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Risks of Lithium Ore Mining and Their Mitigation

Abstract: Lithium is a key mineral for modern technology and the global energy transition. Its use in batteries for electric vehicles, smart devices, and renewable energy storage systems makes it an indispensable resource. However, the extraction process poses significant risks to the environment, local communities, and worker health. Water consumption, land degradation, pollution, and displacement of populations are among the most common challenges. The Jadar Project in Serbia represents a potential positive example of sustainable mining practices. This paper analyses the main risks and mitigation measures, including technological innovations, land reclamation, and community involvement.

Keywords: lithium, mining, mitigation measures, reclamation, environmental risks

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1. Introduction

Lithium has become one of the most significant metals of the 21st century due to its essential role in modern technological and energy transitions. Lithium is a soft, silvery-white alkali metal found in the second period of the Periodic Table. It is an extremely light metal with the lowest density among all solid elements (under standard conditions), making it the least dense of all solid elements. Its use in batteries for electric vehicles, smartphones, portable devices, and renewable energy storage systems has made it a strategic resource. The demand for lithium is growing exponentially, with forecasts suggesting that by 2050 the need for this metal will increase more than fivefold compared to current levels. In the context of combating climate change, lithium is a key element in the production of batteries for storing energy from renewable sources such as solar and wind power. Additionally, the development of electric vehicles as a replacement for fossil fuels depends on a stable supply of this mineral resource. This thesis has placed lithium at the centre of attention for global economies and spurred geopolitical aspirations to control its reserves. The discovery of jadarite in Serbia—a unique mineral containing lithium and boron—represents a significant potential for economic progress. The Jadar Project by the company Rio Tinto, one of the largest mining ventures in the region, aims to position Serbia among the world's leading lithium producers. However, this project has sparked numerous controversies due to its potential environmental and social impacts. The main challenges of lithium mining include land degradation, water consumption, pollution, and potential conflicts with local communities. Examples from Chile, Australia, and Argentina demonstrate that mining activities can significantly affect ecosystems and local populations if not accompanied by sustainable practices.

This paper aims to provide a comprehensive overview of the risks associated with lithium mining, as well as opportunities for their mitigation. Particular emphasis is placed on the application of modern technologies, such as closed water recycling systems and risk monitoring sensors, which can significantly enhance safety and reduce environmental impact. To improve environmental sustainability, projects like the Jadar Project can integrate environmental protection measures, including land reclamation after exploitation and community support programmes.

Through the analysis of risks and proposals for their mitigation, this paper seeks to contribute to a deeper understanding of the complexities of lithium mining and its impact on society and the environment. The goal is to identify steps that will enable the sustainable exploitation of this critical resource while minimising negative consequences.

2. Environmental risks from ore extraction

Water consumption

In arid regions, such as the Atacama Desert in Chile, water consumption often exceeds available water resources, leaving local communities without sufficient water for agriculture and daily needs, while in

areas richer in water resources, mining operations frequently discharge water into local rivers. In regions with weak wastewater management systems, toxic materials can infiltrate aquifers, threatening the survival of ecosystems. The use of filtration systems and closed water recycling systems helps minimise this risk.

Soil degradation

Underground mining offers significant advantages over surface mining when high-quality design decisions are made regarding the method of lithium ore extraction. In many cases, soil degradation results in the inability to restore the land without extensive rehabilitation projects. The application of land reclamation, which involves planting native vegetation and stabilising the soil, can significantly improve existing conditions, though the process is time-consuming and costly.

Air pollution

During excavation, dust particles are released into the mine air, potentially causing allergies and respiratory illnesses. This can be effectively mitigated through the use of modern ventilation systems in underground mining operations.

Water pollution

Mine water often enters local waterways. In areas with weak wastewater management systems, toxic materials can penetrate aquifers, threatening ecosystem survival. The use of filtration systems and closed-loop water systems helps minimise this risk.

Loss of biodiversity

The destruction of natural habitats due to mining has a direct impact on local flora and fauna. In the Atacama region, bird and insect populations have decreased by 30% due to the loss of natural food and water sources. Additionally, large transport routes constructed to access mines accelerate habitat destruction.

Conservation programs for endangered species, such as compensatory habitats, have proven effective in mitigating these effects, but they require significant financial investments.

3. Social, economic, and health risks

Social and economic risks associated with lithium ore mining often stem from the complex dynamics between mining companies, local communities, and national economies. While mining offers potential economic benefits, including job creation and increased state revenue, it also presents numerous social challenges that require careful consideration.

Displacement of communities and social tensions

One of the most significant social risks of mining activities is the displacement of local communities. In many cases, mining companies acquire land belonging to local populations, forcing them to leave their homes and abandon traditional sources of income. This is often accompanied by social tensions, dissatisfaction, and protests. An example from Bolivia illustrates how a major mining project

led to prolonged conflicts between the company and indigenous communities.

Figure 1 – Bolivia, the country with the largest lithium reserves in the world (BIZLife, 2023)

In Serbia, as part of the Jadar Project, the company Rio Tinto has conducted public debates and compensation programs to mitigate social tensions. Such programs include the relocation of affected families, as well as financial assistance to help them find new sources of income. In addition, investing in local infrastructure, such as schools, hospitals, and roads, can significantly contribute to reducing conflicts.

Economic dependency and instability

Economic dependence on mining poses a long-term risk for many countries that rely on lithium ore exports. The volatility of prices on the global market makes economies dependent on mineral resources vulnerable to changes. Chile and China are such examples, where large fluctuations in lithium prices have affected the national budget and economic stability.

Lithium prices on the global market show significant volatility, which directly affects the economies of countries that rely on exports of this metal. For example, between 2020 and 2022, the price of lithium rose from USD 6,320 to USD 71,500 per ton, followed by a decline of around 80% since the end of 2022 (RTBalkan, 2024).

For instance, if the price of lithium today suddenly rises due to increased demand for electric vehicles, and then sharply falls tomorrow due to the discovery of new reserves, this is an example of high volatility.

To reduce this risk, economic activity diversification is required. In Serbia, as part of the Jadar Project, investments are planned in local high-tech industries that could reduce economic dependence on mining. To achieve this, the construction of a lithium-ion battery factory is planned, followed by the production of electric vehicles. Additionally, part of the revenue from mining could be invested in the development of educational and research centres that will encourage innovation and ensure a sustainable economy in the future.

Land right disputes

These are common in mining regions, especially when local communities lack clear legal documentation of their property. In some cases, this leads to prolonged legal disputes that can halt or delay mining projects. In the Jadar Project, the company has focused on purchasing land at fair market prices to avoid legal and social conflicts.

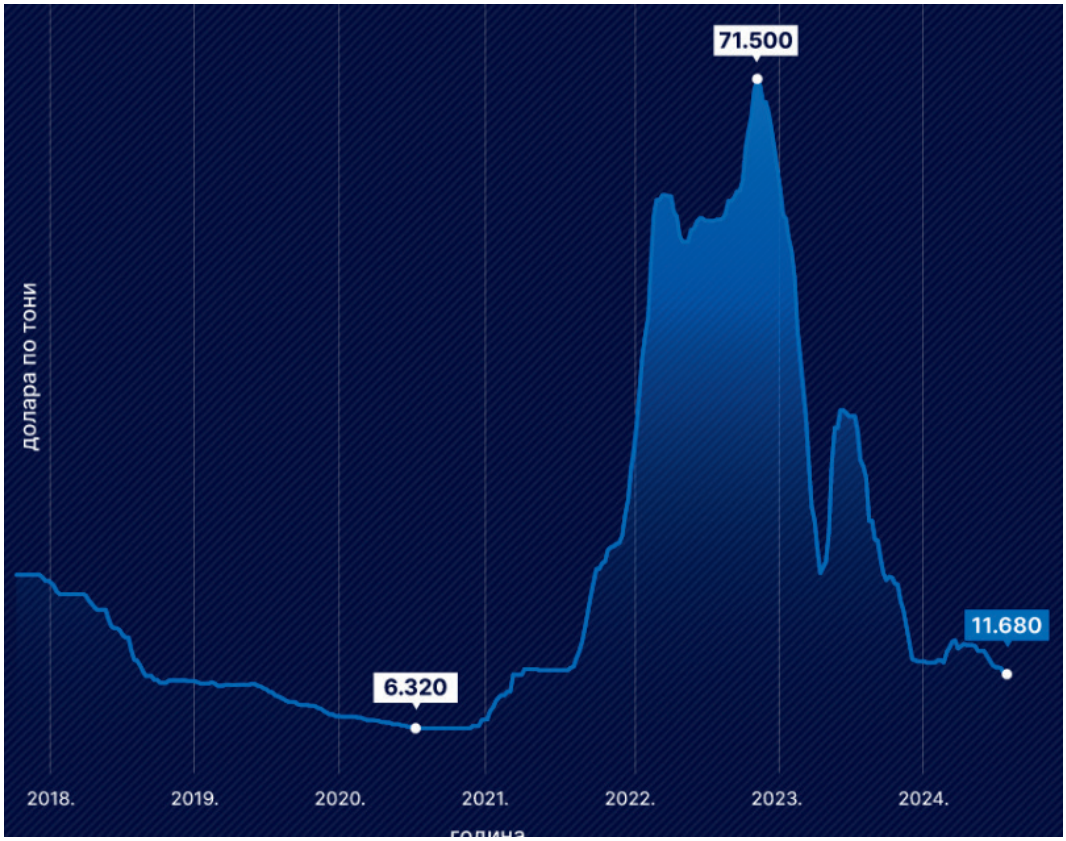

Figure 2 – Lithium price chart on the Chinese stock exchange (RTBalkan, 2024)

Social programmes as a solution

To mitigate social risks, many companies introduce corporate social responsibility programmes. These programmes include investment in education, healthcare, and the development of local businesses. In the Jadar Project, one of the goals is to invest in environmental education for the local population, as well as provide training for workers who will be engaged in the mining and production sectors.

Health risks

Workers and the local population may be exposed to health risks due to mining activities.

Exposure to toxic substances: contact with chemicals used in the extraction process can lead to health issues for employees engaged in production.

Respiratory problems: dust and emissions from mines can cause respiratory diseases.

Workplace accidents: mining is inherently a dangerous occupation with a high risk of injuries.

Environmental measures

Water recycling reduces consumption by 40% (Marković, 2009). The use of less toxic chemicals, such as biodegradable substances (RenovablesVerdes, 2024). Installation of air and water purification systems.

Social measures

Involving local communities in the decision-making process. Compensation programs for affected families. Investment in local infrastructure, including schools and hospitals.

Technological measures

Risk monitoring systems, such as gas sensors and early warning systems, reduce risks in underground mines. The use of advanced algorithms and GIS technologies enables more efficient planning of mining operations (Rudarstvo.org, 2024)

5. Land reclamation after exploitation

This is a key step in reducing the negative effects of mining activities. The main purpose of reclamation is to restore the land to a condition that allows its reuse,

Aerial view of lithium fields in the Atacama desert in Chile, South America - a surreal landscape where batteries are born.
Photo: Shutterstock

whether for natural ecosystems, agriculture, or recreational purposes. In lithium mining, where the focus is often on sensitive ecological regions, this process becomes even more significant. (Envirotis Holding)

Application of reclamation in the Jadar Project

This project in Serbia is an example of a planned approach to reclamation. After the completion of mining activities, it is planned that part of the land will be prepared for agriculture, while other areas will be reforested with local plant species, such as oak and acacia. This ensures not only ecological sustainability but also economic benefits for the local population (Rio Tinto, 2019).

Examples of successful reclamation

Ruhr region, Germany:

Former coal mines in the Ruhr area have been transformed into public parks and lakes, which are now tourist attractions. Reclamation involved removing toxic materials, constructing new infrastructure, and creating habitats for local wildlife species.

Atacama Desert, Chile:

In this region, parts of abandoned mines have been converted into birdwatching centres. By using natural reclamation techniques, such as recharging aquifers, mining companies have managed to restore parts of the ecosystem.

Mineral Jadarite, Natural History Center of Serbia Svilajnac.
Photo: Shutterstock

Greenbushes, Australia:

This lithium mine implemented biological reclamation in collaboration with local scientific teams. Planting eucalyptus trees and establishing new natural habitats contributed to the rapid recovery of the land.

Technical aspects of reclamation

The reclamation process often includes:

Technical remediation: stabilising the terrain, removing toxic materials, and levelling the land; Biological remediation: planting local plant species to restore the natural ecosystem; Ecological monitoring: tracking reclamation results over an extended period to ensure the stability of new ecosystems.

Challenges and costs

Reclamation is a highly expensive process. It is estimated that reclamation costs can account for up to 20% of the total costs of a mining project. Nevertheless, the long-term benefits, including reduced environmental risks and improved quality of life for local communities, justify these costs.

6. Conclusion

Lithium extraction presents challenges but also opportunities for significant economic and technological progress. By implementing sustainable practices and adhering to all domestic and EU environmental regulations, as well as IRMA standards for responsible mining, it is possible to minimise environmental, social, and health risks. The Jadar Project in Serbia serves as an example of a responsible approach that incorporates modern technologies, transparency, and collaboration with local communities. Through water recycling, the use of less toxic chemicals, advanced ventilation systems, and land reclamation, lithium mining can become a model for sustainable development in the industry. However, continued innovation and investment in research are essential to develop new technologies that further enhance this sector.

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