Rehabilitation opportunities of geomorphological modified lands in Panga Open Pit – Coal Basin Berbești

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Abstract. Recovery and reuse of the lands affected by mining activities in the Panga open pit is carried out on a complex project that takes into account pedological, agrochemical and spatial aspects that highlight the physico-chemical properties of the land and, implicitly, the productive and recreational potential. The importance of eliminating or mitigating of the anthropic impact and of land reuse also arises from the fact that once restoration works are completed, the influence of the mining activity on the environmental factors will be considerably reduced and the vegetation, fauna and zonal microclimate will be restored. One of the major consequences of mining activity refers to significant geomorphological changes. In the present paper, these geomorphological changes generated by the mining activities are analysed in order to identify the land reuse opportunities, to ensure the premises of sustainable development of the region.

1 Introduction

This paper is part of a broad geomorphological research applied to the Berbești Basin mining, which has as general objectives mining as a phenomenon of morphogenesis, dynamics and morphology of works surface mining, but also the impact of mining in the area, as well as ecological conversion solutions for coal open pit Panga (one of the open pits of the Berbești Mining Basin), favoring significant opportunities for business development in agriculture, industry, commerce, crafts, recreation, sports, entertainment and tourism.

This paper presents a proposal to choose the type of re-use of the land affected by the geomorphological changes in the Berbești Mining Basin, taking into account the requirements of the local population, but also the adjacent environment, which are two of the important principles of ecological planning.

Recovery of degraded land from mines and geomorphological changes in the economic circuit comes to meet a requirement of current legislation on the one hand, and on the other hand, a requirement of the local community, thus solving the problems related to: eliminating the risk of sliding of positive relief forms occurring in a territory by depositing the sterile material in the external waste dumps; the elimination of the negative visual

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impact of the selenite areas; the need to reintegrate the degraded areas into the productive and/or ecological circuit of the regions where they are located, which leads to the regeneration of their economic potential; improving the quality of the environment; reducing slopes and, together with it, diminishing the intensity of erosion phenomena and accelerating the vegetation installation process; the possibility of creating new spaces for the storage of different types of waste in the pitfalls of quarries. [1]

The main geomorphological changes caused by the mining activities in the Coal Basin Berbești are: the emergence of quarries and the occupation of the land, the appearance of tailings dumps, the occurrence of remaining gaps, micro depressions, landslides and subsidence, erosion, all forming the mining geomorphological landscape. [2]

As the chances of sustainable development of the region under the conditions of recovery and redevelopment, we mention: the attractiveness of the area, the increase of the living standards and the quality of life, the valorization of innovation and technology, the economic growth of the area, the protection of the environment, the capitalization of human capital, the identification of the right solutions for integration, reuse, mining after closure and greening, capitalization of resource potential, reducing risks and mitigating the dysfunctions caused by natural and anthropogenic phenomena, efficient management of existing resources, development and valorisation of partnerships at local, regional, national level, planning of policy directions and policies sustainable development. [3] In this regard, choosing the most suitable destination for these lands is an important premise for the success of ecological rehabilitation.

2 Steps needed to choose the type of land reuse from Panga Area

Choosing the types of reuse of degraded land is a rather difficult decision-making process that involves several important players, including Berbești's regional development plan, the local community's requirements, the area's tourist attractions, and the equivalence between these indicators. [4]

Nowadays, mining activities are underway in Panga's open pit until 2023 under the operating license, but there are also land that can be considered for the start of redevelopment work. The paper presents a global approach to the rehabilitation of the Panga quarries, and the elements considered are the residual gap, the inner tailings pit, the lake, the adjacent areas (Figure 1, 2). [5]

Fig. 1. Panga open pit - satellite image

Fig. 2. Panga open pit- component parts and tailings dumps

In choosing of the final destination of the lands of the Panga open pit we have devised several indicators:

- geomorphological changes in the area, correlated with habitat, ecosystem, microclimate, social changes;
- Panga's green rehabilitation options;
- opportunities for land reuse (agricultural, forestry, recreational) compared to the regional development plan, population requirements, elements of local tourist interest.

The importance of choosing the best option for re-use also involved an initial consultation of the local population and decision-makers on land reuse in the Panga open pit.

Also, for the selection of the way of rehabilitation and restoration of the lands affected by the geomorphological processes from the Panga open pit, Table 1 was created, in which are presented the main geomorphological changes in the studied area - the open pits and the occupation of the land, the occurrence of the sterile rocks dumps, micro depressions, landslides and drowning and erosion, correlated with habitat changes, ecosystem changes, microclimatic, social and land reuse opportunities, as indicated in Table 1.

- the appearance of the open pits generates a negative visual impact and determine species migration, displacement of people; if the open pits voids are flooded result lakes pit or swamps and implicitly increases the amount of evaporated water, appear new ecosystems. At the same time, increase the risks as illness by inhalation of dust and as follow of noise pollution.
- dumps-emergence alter the habitat by occupying large areas of land, changes in the ecosystem by landslides, ravines, landslides, species migration, disappearance, changes in microclimate by sedimentation powders, dust inhalation, social changes, causing damage to property or personnel.
- appearance of remanent void implies habitat changes through the lunar landscape, ecosystem changes through species disappearance, biodiversity change, climate is polluted with sedimentary dust and dust affecting the respiratory system, social changes are imposed by accidents, rock falls.

Table 1. Geomorphological changes and opportunities for land re-use in the Panga pit

Geomorphological changes	Habitat Changes	Ecosystem Changes	Microclimate Changes	Social Changes	Land Reuse Opportunities
The emergence of open pits and the occupation of the land	Negative visual impact Migration of species Removing people	The emergence of career lakes Formation of ponds, marshes	Increasing the amount of evaporated water The emergence of new ecosystems	Stress accentuation community Risk of illness	Agricultural / Forestry / recreation
The occurrence of sterile rocks dumps	Land occupation	Slips	Inhalation of dust	Material damage	Agricultural /Forestry / Recreation
Remanent voids occuring	Moon landscape	Migration of species	Evaporation	Accident risk	Recreation lake
Micro-depressions	Storm / underground accumulations	Career lakes	Evaporation	Risk of drowning	Fishing, recreation
Land landslides and landslides	Shifting the community	The disappearance of species	New ecosystems	Human damages	Adventure park
Erosion	Migration of species	New ecosystems	Dust	Material damage	Agricultural / Forestry

- micro depressions bring about habitat changes through rainwater and underground accretions, through changes in the ecosystem because the local flora and fauna species migrate, disappear; through climate change, evaporation is intense; through social changes the inhabitants are prone to various accidents.
- landslides and landslides alter the habitat and grab the community at resettlement; alter ecosystems by changing biodiversity, local climate change; social changes occur when landslides are large even leading to loss of life.
- erosion changes the habitat by changing biodiversity through the emergence of new ecosystems through anthropic change.

3 Research methods and tools

In order to determine how land reuse was used in the studied area, we used the following working tools: questionnaire and opinion surveys to test the requirements of the resident population and specialists and the WRAM matrix method for testing environmental requirements.

3.1 Questionnaire

The questionnaire (Figure 3) consists of questions related to Panga open pit rehabilitation activities and the restoration of lands modified by geomorphological and mining processes and to its effects on environmental components, on the community.

Fig. 3. Questionnaire for land rehabilitation and restoration in the Panga open pit and interpreting questionnaire results

The questionnaire consists of 6 questions focused on the environmental factors affected by the geomorphological changes and the mining exploitations: air, landscape, soil, flora, fauna, human collectivities. Each environmental factor has 5 key questions for an interpretation of results that ultimately highlight the optimal Panga open pit design.

The answers are the sum of the answers selected by the participants to the question. The percentage for each option is calculated by dividing the sum of the same options into total answers. The questionnaire was completed by 30 respondents trained by specialists (Figure 3).

In order to have a common basis as response variants with the online survey and the WRAM matrix, to the environmental human factor (Figure 3), has been applied the question from the online survey of the Panga open pit land reuse and the questionnaire, and the result of the questionnaire turned to agricultural recultivation 30% with 9 answers, forest recultivation 10% with 3 answers for, 50% with 15 respondents who chose the touristic arrangement, the arrangement as a mining museum had a 10% with 3 answers.

In the WRAM matrix, by conversion of the 34 answers (using the Google Drive program) to the same question in human collectives the answers were: 8 (23.5%) for agriculture, 3 (8.8%) for forestry, 20 (58.8%) for landscaping tourism and 3 (8.8%) for the mining museum (Figure 4).

Figure 4. Converted answers to Human collectivities - Wram matrix

3.2 The online survey

Taking into account their needs and the local community, the importance of the socio-economic development of the region and the rehabilitation of the environment, respondents from different localities (Râmnicu -Vâlcea, Petroșani, Berbești, Bucharest, Petrila, Baile Govora).

Fig. 4. Responses on the online survey

Of the 117 persons interviewed online, 72 (61.5%) chose the recreation area as a redevelopment of Panga's (18.2%) agriculture 25 (21.4%) forestry 14 (12%), 1% of the mining museum (Figure 4).

3.3 WRAM matrix

This method allows a quantitative assessment of the environmental impact of a project or several alternative projects. The method goes through the following stages: choosing an interdisciplinary team; identifying and selecting significant components and environmental factors; forecasting and impact assessment; commenting on the evaluation results. [1]

Significant individual factors serve to determine the Relative Importance Coefficients (RIC), which identifies the weightings attributed to the various factors in the assessment process. [1]

In order to establish the most appropriate way to rehabilitate the studied land, six significant environmental factors are included: air, landscape, soil, fauna, flora, human collectivities. Four variants of ecological rehabilitation were also considered, the D variant being the only control variant (Table 2).

Table 2. Variants of ecological rehabilitation of Panga open pit

Panga Pit Type of reuse	Panga Pit- indoor heap	Panga Pit- the excavation area	PangaPit- empty remanent
Option A	Agricultural recultivation	Forest- fruit tree recultivation	Fishing lake
Option B	Forestry recultivation	Wine and fruit tree recultivation	Domestic waste disposal
Option C	Settlement as a leisure area-touristic complex	Outdoor Design-Panga Adventure Park	Recreational lake- fishing
Option D	Arrangement of mining museum	Forestry recultivation and fishing	Fishing lake

Each environmental factor is compared to everyone else, two by two, to determine which of them is more important for the studied area. The most important factor is assigned the value 1 and the other value 0. If both factors have the same importance, each value is assigned to 0.5. [4]

The values attributed to each factor are summed up and the sum is divided by the value obtained by summing the values of all the factors, thus obtaining the value of the coefficient of relative importance, after which the ordering according to the importance of the factors considered (in the case presented first is the soil and the landscape, followed by human collectives, flora, fauna, air).[1]

Through geomorphological changes in Panga open pit, the most affected factors are the landscape (1.51) - this is modified by the appearance of lignite quarries that change the topography of the area through negative relief forms, tailings dumps create new positive relief forms; the original relief is altered and leads to perturbation of the overall perception, forcing the eye to a continuous adaptation, producing a sense of perceptive chaos. Soil (1.60) is altered by destroying the natural geological environment, by building buildings, infrastructure, soil impoverishment in nutrients and degrading it, losing fertility on large surfaces by changing the original agricultural/forestry destination in the mining, physico-chemical imbalance (1.06) is modified by land-stripping, it is destroyed by deforestation, spontaneous flora appears on the heaps, new lake ecosystems appear. The human communities (1.14) are affected by the partial decommissioning of the villages, the resettlement of the inhabitants, damage to water, air with dust, sedimentary dust, noise, vibration, landscapes become natural industrial, occupational diseases occur; economic is a mono-industrial area. Fauna (0.30) is affected by the disappearance of species, their migration, spontaneous occurrence (career lake). The air (0.30) has sedimentary suspended particulates, which are arranged in relief microforms, and the air also exhibits flue gas emissions, acoustic emissions. For space reasons, only the final evaluation matrix (Table 3) is presented in this paper.

Table 3. Final evaluation matrix

	RIC	ACC (projects)				RIC * ACC (Final matrix)			
		A	B	C	D	A	B	C	D
Air	0.30	0.16	0.34	0.50	0.00	0.05	0.10	0.15	0.00
Landscape	1.51	0.16	0.34	0.50	0.00	0.24	0.51	0.75	0.00
Soil	1.60	0.34	0.16	0.50	0.00	0.54	0.25	0.80	0.00
Fauna	0.30	0.16	0.34	0.50	0.00	0.04	0.10	0.15	0.00
Flora	1.06	0.25	0.35	0.40	0.00	0.26	0.37	0.42	0.00
Collectivity human	1.14	0.16	0.34	0.50	0.00	0.18	0.38	0.57	0.00
	Total					1.31	1.71	2.84	0.00

According to the final assessment matrix, the project C corresponding to the land reuse option 3 in Panga (recreational complex, fishing lake, adventure park) has the highest value of 2.84 being the highest of all aggregated indicators for this final result, compared to 1.31 for project A targeting an agricultural development and to project B with 1.71 for a forestry arrangement.

An online survey on the choice of land use type in Berbești, a questionnaire consisting of questions about Panga open pit rehabilitation activities and the restoration of lands modified by geomorphological and mining processes, highlighting its effects on environmental components, on community, the respondents being specialists from E.M. Berbești. The questionnaire was converted to Google Drive, based on the online survey and the WRAM matrix, with the answer to the question of the land use reuse option in Berbești; the WRAM matrix for the quantitative assessment of the environmental impact of the rehabilitation project, this method having as stages the selection of the specialists, environmental factors, forecasting and estimating the impact, interpreting the final results and preparing the design and implementation of the structures necessary to achieve the proposed goal. To these I added the basic question of land reuse in the Panga open pit, with the answers being converted in percent.

Accepting this option of reuse and application in the field is an unusual variant for mining quarries in Romania, the ones from abroad have long been transformed into mining tourist attractions, obviously with beneficial environmental benefits through the appearance of recreational landscapes, the increase of the local economic level through approaches tangential to sustainable development in the context of globalization. [3]

At this stage, the choice of the land reuse option was supported by discussions based on the suggestions of the specialists from E.M. Berbești, which highlighted the traditional reuse of land based on agricultural and forestry-farm recultivation, and the local people's mentality and even the local administration's projects are directed to the traditional reuse option because the area was always mono industrial, and before the exploitation of coal was an agricultural area. [6]

4 Results and discussion

The synthesis of land re-use opportunities in the Panga open pit illustrates the percentage of reuse opportunities, taking into account the equivalences between land reuse opportunities, regional development plan, local community requirements, tourism area features, and of the control matrices (survey, questionnaire, WRAM matrix) measured in percent and based on the joint questionnaire reuse of degraded land in Panga with 4 options of land reuse (Table 4).

Table 4. Exploring options for land re-use in the Panga open pit

Land Opportunities	Use	Sondaj online Online Survey	Query Field Converted Drive	Matrix Wram- Converted Converts to Drive
Agricultural		21,4%	30%	23,5%
Forestry		12%	10%	8,8%
Recreation/lake/Panga Park		61,5%	50%	58,8%
Museum of Mining		5,1%	10%	8,8%

- agricultural reuse 21,4% in the online survey, 30% in the questionnaire and 23,5% in the WRAM matrix is useful on the external dumps (Valea Muncelului, Panga Sud, Panga Nord-Matești) for further land use in these areas initial.

- forest reuse is 12% in the online survey and 8,8% in the WRAM matrix, 10% for field survey respondents who want reuse of the quarry lands, vineyards and fruit trees.
- the creation of a recreational complex has obtained 61,5% of the survey, 50% of the questionnaire, 58,8% of the WRAM matrix.
- Museum of Mining is 5,1% in the online survey, 10% of the questionnaire, 8,8% in the WRAM matrix.

Gender studies and projects in former international mining quarries marked the implementation of tourism projects on former mining sites with positive economic outcomes but also with obvious environmental rebounds, and tourism specialists in Valcea County agreed to the Panga leisure complex development project, considering it a new concept of tourism development, which can be successfully integrated with the Valcea Tourism Strategy.

If the main ways of recovery so far were agriculture and forestry, which was caused by large areas of land exploitation by quarrying and overburdening of landfills and dumps, the present objective is to confer on post-mining areas, often with extensive infrastructure and housing industries, new values of use, appropriate to the social conditions it needs. [6]

The implementation of such a Panga open pit rehabilitation project could illustrate the true ecological value of the Panga mining area, the rehabilitated area becoming an important point for biodiversity for the Valcea tourism, and the Panga mining perimeter can be developed and highlighted in a manner that is most useful, which will give the whole region a new value with effects beyond its borders.

5 Conclusions

In the paper has been approached transdisciplinary the subject of re-use of the land with modified geomorphology, as follow of coal extraction. Also, we presented viable variants for ecological rehabilitation of the geomorphological modified land and the methodology of choosing the most appropriate reuse type of the land in Panga open pit.

The correct choice of the destination of these degraded lands is the most important aspect of the rehabilitation of the degraded geomorphological changes so that the results are in line with the expectations.

In this paper, we used three methods in order to determine the best land destination from point of view of the population (questionnaire and online survey) and from point of view of the necessity to protect the environment (WRAM matrix).

All three methods have led to the conclusion that the most appropriate type of reuse of land in the Panga open pit is to create a recreational complex (see Table 4). Such a complex can consist of the lake created in the remanent void of the open pit, which can take on many uses and an adventure park set up on the dumps. Designing and planning solutions are the subject of further research.

This variant of re-use of the geomorphologically modified land by mining can bring added value to the area, in the sense of ensuring sustainable development and stimulating tourism after closure of mining exploitations.

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