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AN INTEGRATED METHODOLOGY FOR PROJECT PORTFOLIO SELECTION AND OPTIMIZATION IN MINING INDUSTRY

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Abstract

Project portfolio selection in the mining sector requires the simultaneous consideration of economic, technical, environmental, regulatory and resource-related objectives. Traditional project ranking methods are often insufficient because they evaluate projects individually and do not ensure a feasible portfolio structure. This paper proposes an integrated MCDM–MOO framework for project portfolio selection and optimization in mining. MCDM supports the evaluation of project candidates and the incorporation of decision-maker preferences, while MOO generates portfolio alternatives under budgetary, resource, technical and regulatory constraints. The framework enables the identification of Pareto-efficient portfolios and supports transparent compromise decision-making.

***Keywords**: project portfolio management, project selection, portfolio optimization, mining, MCDM, MOO, sustainability*

1. INTRODUCTION

Project portfolio selection is an important decision-making problem in the mining industry, where companies must allocate limited financial, technical and human resources among competing investment projects. Due to high capital intensity, long implementation periods, technical risks, operational interdependencies, and environmental and regulatory requirements, project selection should consider both individual project attractiveness and portfolio-level contribution to strategic, operational and sustainability objectives. Traditional selection methods, such as financial indicators, scoring models and ranking procedures, support the initial assessment of project candidates, but they do not necessarily ensure a feasible portfolio under budgetary, resource, technical and regulatory constraints. This is particularly relevant in mining, where modernization, capacity expansion, energy efficiency, safety, environmental and compliance projects often compete for the same resources. To address this issue, this paper proposes an integrated framework based on multi-criteria decision-making (MCDM) and multi-objective optimization (MOO). MCDM evaluates project candidates according to economic, technical, environmental, regulatory and strategic criteria, while MOO generates feasible portfolio alternatives under defined constraints and conflicting

objectives. The objective is to improve the transparency, consistency and analytical basis of portfolio decisions in mining organizations.

2. PROJECT PORTFOLIO SELECTION IN THE MINING SECTOR

Project portfolio selection in the mining sector involves choosing a set of investment projects that supports organizational strategy while respecting financial, technical, operational and regulatory constraints. Unlike individual project evaluation, portfolio selection focuses on the combined effects of projects and the feasibility of their simultaneous implementation. This is particularly important in mining, where projects often require large capital investments, specialized equipment, skilled personnel and long implementation periods.

Mining companies manage different types of projects, including mine development, equipment modernization, capacity expansion, energy efficiency, digitalization, environmental protection, waste management, occupational safety and regulatory compliance. These projects often compete for the same budget, engineering teams, production downtime, machinery and infrastructure. Some projects may also be mutually dependent or mutually exclusive. Therefore, selecting projects only according to individual financial performance may result in a portfolio that is neither feasible nor aligned with long-term strategic objectives.

Traditional project selection methods, such as net present value, internal rate of return, payback period and scoring models, are useful for the initial assessment of project candidates. However, they often do not sufficiently address interdependencies, resource limitations, sustainability criteria and conflicting objectives at the portfolio level. Previous research emphasizes the need to consider both individual project value and portfolio-level constraints and interactions [1,2]. Similar issues are also discussed in regional research on multiproject and portfolio management, especially regarding structured selection, prioritization and optimization in industrial organizations [3,4].

In industrial context, sustainability and regulatory compliance further increase the complexity of portfolio decisions. Projects should be evaluated according to their economic benefits, but also according to their contribution to environmental protection, emission reduction, energy efficiency, worker safety and legal compliance. For this reason, portfolio selection in mining requires a structured approach that integrates multiple criteria, optimizes limited resources and supports transparent compromise decisions.

An integrated MCDM–MOO approach is therefore suitable for this type of decision problem. MCDM supports the evaluation and prioritization of project candidates, while MOO enables the formation of portfolio alternatives under defined constraints and conflicting objectives [9,10]. This provides a stronger analytical basis for selecting portfolios that are economically justified, technically feasible and sustainability-oriented.

3. A PROPOSED METHODOLOGY FRAMEWORK

The proposed framework integrates MCDM and MOO to support project portfolio selection in the mining sector. Its purpose is to connect the evaluation of individual project candidates with portfolio-level optimization. This avoids selecting projects only according to individual ranks and enables the identification of feasible portfolio alternatives under organizational and regulatory constraints. The general structure of the

framework is presented in Fig. 1. The process begins with the identification of project candidates and the definition of evaluation criteria. In mining, relevant criteria may include economic performance, technical feasibility, contribution to production capacity, resource requirements, environmental impact, safety improvement, regulatory compliance and strategic alignment. Decision-maker preferences are incorporated through criteria weights, while methods such as AHP, TOPSIS, VIKOR or PROMETHEE can be used for project evaluation [5,6].

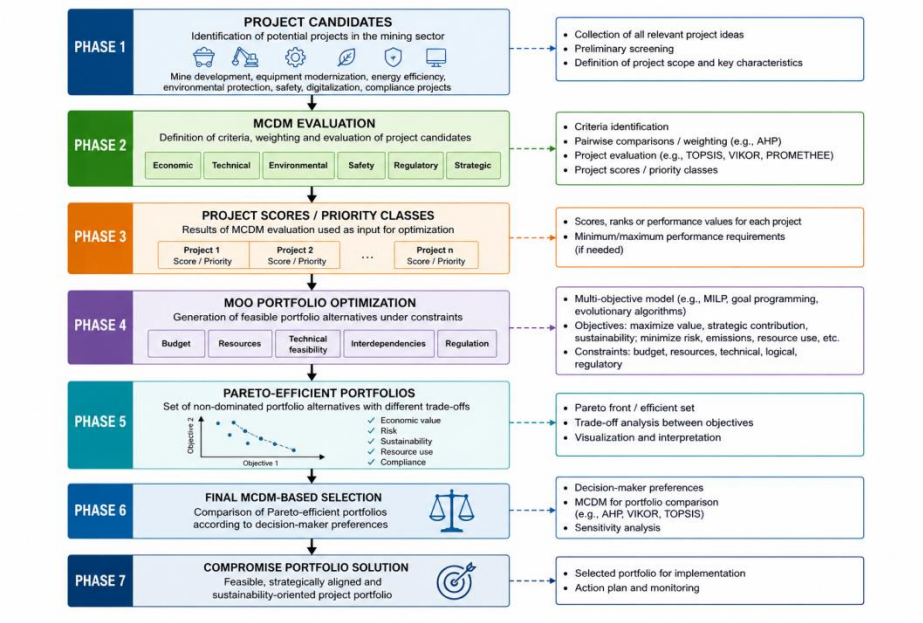


Figure 1. *Proposed MCDM–MOO framework for project portfolio selection and optimization in mining industry*

The results of the MCDM stage, such as project scores, ranks, priority classes or threshold values, are used as inputs for the MOO model. The model generates feasible portfolio combinations under budgetary, resource, technical, logical and regulatory constraints. Objective functions may include maximizing portfolio value, strategic contribution and sustainability performance, while minimizing risk, emissions, resource overload and implementation complexity [7,8]. Since mining portfolio decisions usually involve conflicting objectives, there is rarely a single optimal solution. Instead, MOO generates Pareto-efficient portfolio alternatives that represent different trade-offs between economic, technical, environmental and regulatory objectives. In the final stage, MCDM supports the selection of a compromise portfolio solution or a reduced set of preferred alternatives. The proposed framework therefore combines project-level evaluation, portfolio-level optimization and preference-based final selection into a single decision-support process.

4. CONCLUSION

This paper presented an integrated MCDM–MOO framework for project portfolio selection and optimization in mining industry. The proposed approach links the evaluation of

individual project candidates with portfolio-level optimization, enabling decisions based on project value, feasibility, strategic alignment and sustainability objectives. The framework supports the consideration of economic, technical, environmental, regulatory and strategic criteria, while generating feasible portfolio alternatives under budgetary, resource, technical, logical and regulatory constraints. MOO enables the identification of Pareto-efficient portfolios, and the final MCDM-based step supports the selection of a compromise solution according to decision-maker preferences. The main contribution of the paper is a structured decision-support framework that can improve the transparency, consistency and analytical quality of portfolio decisions in mining organizations. Future research should apply the framework to a real mining project portfolio, including sensitivity analysis and comparison with traditional selection approaches.

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