape features that, in combination with the existing natural capital, can form the basis for promising local initiatives.

3.10. Revitalization Opportunities for Future Development Paths

Successful examples all around the world have shown that former mining areas can be reused to provide social, ecological, and economic benefits [13,57]. Some mines have become touristic attraction

points (Kansas, Texas, USA; Wieliczka, Poland), public parks (Konya, Turkey; Lawrence, MA, USA), stadiums (Braga, Portugal), solar power plants (Senftenberg, Germany) or UNESCO sites (Rosas mines in Sardinia—Italy, Almaden Mining Park in Spain, Falun Mine in Sweeden, Cornwall and West Devon in the UK) [13,58–61]. But for these transformations to take place, large projects approved by authorities and supported by governments need to be considered. In the study area, there is one site (Rosia Montana) that has been submitted to the UNESCO World Heritage List. Rosia Montana's inclusion on the UNESCO list was resumed in January 2020, after it had been withdrawn by the previous government who attributed their decision to possible negative impacts in the ongoing lawsuit at the International Centre for Settlement of Investment Disputes, where the Canadian group requested compensations, claiming that the Romanian government had blocked the development of their mining project [62]. The inclusion proposal was to be discussed during the 44th session of the World Heritage Committee that was to take place in China in the summer of 2020, but it was postponed due to the Covid-19 pandemic.

Of the three mining areas, Zlatna-Almasu Mare is the area where most investments in rehabilitation and remediation were made. Almost all lands affected by pollution have been cleaned up and subjected to the reclamation process. However, there are no large reuse perspectives in this area. The former mining town of Baia de Aries has also benefitted from remediation and rehabilitation projects funded by the World Bank, but the cleaned areas have not been used for any other purposes. Despite the rehabilitation and reclamation projects, there are still hot spots (such as the Valea Sesii tailings pond of the Rosia Poieni copper mine in MA 2), which threaten the water of the river Aries and, through the rivers Mures, Tisa, and Danube, pose cross-border pollution risks [21].

Considering the current situation in the study area (outdated, insufficient, and unmodernized infrastructure), the local authorities have focused in the last few years on implementing specific development projects. Generally, the main local projects were implemented following Romanian's accession to the European Union with the support of European funding. As such, starting in 2007, major investments focused on primary utilities and infrastructure in all ATUs: the rehabilitation and modernization of transport infrastructure (streets, communal roads, etc.), technical-municipal infrastructure (the establishment of a drinking water supply network, sewage, and treatment plant), rehabilitation, modernization, education facilities, social, health, and leisure infrastructure (including sports).

These projects improved the local authorities' experience in writing and accessing grants and implementing infrastructure projects, which is beneficial for the future as numerous investments are planned (See Supplementary Material—Table S4). These investments consider mainly the technological development of the area, tourism promotion, the increase of the local features visibility, and the involvement of the communities in developing local initiative and policies.

However, discussions with the local authorities demonstrated a short-term thinking in many contexts, poor collaboration at the territorial level, and poor performance in attracting investors. On the other hand, while authorities concentrate on ensuring the basic needs of the communities, the civil society is struggling to identify means for diverging from the old paths, through local initiatives. These initiatives are more frequent and better organized in Rosia Montana, where residents and non-residents opposing the new mining project have joined their efforts into actions to attract tourists and provide them with diverse entertainment services. Among these are bike rental, hiking in the area, guided tours by local herbalists to discover the local flora, workshops to produce natural products, other guided tours, visits to the mining galleries, and movie nights. Local dairy products and vegetables are also promoted by the initiatives of the local communities. Not all of these are completely new paths of development, as many of them stem from the old one related to mining; e.g., visits to several mining museums in the area (private mining museum "Emilian Achim" in Almasu Mare, the Mining Museum in Rosia Montana, and the Buciumani Museum in Bucium), visits to old mining galleries, entertaining activities for tourists involving old mining artisanal techniques, etc. All of these efforts also benefit from the fact that the area is well known in the country and abroad due to the massive protests surrounding the intended mining project in Rosia Montana [63,64] and the intense media coverage.

Conclusively, with the downsized but still profitable operation of the Rosia Poieni mine and the revitalization opportunities identified above, the second mining area (MA 2) has experienced a relative boom—relative bust situation, combining the old-path and new-path development opportunities. With considerable infrastructure investments and major ecological reclamation work at the former mining facilities already completed, the Zlatna–Almasu mining area (MA 3) can be seen as turning away from mining and looking for new development paths. On the other hand, MA 1 (Baia de Aries) still lacks a planned replacement of the mining industry and undergoes an indefinite decline.

4. Conclusions

The importance of socio-economic elements in reaching the sustainable development of the communities in the analyzed mining areas cannot be overlooked. Specifically, the demographic and socio-economic profile of these communities revealed a lack of the resources necessary for dealing with external or internal disturbances.

The concentration of employment in one specific sector (i.e., the extractive industry) indicated a high dependency level; when the specific industry declined, a large number of people lost their jobs or experienced long unemployment periods.

After the closure of mines and processing plants in the area, the communities relying mainly on the extraction and processing industry faced major economic and social problems, and they are currently experiencing a state of decline. Moreover, during the years of intense metallurgical processing and extractive activities, the quality of the physical environment degraded because environmental protection was not a priority for the communist regime. This also decreased the chances for the communities to engage in new economic activities such as tourism or agriculture.

The analyzed factors revealed few promising sustainable development capacities because of the aged population, the decline of healthcare and educational capacities, as well as poor infrastructure. However, there are some factors that could contribute to SD, such as tourism, agriculture, or investment opportunities attempted by the local authorities. People's perception of their place, the strong sense of belonging, and the history of these communities represent warranties for the existing development potential of these small mining towns and villages, despite the many challenges they might be facing.

Considering their specific characteristics, mining communities require tailored policies and strategies for their development following mine closures and the downsizing of mining activities. These communities, once highly dependent on mining activities, are currently facing a lack of employment opportunities due to the low level of economic diversity. Policies should be designed to diversify the local economies and to provide more jobs and employment opportunities. The planning strategies should address the issue of the ageing population by encouraging child birth and improving living conditions for young people in order to keep them in the community because they have the ability to support its redevelopment. These social policies, together with infrastructure development, land use planning, and ecological rehabilitation strategies will provide local communities with more opportunities for sustainable development. Citizen engagement in their local policy-making and planning is an asset with a significant impact on reaching sustainable development. Although the interviews revealed a high level of place attachment and concern for community issues, citizen participation as a characteristic of developed communities was not addressed in this paper and needs to be discussed in future research.

The structural obstacles that have limited these communities to the use of only one resource type, combined with the weak governance tools to find and implement other sustainable development paths, may continue to keep these communities locked in their current state of decline. In response to the question of whether sustainable development is possible after mining, it can be argued that the overall conditions are not conducive to sustainability, given the intertwined industrial and demographic declines, but new development paths can nevertheless be achieved in particular local contexts.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/23/9791/s1: Figure S1: Population growth rate in the study area during the last five decades (%); Figure S2: Number of

hospital beds; Figure S2a: Number of hospital beds and trendline for all three mining areas; Figure S2b: Number of hospital beds and trend per each town; Figure S3: Number of dwellings completed by the end of the year; Figure S4: Agricultural land area; Table S1: The total global industrial production (in thousand ROL); Table S2: The global industrial production of non-ferrous metallurgy (in thousand ROL); Table S3: Population changes 1966–2018; Table S4: Investment projects of the local authorities in the three mining areas.

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