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Review paper

CRITERIA FOR DECISION-MAKING FOR THE BEST RECLAMATION SOLUTION

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Abstract:

Mine site reclamation is a relevant step in maintaining ecological balance after mining activities. Although mining activities provide many economic benefits, they often have a negative impact on the environment. These environmental problems require effective and sustainable solutions. To minimize the effects of mining, environmental management is obligated to stabilize the land, so it is productive after mine closure and leads to the best possible purpose. Regulatory authority sets out the criteria for reclamation to be accomplished by the mine reclamation program such as compliance, land re-contouring, revegetation, and final completion.

Keywords: mine reclamation, post-mining land-use, mine land suitability analysis (MLSA), criteria

1 INTRODUCTION

The exploitation of mineral resources has been one of the prime industries of Serbian economic develop. The environmental surroundings are complex in Serbian mines, so it is needed to carry out land recultivation after mining to reclaim ecology. Recultivation and reclamation of the landscape after mining exploitation has a complex multidisciplinary character and requires a series of activities: technical-technological, engineering-geological, hydrotechnical, spatial planning, agronomic and forestry, business, social, etc. The aim of the mentioned activities is to restore natural functions to degraded land and create conditions for new functions of the area (agriculture, forestry, tourism and recreation, park complexes, industry).

According to Liu, the mining surface provides crude materials and energy for economic construction and for people's working, but the development of mineral resources inevitably causes damage to land resources. The reuse of deserted mining areas directly restricts the sustainable development of the mining area (Liu, 2017). In his work, Guobin

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assumes that the direction of recultivation should be determined, which in turn requires land evaluation. (Guobin, 2020). Based on ordering and optimizing multiple plans, Land reclamation benefits in mining areas can be examined (comprehensive evaluation, ranking, and optimizing the plans based on some evaluation criteria (Yu, 2020).

The reclamation process as a business system, modeled through its sub-processes: technical recultivation, biological recultivation, monitoring of the living and working environment, and management is relayed through the management process, which consists of the sub-processes of planning, organizing, monitoring the implementation and control of the implementation of business activities (Dimitrijević, 2014). The principal model of reclamation management is shown in Figure 1.

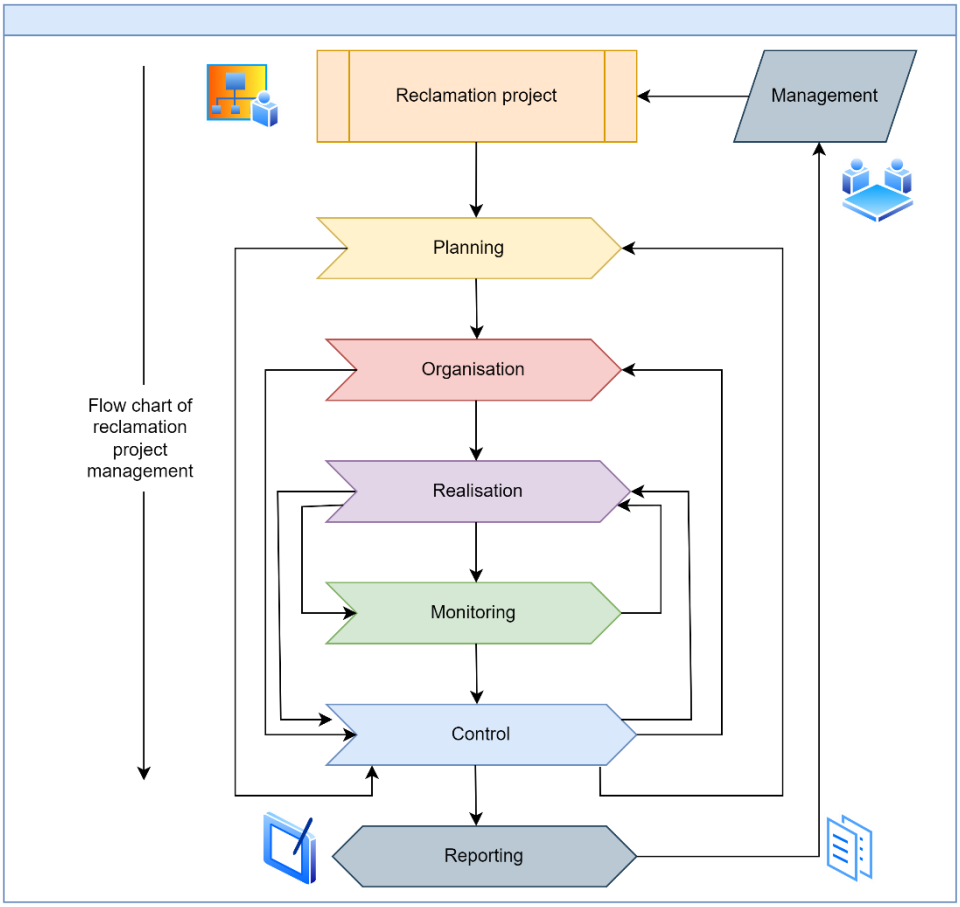

Figure 1 The principal model of recultivation management

Land reclamation includes the following - physical soil stabilization, monitoring surface and groundwater quality, topsoil solution, erosion, landscaping, the re-vegetation, and

wildlife habitats. For each of these stages of recultivation, it is important to determine the criteria based on which individual optimization of land use can be carried out.

Reclamation is constantly taken out throughout the production phases at the mining area and is intensified during the mine closure. At the beginning of working, the vegetation is cleared up and the topsoil is removed (stored in a process called "topsoil management"). The next stage starts after the mining area has been excavated and already announced as finished and reclaimed. In this last stage, the land area is prepared for revegetation and includes observance work. Figure 2. shows the range of reclamation stages and affiliated activities.

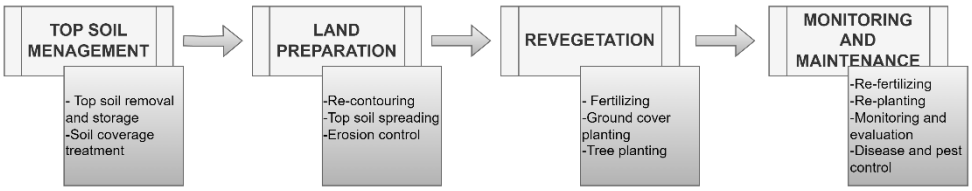

Figure 2 Mining reclamation stages

For mine planning and design, identifying proper Post-Mining Land Use is crucial for achieving good environmental quality regeneration.

2 LITERATURE REVIEW

Mine exploitation usually has devastating effects on the environment, due to large land use and occupation of big areas. Recultivation plans should be submitted at the same time as the mine exploitation plans. Mine land reclamation includes rehabilitation measures to impair the adverse environmental impacts of mine works throughout the mining process (Setiawan et al., 2021). Sengupta in his paperwork defines the aim of reclamation, as establishing a stable landscape that is aesthetically and environmentally suitable with the ambient undisturbed area (Sengupta 1993).

The first impression in much of the landscape devastated by mining is one of dereliction and negligence, but a mined land can be sustained as an Industrial or Commercial area if it is convenient and have a broad range of potential role such as, Recreational Areas, Swimming Pools, Theme parks or an open-air museum In their paperwork Masoumi and others defined Land suitability analysis as a basic step in sustainable reclamation planning and design. They also propose different types of reclamation alternatives that could be received for post-mining land use, such as agricultural land, industrial areas, residential land, recreation areas, etc. (Masoumi at al., 2014).

The resolution for the most appropriate land use for every part of the mined area is based on the findings got from the characteristics of locality, the opinions of experts in that field, the development plans of local authorities and population, the legal environmental

regulations, and the environmental constraints (Palogos at al., 2017). Land reclamation experts elect the decision parameters and their optimal benefit for each land purpose. In Table 1 have been shown eight-group, common land-use practices after recultivation of degraded land common in literature have been shown, consisting of 24 individual land-purposes.

Table 1 Common post-mining land use practices

Alternatives number	***Land use type***	***Realized Post-mining Land Uses***
A1	***Agronomy***	Arabble farmland, Gardening, Grassland or hay-land,
A2	***Forestry***	Woodland, Wood production, Shrubs and natural forestation
A3	***Lake / pool***	Sailing, Swimming, Aquaculture, or supply of water
A4	***Intense Recreation***	*Sport fields, Hunting, Swimming, Fishing*
A5	***Non-Intense Recreation***	*Open green space - parks, Open space Museum or exhibition of mining innovation*
A6	***Structural***	*Housing, Industrial, Educative, A sustainable society*
A7	***Preserving***	*Wild habitat, Supply of water*
A8	***Filling the Pit***	*Use as landfill (last purpose)*

Some of these land uses have been very successful, while others have met off fail. Several studies show that without land use suitability analysis sometimes the results are unacceptable. Therefore, it is necessary to observe the standard criteria for choice of land purpose use.

3 HIERARCHICAL FRAMEWORK FOR MINE LAND SUITABILITY ANALYSIS

In their paperwork, Mborah and others set the ultimate objective of post-mine land-use and reclamation planning. They are identifying convenient alternate land uses which mined land could be put. This can provide that land-use of specific location will be capable of supporting either the earlier land-use or pre-mining environment (Mborah et al., 2016).

According to Wang and others, there are several deficiencies in the present assessment of land reclamation quality in mining zone. Also, there is the absence of an established

set of evaluation index systems and standard criteria, as well as the use of traditionally sampling techniques, which are long term, expensive and in effectiveness (Wang et al., 2023).

The major challenge for deciding of land purpose after reclamation is selection of variables that must be considered. Criteria identified as insignificant in the land use election process involve land type characteristics (physical, biological ones and also cultural characteristics), location, types of mining actions, legal act requirements, needments of the local community, ownership, economic, environmental, technical and social factors.

Assessment attributes from literature are divided into four groups as criteria for the formation of a hierarchical level of mined land suitability. The overall goal and criterial level (Technical, Economical, Mine site Factor, Social) have been shown in Figure 3.

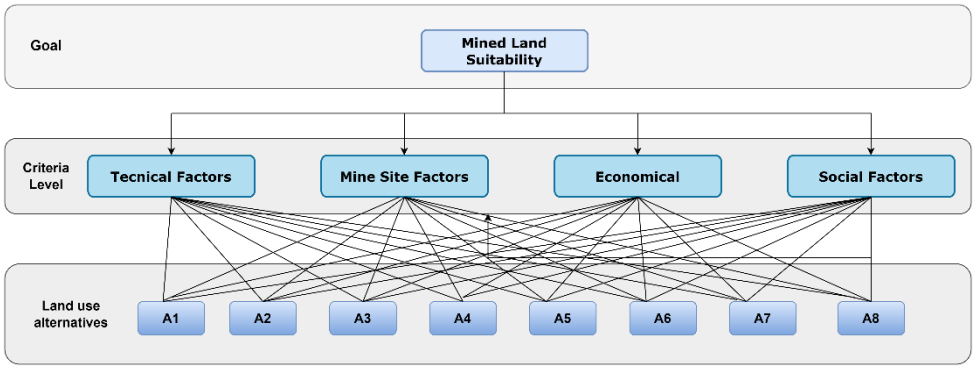

Figure 3 Hierarchical structure of Mined Land Suitability Analysis

Then, each main criterion is extended to the next attribute level.

4 CRITERIA

Technical Criteria denote limits that each one has affinity to compel decision-makers to a separate post-mining land-use that is the most convenient for technological shortcomings associated to that attribute. As shown in Figure 4, The Technical Factors include attributes such as size and shape of mined land area, reclamation techniques availability, distance to nearest supply of water, availability on the market, current land-use in surroundings, mine area prosperity, structural geology, remoteness from special services, environmental pollution, potential of extreme events, re-using potential of mine facilities, quality of landscape.

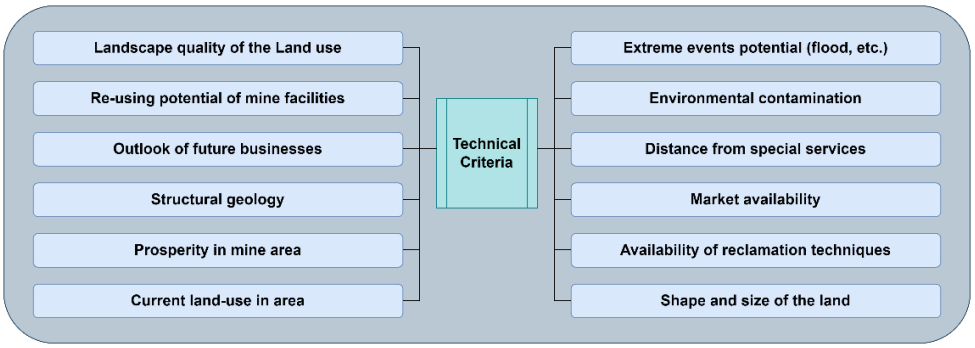

Figure 4 Technical Criteria for MLSA

The Mine terrain - site Criteria presents specific attributes that have impact on decision and consist of three attribute groups - Soil, Climate and Topography as shown in Figure 5. In general, Mine Site Factors are devided; Soil (soil's physical properties and chemical properties), Topography (slope, elevation, surface relief, Exposure to sunshine) Climate (temperature, evaporation, frost freedays, precipitation, wind speed, air moisture, hydrology of surface and groundwaters).

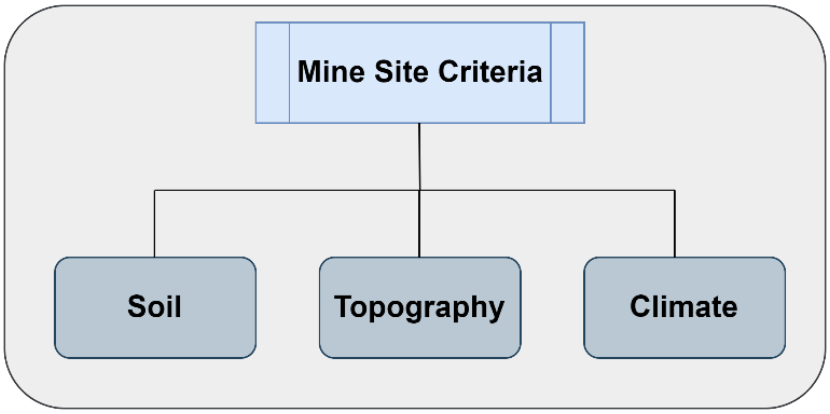

Figure 5 Mine terrain Criteria for MLSA

Economic Criteria are shown in Figure 6, they include attributes: in first place, Costs (Operational, Capital and Maintenance and Monitoring), Changes in real estate values, increase in governmental incomes, positive changes in real estate values and increase in local community.

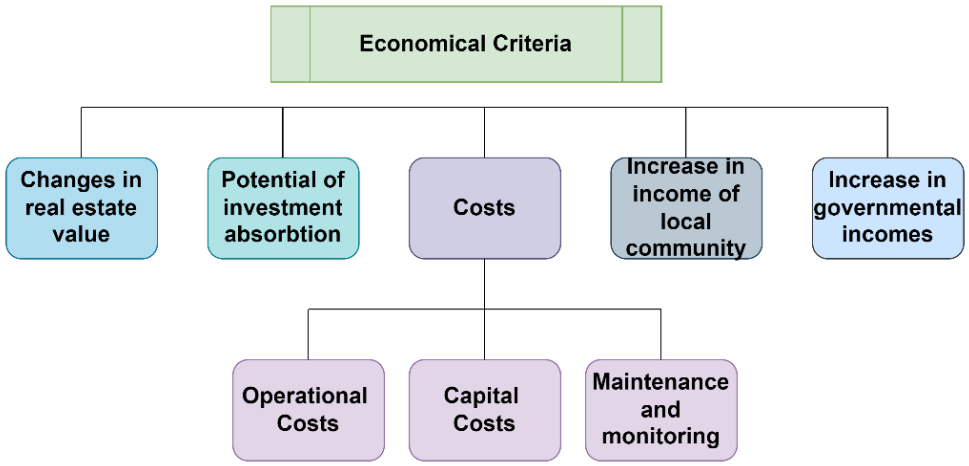

Figure 6 Economic Criteria for MLSA

Finally, Social Criteria are of main significance and they are shown in Figure 7, including attributes: positive changes in livelihood quality, ecological acceptability, need to specialist workforces, opportunities for employment, availability the public education, frequency of passing through mine site, tourism attraction, stakeholders engagement, impact on immigration to the local area, the proximity of the mine location to populated centers, mining company and government policy, consistency with local requirements.

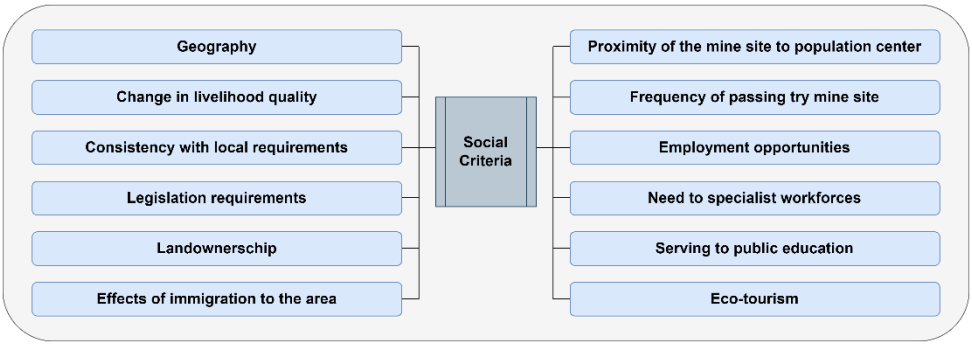

Figure 7 Social Criteria for MLSA

During the process of mine land suitability analysis, society, community and stakeholders should be consulted, when a post-mining land-use is dissimilar to the pre-mining land-use. The existing landowners and neighbors should be consulted even if they are small mines. It is very significant that the post-mining land-use would be receptive to the local society.

5 CONCLUSION

Reclamation of land degraded by mining should be the most important responsibility of companies. Mine exploitation is time bounding and must be well planned before mining begins, so requiring that post-mining activities meet the needs of local society and the environment. Mine site reclamation aims to upgrade the mined land environment, making it more productive by utilizing it in proper way. In this paper, in the evaluation, to the greatest extent possible, factors that influence the suitability of land reclamation and the direction of land reclamation are included.

Research into this paperwork has shown that much information on the subject of criteria for selection land use are accessible in the literature. Also, it shows that many successes were accomplished all over the world. The principal goal of some specific reclaimed post-mining land use must be achieving success in economic and sustainable outcomes respecting human needs and protecting environment in surroundings. Community involvement in selection land use after reclamation and use process stays one of the basic factors to a prosperous reclamation.

Reclamation Criteria can be used to restore other disturbed lands with similar contexts, and not only provide theoretical guidance for ecological restoration of post-mining areas. In conclusion, mine reclamation has as a goal to restore mined-out areas to a state of acceptable social and ecological.

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