

Chapter 1.

ENVIRONMENTAL INSURANCE AS A RESPONSE TO INCREASING ENVIRONMENTAL RISKS: CHALLENGES AND PERSPECTIVES

The environment is considered a public good. Natural resources, including air, water, land, flora, and fauna, are accessible to all, and their degradation negatively impacts society as a whole. As natural resources become increasingly scarce, environmental protection has never been more important than today.¹ However, environmental risks are a relatively new area of societal concern. Only in the past half-century has society started to prioritise them. Therefore, practical methods for managing these risks are still in their infancy.² This chapter examines environmental insurance as one of the most effective contemporary instruments for preventing and managing environmental risks.

An inevitable consequence of economic development is the degradation of the ecological environment and the increasing frequency of environmental pollution. Persistent environmental challenges exert significant pressure on the sustainability of economic growth. Industrial expansion and rapid urbanisation drive economic progress but also lead to resource depletion, pollution, and ecological degradation. These issues threaten public health, biodiversity, and the stability of key economic sectors. Sustainable development requires striking a balance between economic activities and environmental protection to ensure that growth does not come at the expense of future generations. Governments are responding to these challenges by introducing stricter environmental regulations and encouraging the adoption of green technologies, while economic entities are increasingly embracing sustainable business practices and implementing responsible investment policies. Environmental insurance plays a crucial role in this process by encouraging companies to internalise environmental risks, comply with sustainability standards, and mitigate financial losses from pollution incidents.

¹ OECD (2003). Environmental Risks and Insurance No. 6: A comparative Analysis of the Role of Insurance in the Management of Environment-Related Risks. *Policy Issues in Insurance*, Paris: OECD, p. 22.

² Freeman, P. K., & Kunreuther, H. (2012). *Managing environmental risk through insurance*. Springer Science & Business Media, p. 4.

Environmental insurance is a type of insurance coverage that protects against risks threatening the environment, including air, water, and soil pollution, loss of biodiversity, destruction of natural resources, and other damages resulting from accidents or negligent behaviour by companies or individuals. This type of insurance focuses on protecting the environment and minimising the consequences of ecological disasters. The primary function of environmental insurance is to provide financial protection against the realisation of environmental risks. These risks refer to hazards that may endanger the natural environment, human health, or the quality of essential resources. They can be natural, such as floods, earthquakes, or droughts, or anthropogenic, meaning caused by human activities, such as pollution, deforestation, improper waste management, or the emission of harmful gases. Identifying environmental risks is crucial for the implementation of environmental insurance, as it enables the anticipation of potential damages that may result from specific activities.

In response to the global challenge of sustainable environmental development, the European Union has recognised the importance of environmental protection and established standards and regulations that its member states must observe. These efforts have created an institutional framework for managing environmental risks and their consequences through the implementation of environmental insurance. This chapter aims to explore the potential for introducing environmental insurance in Serbia based on a comparative analysis of international experiences, with particular attention given to the necessary conditions for its effective application.

1. GROWING ENVIRONMENTAL POLLUTION RISKS

Since the publication of "Silent Spring" by Rachel Carson in 1962, which highlighted the detrimental effects of human development on the environment, global awareness of ecological issues has increased significantly. This seminal work sparked the modern environmental movement and led to the first United Nations Conference on the Environment in 1972. Despite ongoing assessments of environmental damage caused by human activities since then, ecological degradation has continued both sporadically and systematically to this day.³

Climate change is no longer a looming threat—it is a present reality intensifying the frequency and severity of environmental disasters. As floods, droughts, wildfires, and biodiversity collapse increasingly affect lives and economies worldwide, new tools are urgently needed to govern environmental pollution

³ Rahmatiar, Y. (2018). The role of environmental insurance as the prevention effort of environmental pollution. *Journal of Arts and Humanities*, 7(5), p. 46.

risks and ensure equitable resilience. Traditional responses have proven insufficient, often reactive rather than preventive. Insurance, traditionally associated with post-disaster compensation, is now evolving to play a more proactive role in managing environmental risks and supporting climate adaptation.

This text explores environmental insurance as a forward-looking mechanism that addresses both natural and anthropogenic environmental risks. Building on critical insights into the colonial nature of extractive capitalism and the need to achieve resilience in interconnected economic systems, this section outlines how environmental insurance can transition from niche application to a structural component of climate governance, especially under conditions of ecological debt and systemic inequality.

According to the IPCC the global economy is currently experiencing profound ecological disruption, already facing 1.5°C of global warming⁴. Scientific forecasts predict a trajectory toward 3.5°C warming if current policies persist⁵. With the historical shift out of ecological reserves in the 1960s, the ongoing exploitation of nature is unsustainable. Planetary boundaries have been breached, and yet, extractivist logic continues to dominate economic policy, particularly in high-income nations.

This trajectory is not an accident, but the result of capitalism's colonial orientation. Post-growth scholars argue that the current system's requirement for perpetual expansion externalises socio-environmental costs onto vulnerable populations. Climate change, biodiversity loss, deforestation, and water contamination are all exacerbated by development models that are rooted in the Global North's extraction of resources from the Global South. These extractivist policies continue under the guise of "green transitions", where supposedly sustainable technologies still demand heavy environmental tolls.

A contemporary example is lithium extraction, often framed as essential to decarbonisation and the electrification of transportation. However, the ecological, social, and cultural risks are especially pronounced when this extraction occurs

⁴ Tešić, N., Kočović De Santo, M., & Radosavljević, K. (2023). New insurance directions as a response for climate change. In: *Challenges and insurance market's responses to the economic crisis*, Kočović, J. et al. (eds.), Belgrade: University of Belgrade, Faculty of Economics and Business, pp. 191-213.

⁵ Intergovernmental Panel on Climate Change (2021). Climate change 2021, The physical science basis. *Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva: IPCC (Retrieved May 1, 2023 from <https://www.ipcc.ch/report/ar6/wg1/>)

in fertile, rich cultural and biodiversity areas with access to non-renewable supplies of clean water. As shown in the case of Serbia, lithium extraction proposals threaten rich agricultural land and aquifers, because the process often disregards local community members who oppose projects which violate environmental and social justice principles. Such and similar projects produce not only physical pollution but also ecological debt—deferred environmental destruction with intergenerational consequences.

Climate change-induced droughts, floods, and erratic weather patterns severely threaten food security, which is the reason to bring the comparisons between ongoing economic and agricultural activities and their effects versus lithium extraction in the Jadar valley. Insurance mechanisms are being introduced, but without structural changes to production models or environmental safeguards, these remain reactive rather than preventative.

Joan Martínez-Alier's foundational concepts of the *environmentalism of the poor*⁶, *sacrifice zones*, and *ecological debt*⁷ offer critical insights for understanding the ecological conflict dynamics surrounding the Jadar Valley lithium project in Serbia. These frameworks help understand the role of Serbia as part of Europe's periphery—a sacrifice zone increasingly subjected to extractivist projects in the name of the "green transition" and the "greater good." Such narratives, while invoking climate urgency, often obscure the neo-colonial patterns underpinning extractive development.

Discourses on climate change articulated by hegemonic political and corporate actors frequently perform a subtle expropriation of local autonomy. Communities resisting imposed megaprojects are routinely constructed as irrational, misinformed, or manipulated, thus justifying continued exploitation under the banner of progress. This rhetorical framing delegitimises local knowledge systems while privileging technocratic and corporate visions of sustainability.

A clear structural divide persists in today's global order—between the Global North and South, between centre and periphery—manifesting in the unequal distribution of resources, political power, and environmental burdens. Peripheral regions, like western Serbia and the Jadar valley, are systematically selected as

⁶ Martínez-Alier, J. (2002). *The Environmentalism of the Poor: A Study of Ecological Conflicts and Valuation*. Edward Elgar Publishing.

⁷ Martínez-Alier, J., Temper, L., Del Bene, D., & Scheidel, A. (2020). Is there a global environmental justice movement? The Global Environmental Justice Atlas (EJAtlas): Ecological Distribution Conflicts as Forces for Sustainability. *Journal of Peasant Studies*, 47(5), pp. 999-1024.

destinations for the externalisation of ecological costs associated with the industrial production of the Global North. This process represents an embedded form of neo-colonial logic, whereby natural wealth is extracted and environmental damage localised, while economic benefits flow elsewhere⁸.

Recent political narratives deployed by European officials, corporate representatives, and supportive media outlets reveal a troubling inversion of knowledge. Legitimate concerns raised by residents of the Jadar Valley are often dismissed as products of misinformation or foreign (specifically Russian) interference, while other alternative visions of development are subordinated to techno-economic and corporate framings.

The lithium extraction project is thus discursively framed as a precondition for modern development, but where, and for whom? At the same time, rural life and agriculture are characterised as outdated or backwards alternatives. This framing reinforces the implicit global role assigned to peripheral nations: to service the needs of the industrialised core, often at their own ecological and social expense. As expressed by EU officials, Serbia is offered the "opportunity" to become part of the lithium value chain. This becomes clearer if we add that the wealthiest 1% produce over 15% of global emissions, while the poorest 50% are responsible for only 7%. Yet, environmental degradation—polluted rivers, toxic air, and degraded soils—disproportionately impacts the poorest communities⁹. Despite an increase in global disaster-related losses, averaging \$170 billion annually, only 45% were insured in 2022.¹⁰ In many developing countries, less than 10% of losses are covered by insurance, revealing not only unequal exposure to climate risks but also unequal access to recovery mechanisms.

These risks extend to the rise of diffuse and chronic pollution forms: soil contamination from industrial waste, air pollution from extractive, energetic and

⁸ Kočović De Santo, M. (2024). Životna sredina za sirotinju: Srbija kao zona žrtvovanja. *Danas*, print edition, Saturday–Sunday, July 27–28, 2024; Kočović De Santo, M. (2024). Da li je vredno i za koga da Srbija bude nova kolonija?, *Danas*, August 3, 2024, <https://www.danas.rs/dijalog/licni-stavovi/da-li-je-vredno-i-za-koga-da-srbija-bude-nova-kolonija/>

⁹ Oxfam (2020). Confronting Carbon inequality - Putting climate justice at the heart of the COVID-19 recovery. *Oxfam Media Briefing* (retrieved May 1, 2023 from <https://oxfamlibrary.openrepository.com/bitstream/handle/10546/621052/mb-confronting-carbon-inequality-210920-en.pdf?sequence=1&isAllowed=y>)

¹⁰ Cvijanović, D., Radosavljević, K., & Kočović De Santo, M. (2024). Agricultural insurance in response to climate challenge. In: *Transformation of the insurance market: responses to new challenges*, Kočović, J. et al. (eds.), Belgrade: University of Belgrade, Faculty of Economics and Business, pp. 165-189.

more related projects, and freshwater degradation from overuse and runoff. The environmental insurance is now emerging as a possible buffer to these risks. However, it remains in its infancy and struggles with core challenges: a lack of adequate legal frameworks, insufficient data for environmental damage valuation, and institutional inefficiencies.

Environmental insurance can potentially serve as both a compensatory and preventative tool. Ultimately, managing rising environmental risks means acknowledging the deep structural forces at play: the historical overconsumption of natural resources by the Global North, the continued exploitation of the Global South under green capitalist paradigms, and the urgent need for ecological reparations and solidarity-based insurance frameworks. Insurance is one tool, but without fundamental shifts in how we define growth, development, and risk, it will remain a bandage over deeper wounds.

2. REGULATORY FRAMEWORK OF THE EU IN THE FIELD OF ENVIRONMENTAL PROTECTION

In the practice of European Union (EU) member states, differing views on environmental insurance persisted for a long time. However, the scope of liability insurance for environmental pollution was established with the adoption of the EU Environmental Liability Directive concerning the prevention and remediation of environmental damage in 2004 (Directive 2004/35/EC)¹¹. This directive assigns responsibility for the costs of preventing and remedying environmental damage and sets requirements for financial guarantees to ensure environmental liability.

The aim of Directive 2004/35/EC is to prevent and remediate environmental damage, as well as to establish liability for such damage based on the "polluter pays" principle. This principle implies that the party responsible for causing the damage through a hazardous activity, one from which they derive economic benefit, must bear the costs of the damage.¹² Article 3 of this Directive stipulates that its provisions must be applied to: a) environmental damage resulting from any of the economic activities listed in the Annex to the Directive,¹³ as well as in

¹¹ Directive 2004/35/EC of the European Parliament and of the Council on environmental liability with regard to the prevention and remedying of environmental damage, *Official Journal of the European Union*, L 143/56

¹² Labudović Stanković, J. (2012). Osiguranje od odgovornosti za štete prouzrokovane životnoj sredini. *Teme*, XXXVI(3), p. 1263.

¹³ The list of activities includes the operation of industrial installations covered by Directive 96/61/EC on integrated pollution prevention and control, which has since

cases where there is an imminent threat of such damage; and b) damage to protected species and natural habitats resulting from any other economic activity, including cases where there is an imminent threat of such damage, regardless of whether the operator acted negligently or without fault. The concept of environmental liability has evolved significantly from the understanding that liability for large-scale environmental disasters falls under the category of "comprehensive general liability" to the recognition of environmental insurance as a distinct type of liability insurance for environmental damage. This type of insurance defines the insurer's liability in the event of claims for compensation resulting from environmental harm, regardless of its scale.¹⁴

The European Union has established a comprehensive legal framework governing environmental protection, with several key directives forming the foundation for the implementation of environmental insurance, including:

1. *Environmental Liability Directive – ELD (2004/35/EC)* – assigns environmental liability to those responsible for causing environmental damage, establishing clear guidelines for prevention and remediation;
2. *Water Framework Directive (2000/60/EC)* – regulates the protection of water resources from pollution and, in the context of insurance, enables coverage for damages caused by water contamination;
3. *Industrial Emissions Directive – IED (2010/75/EU)* – sets guidelines for the prevention and control of industrial pollutant emissions, which may also be covered by environmental insurance in the event of an accident;
4. *Thematic Strategy for Soil Protection* – sets out basic guidelines for protecting soil from degradation and pollution, providing a legal basis for insurance coverage of remediation costs for land contaminated by industrial activities or chemical substances;
5. *Seveso III Directive (2012/18/EU)* – establishes strict requirements for the prevention and control of industrial accidents involving hazardous substances, requiring operators to implement measures to limit environmental consequences. In the context of environmental insurance, this directive stimulates demand for insurance policies that cover remediation costs and liability in the event of major chemical incidents.

been repealed and replaced by Directive 2010/75/EU on industrial emissions (IED), as well as waste management, operation of landfills and incineration plants, discharge of hazardous substances into surface or groundwater, water abstraction and impoundment, production, storage, processing and transport of dangerous substances, operation of installations emitting pollutants into the air, use and release of genetically modified microorganisms, and transboundary shipment of waste.

¹⁴ Моткин, Г. А. (2010). *Экологическое страхование: Итоги и перспективы*, Москва: НИЦ Экопроект, p. 20.

The directives mentioned above define environmental risks as hazards that may potentially endanger the environment as a result of human activities. Environmental risks include:

1. *Pollution* – Pollution of air, water, and soil represents one of the most significant environmental risks. Activities such as industrial production, transportation, agriculture, and improper waste disposal can lead to serious environmental problems. These activities may result in the emission of harmful gases that pollute the atmosphere. Industrial wastewater, oil spills, chemical leaks, and improper storage or disposal of waste can contaminate soil, groundwater, rivers, lakes, and seas, causing severe damage to the environment and ecosystems.
2. *Soil erosion* – Agricultural activities and deforestation can lead to soil erosion, which negatively affects soil quality, biodiversity, and food production.
3. *Climate change* – Changes in climatic conditions caused by human activities, such as the emission of CO₂ and other greenhouse gases, can lead to extreme weather events, including floods, droughts, and heat waves.¹⁵
4. *Biodiversity loss* – The excessive exploitation of natural resources and the destruction of habitats lead to a decline in biodiversity, which can threaten ecosystems and the living conditions of many species.

The European Union directives establish strict standards that ensure accountability for environmental damage, thereby reducing risks to nature and communities. Understanding these regulations and securing adequate environmental insurance lays the foundation for a sustainable future.

3. THE ROLE OF ENVIRONMENTAL INSURANCE IN ENSURING SUSTAINABLE DEVELOPMENT

Environmental pollution liability insurance, hereafter referred to as "environmental insurance," emerged in industrialised countries in response to the environmental challenges brought about by rapid industrialisation. Since the mid-1960s, the introduction of increasingly stringent environmental regulations has made it difficult for some enterprises to bear the high costs associated with major

¹⁵ See more in: Kočović, J. (2022). Contemporary challenges and perspectives of insurance market development. In. *Development of modern insurance market – constraints and possibilities*, Kočović, J. et al. (eds.), Belgrade: University of Belgrade, Faculty of Economics and Business, pp. 8-10; and Kočović, J., Tešić, N., & Koprivica, M. (2023). Izazovi osiguranja u eri klimatskih promena, *Proceedings of the 11th Scientific Conference EkonBiz*, Mitrašević, M. (ed.), Bijeljina: University of East Sarajevo, Faculty of Business Economics, pp. 73-75.

pollution incidents. Consequently, the growing need for financial protection led to the development of environmental insurance,¹⁶ as a mechanism for balancing environmental responsibility with economic interests.

Environmental insurance is a specific type of insurance that protects against financial losses arising from the realisation of environmental risks. The essence of environmental insurance lies in compensating for damage to the environment that results from economic activities. This may include air, water, and soil pollution, as well as harm to human and animal health. Environmental insurance ensures the coverage of costs associated with the remediation of environmental incidents, including the cleanup of contaminated areas, compensation to affected parties, and the restoration of ecosystems.

Environmental insurance is a significant factor that can contribute to sustainable development. In order to achieve sustainability, economic development and environmental protection must be aligned. Sustainable development entails meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. This approach involves the integration of environmental, economic, and social dimensions of development, with a particular emphasis on minimising the negative impact on nature. Sustainable development can be achieved through the proactive management of environmental risks and the implementation of preventive measures aimed at reducing environmental harm, raising awareness about the importance of environmental protection and the role of environmental insurance in risk reduction, and fostering cooperation among government institutions, insurance companies, and other economic actors exposed to environmental risks.

Typically, environmental insurance applies to businesses, industrial complexes, transportation companies, and other entities that may cause environmental damage. It may also be held by landowners and property operators whose activities could impact the environment. For example, facilities that use hazardous chemicals or nuclear power plants are expected to carry environmental insurance due to the potential for soil contamination, air pollution, and harmful effects on human health.

Environmental insurance fulfils three main functions. First, it protects individual companies from bankruptcy by spreading the risks and costs of environmental pollution across a group of polluters. Second, it ensures that victims of

¹⁶ Ren, G., & Shang, J. (2010). The Conditions of China's Environmental Liability Insurance System. In: *4th International Conference on Bioinformatics and Biomedical Engineering*, IEEE, p. 1.

environmental damage can receive compensation, even if the company responsible for the disaster goes bankrupt. Lastly, environmental insurance helps reduce environmental risks by incentivising polluters to invest in risk reduction and prevention measures.¹⁷

By transferring environmental liability risks to insurers, environmental insurance alleviates financial pressure on enterprises, helping them mitigate potential cash flow disruptions caused by litigation claims, pollution compensation, and remediation costs. In turn, by reducing banks' credit risk, environmental insurance provides polluting enterprises with better access to bank loans.¹⁸ Additionally, purchasing environmental insurance sends a positive signal of corporate social responsibility to investors, thereby reducing the cost of capital.¹⁹

Beyond financial relief, environmental insurance plays a key role in fostering green innovation. Its risk-sharing mechanism allows enterprises to allocate more resources to R&D without fear of unexpected environmental costs. Insurers can adjust pricing to incentivise and reward policyholders for investing in environmental innovation to mitigate potential risks. To lower their premiums, insured companies are motivated to comply with environmental standards, invest in safer technologies, and implement other preventive measures, thereby mitigating environmental risk. Consequently, environmental insurance plays a crucial role in maintaining ecological balance and protecting the natural environment. Additionally, to prevent moral hazard and minimise insured losses, insurance companies perform an external supervisory function through pre-underwriting assessments and continuous post-underwriting monitoring.²⁰ By acting as third-party regulators alongside government regulations, insurance companies help create a dual regulatory framework that enhances environmental awareness and promotes sustainable business practices.²¹

¹⁷ Freeman, P. K., & Kunreuther, H. (2012). *Managing environmental risk through insurance*. Springer Science & Business Media

¹⁸ Lyu, C., Xie, Z., & Li, Z. (2022). Market supervision, innovation offsets and energy efficiency: Evidence from environmental pollution liability insurance in China. *Energy Policy*, 171, p. 2.

¹⁹ Ning, J., Yuan, Z., Shi, F., & Yin, S. (2023). Environmental pollution liability insurance and green innovation of enterprises: Incentive tools or self-interest means? *Frontiers in Environmental Science*, 11, p. 3.

²⁰ Косариков, А. Н., Иванов А. В., Шевченко, Ж. А. (2003). *Экологическое страхование и оценка рисков*, Нижний Новгород, p. 57.

²¹ Wen, H.-x., Cui, T., Wu, X.-q., & Nie, P. (2024). Environmental insurance and green productivity: A firm-level evidence from China. *Journal of Cleaner Production*, 435(2024), p. 3.

Several studies have provided evidence on the relationship between environmental insurance and corporate performance, green innovation, energy efficiency and pollution reduction. Wu et al. (2022) claim that environmental insurance positively affects corporate environmental performance by alleviating financing constraints.²² Wen et al. (2024) find that environmental insurance promotes a firm's green total factor productivity. Ning et al. (2023) show that environmental insurance facilitates green innovation of enterprises by relaxing financing constraints and reducing agency costs.²³ A positive relationship has also been found between environmental insurance and energy efficiency.²⁴ Zhu et al. (2023) argue that environmental insurance encourages enterprises to cut emissions by reducing coal and oil consumption while expanding investments in emission control technologies.²⁵ Yin et al. (2011) find that mandating environmental insurance contributed to reducing toxic releases from underground storage tanks in the United States.²⁶

4. IMPLEMENTATION OF ENVIRONMENTAL INSURANCE: EVIDENCE FROM DEVELOPED AND DEVELOPING COUNTRIES

Environmental insurance was first introduced in the 1970s in developed countries with mature insurance markets, such as the United States, Germany, France, and the United Kingdom. In the 21st century, developing countries face a complex Prisoner's Dilemma when balancing economic growth and environmental protection.²⁷ In pursuit of rapid development, they tend to prioritise industrial growth and infrastructure at the expense of environmental protection. However,

²² Wu, W., Zhang, P., Zhu, D., Jiang, X., & Jakovljevic, M. (2022). Environmental pollution liability insurance of health risk and corporate environmental performance: evidence from China. *Frontiers in Public Health*, *10*, p. 8.

²³ Ning, J., Yuan, Z., Shi, F., & Yin, S. (2023). Environmental pollution liability insurance and green innovation of enterprises: Incentive tools or self-interest means? *Frontiers in Environmental Science*, *11*, p. 9.

²⁴ Lyu, C., Xie, Z., & Li, Z. (2022). Market supervision, innovation offsets and energy efficiency: Evidence from environmental pollution liability insurance in China. *Energy Policy*, *171*, p. 4.

²⁵ Zhu, D., Chen, K., Sun, C., & Lyu, C. (2023). Does environmental pollution liability insurance promote environmental performance? Firm-level evidence from quasi-natural experiment in China. *Energy Economics*, *118*, p. 9.

²⁶ Yin, H., Pfaff, A., & Kunreuther, H. (2011). Can environmental insurance succeed where other strategies fail? The case of underground storage tanks. *Risk Analysis: An International Journal*, *31*(1), pp. 15-16.

²⁷ Zhu et al. (2023), op. cit., p. 1.

this short-term strategy can result in long-term ecological degradation. The introduction and development of environmental insurance can help developing countries pursue more sustainable growth while preserving natural resources for future generations.

Two primary forms of environmental insurance can be identified: voluntary and compulsory. Voluntary environmental insurance allows companies to make their own decision about purchasing coverage. In contrast, compulsory environmental insurance mandates specific industries to obtain coverage.²⁸ Experience from both developed and developing countries shows that compulsory environmental insurance tends to perform better than voluntary environmental insurance.²⁹ The need for introducing compulsory environmental insurance arises from constraints on both the demand and supply sides of the insurance market.

On the one hand, industrial enterprises often tend to underestimate the environmental risks arising from their operations, which makes them reluctant to purchase environmental liability insurance.³⁰ In developing countries in particular, polluting companies frequently have limited awareness of their environmental responsibilities, as governments have traditionally borne the costs of environmental damage. Weak enforcement and deficiencies in environmental compensation laws further reduce the incentive for companies to seek coverage. Due to the limited number of insured entities, it is not possible to establish a sufficiently large risk pool for effective risk dispersion.

On the other hand, the unique characteristics of environmental pollution risks make them particularly challenging to insure. These risks, especially gradual pollution, are often hard to detect and may not become evident for years, making causal links with actual loss unclear.³¹ Environmental losses also tend to be large—and in some cases, catastrophic—often exceeding the financial capacity of the insurance sector. Moreover, the amount of loss is typically difficult to

²⁸ Feng, Y., Mol, A. P., Lu, Y., He, G., & van Koppen, C. K. (2014). Environmental pollution liability insurance in China: compulsory or voluntary? *Journal of Cleaner Production*, 70, p. 212.

²⁹ Ibid, p. 217.

³⁰ OECD (2012). *Liability for environmental damage in Eastern Europe, Caucasus and Central Asia (EECCA): Implementation of good international practices*, Paris: OECD, p. 27.

³¹ Rahmatiar, Y. (2018). The role of environmental insurance as the prevention effort of environmental pollution. *Journal of Arts and Humanities*, 7(5), p. 47.

estimate at a specific point in time.³² Gradual pollution, characterized by latency and long-term effects, complicates insurance coverage because it is hard to determine when the pollution began and how long it lasted. Insurance limits may become inadequate due to inflation given the long-tail nature of environmental risks. Synergetic pollution, where multiple sources contribute to environmental harm, further complicates risk identification and underwriting. Additionally, the insurability of environmental risks is closely tied to the regulatory framework. Uncertainty or a lack of clear regulations can limit the insurability of risk, while well-defined environmental rules can foster the development of an effective pollution insurance market. Moral hazard is also a significant concern, as high-risk polluters may perceive insurance coverage as a "license to pollute."³³ In developing countries in particular, the insurance sector often faces limited financial resources and lacks the necessary expertise to model environmental risks and establish adequate insurance premium rates.

These constraints in the insurance market result in a limited number of companies willing to purchase coverage and a lack of attractive and affordable products offered by insurers.³⁴ Consequently, voluntary schemes struggle with low demand, slow market development, and minimal competition,³⁵ which hinders the potential of environmental insurance to contribute to sustainable development. In contrast, compulsory environmental insurance fosters larger risk pools, greater competition and lower premiums.

EU Member States, pursuant to Article 14 of the Environmental Liability Directive (ELD), are required to encourage the development of financial security instruments and related markets to enable operators to meet their environmental liability obligations. These financial security instruments may take various forms, including insurance policies, bank guarantees, bonds, or own reserves. However, Member States are not legally obliged to make such financial security mandatory.

³² Anderson, D. R. (1998). Development of environmental liability risk management and insurance in the United States: lessons and opportunities. *Risk Management and Insurance Review*, 2(1), p. 2.

³³ OECD (2003), op. cit., p. 41.

³⁴ See more in: Kočović, J., Koprivica, M., & Jović, Ž. (2021). Sustainable development of insurance in crisis conditions. In: *Contemporary Challenges and Sustainability of the Insurance Industry*, Kočović, J. et al. (eds.), Belgrade: University of Belgrade, Faculty of Economics and Business, p. 18.

³⁵ Ren, G., & Shang, J. (2010). The conditions of China's environmental liability insurance system. In: *4th International Conference on Bioinformatics and Biomedical Engineering*, IEEE, p. 3.

Figure 1. Financial security for ELD liabilities in the EU



Source: European Court of Auditors (2021), *op. cit.*, p. 28.

The system of mandatory financial security exists in only a few EU Member States, including the Czech Republic, Ireland, Italy, Poland, Portugal, Slovakia, and Spain (Figure 1).³⁶ Most Member States have opted for voluntary mechanisms. While environmental liability insurance is the main form of voluntary financial security, take-up remains low. Research findings indicate that insurance policies covering ELD liabilities are not widely available across the EU, and in some Member States, they do not exist at all. Additionally, availability does not always match demand, as some countries report high availability but low demand (Figure 2). However, in countries where financial security is mandatory, this has helped develop the environmental insurance market.³⁷ As a result, the European Commission is considering a mandatory EU-wide financial security scheme that includes insurance.³⁸ Introducing a mandatory insurance mechanism is considered "one of the most controversial and crucial focal points in the development process of the Environmental Liability Directive".³⁹

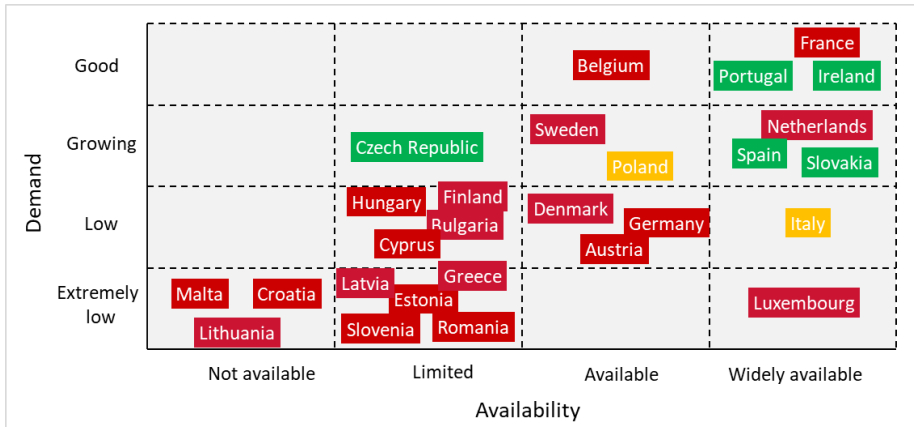
³⁶ European Court of Auditors (2021). *The Polluter Pays Principle: Inconsistent application across EU environmental policies and actions*. Luxembourg: ECA, p. 27.

³⁷ Fogleman, V. (2020). *Improving financial security in the context of the Environmental Liability Directive*. Brussels: European Commission, pp. 204-206.

³⁸ Skinner, N. (ed.) (2011). *A Guide to Environmental Liability in Europe*. *StrategicRISK*, p. 1, <https://www.strategic-risk-global.com/download?ac=21944>

³⁹ Cassotta, S. (2012). *Environmental Damage and Liability Problems in a Multilevel Context. The Case of the Environmental Liability Directive*. Kluwer Law International, p. 198.

Figure 2. Availability and demand for stand-alone environmental insurance policies in the EU



Source: Prepared based on Fogleman (2020), *op. cit.*, pp. 200-206.

It is important to note that Many EU Member States have imposed mandatory financial security requirements for environmental liabilities beyond EU law. For example, insurance or equivalent instruments are required for waste management permit holders (Croatia, Cyprus, Hungary), waste transporters (Germany, Greece), exploration permit holders (Finland), home oil tank owners (Denmark), and land transactions (Belgium).

An increasing number of developing countries are introducing mandatory environmental liability insurance. In recent years, such measures have been adopted in Argentina, China, Kazakhstan, and Turkmenistan (Table 1). In Kazakhstan, the Law on Mandatory Environmental Insurance requires legal and natural persons engaged in environmentally hazardous activities to hold environmental insurance. These entities are not permitted to operate without an environmental insurance policy issued by an insurer licensed to provide this type of coverage. The insurance contract must specify the sum insured (coverage limit), which represents the insurer’s maximum liability per insured event, with the minimum sum insured prescribed by law. The insurance premium is negotiated between the policyholder and the insurer, with a lower and upper limit of the premium rate defined, which is applied to the agreed sum insured. The minimum contract duration is 12 months. The law also sets a deadline within which the insurer must pay compensation following the occurrence of an insured event. The list of environmentally hazardous activities is determined by the competent state authority.⁴⁰

⁴⁰ <https://adilet.zan.kz/rus/docs/Z050000093>

Table 1. Key features of mandatory environmental insurance systems in selected developing countries

	Argentina	China	Kazakhstan	Turkmenistan
Year introduced	2002 – Legal requirement introduced; operational enforcement started in 2007–2008.	Pilot programs from 2008; guidelines issued in 2013; draft national regulation in 2017 (not yet enforced)	2005 – Law adopted; system effective from 2006.	2013 – Mandatory environmental insurance in force since March 1 for all applicable entities.
Covered industries	Activities with medium or high environmental complexity, based on a government risk classification system.	Defined list of high-pollution sectors (e.g. chemicals, oil/gas, hazardous waste), including firms with major incidents since 2005.	List of hazardous activities defined by decree; includes heavy industry and high-risk operations.	Government-issued list of environmentally hazardous activities (e.g. mining, chemicals, oil/gas).
Insurer	Licensed private insurance companies	Licensed private insurance companies	Licensed private insurance companies	State insurance company
Minimum insured amount	Yes – set by regulation, based on the environmental risk level of the activity.	No fixed minimum; sum insured is determined by contract.	Yes – set by law: 5,000× MCI (individuals), 65,000× MCI (companies), where the MCI is a monetary index set by the budget law each year.	Yes – set by law: 100 times base value for injury, 4,000 times base value for property/environmental damage, where base value is a government-set reference amount.

Premium rates	Risk-based and negotiated; no fixed tariffs; insurers assess risk individually.	Risk-based within regulatory framework; insurers set base rates adjusted for risk factors; regulator approval required.	Negotiated but legally bounded; premium must stay within 0.76%–2.65% of the insured sum.	Fixed tariff rates set by law according to category of hazardous activity.
Covered risks	Environmental damage and remediation costs. Third-party injury/property damage is not covered. Gradual pollution is implicitly covered.	Environmental damage, third-party injury/property damage, and cleanup costs. Legal expenses may be included. Gradual pollution is generally covered.	Environmental damage and third-party losses from accidental pollution events. Only sudden incidents are insured. Gradual pollution is not covered.	Environmental damage and third-party injury/property damage from accidental pollution events. Only sudden incidents are insured. Gradual pollution is not covered.
Sanctions for non-compliance	Denial or revocation of permits, fines, and suspension of operations until insurance is obtained.	Fines, suspension of permits or approvals, restriction of access to environmental subsidies, and temporary shutdown until coverage is obtained.	Fines and temporary suspension of facility operations until insurance is provided.	Fines and suspension of operations until insurance is provided.

Source: Prepared based on Molina & Chona (2009); www.argentina.gob.ar; www.eldial.com; www.marval.com; Rödl & Partner (2017); www.chinalawvision.com; <https://english.mee.gov.cn>; <https://practiceguides.chambers.com>; <https://theeurasia.kz>; <https://vic.kz>; Jafarova (2013); <https://turkmeninform.com>; <https://insurance.gov.tm>; www.global-regulation.com.

Global annual premiums for environmental pollution liability insurance are estimated at less than USD 3.5 billion,⁴¹ representing less than 0.1% of total global non-life insurance premiums.⁴² More than half of this amount is attributed to the U.S. market alone. According to the World Economic Forum's Global Risk Report 2024, five of the ten most severe global risks projected over the next decade are environmental in nature: extreme weather events (ranked 1st), critical changes to Earth systems (2nd), biodiversity loss (3rd), natural resource shortages (4th), and pollution (10th).⁴³ Given this context, it is evident that there is substantial potential for the development of the environmental liability insurance market at a global level.

5. CHALLENGES IN THE IMPLEMENTATION OF ENVIRONMENTAL INSURANCE IN SERBIA

For the widespread implementation of environmental insurance in Serbia, several significant objective challenges must be overcome to establish an effective system for environmental protection and maintain ecological balance. These challenges are not merely administrative or legislative in nature but also relate to a broader range of factors, including financial capacities, damage assessment methodologies, data availability, and the quality of institutional support. Some of the most prominent challenges include:

- a) inefficiency of the state in remediating environmental damage;
- b) lack of sufficient financial resources within companies to remedy the effects of environmental incidents (accidents);
- c) lack of a standardised methodology for determining the monetary value of environmental damage;
- d) lack of transparent statistics on natural resources and the state of the environment;
- e) lack of an adequate institutional and legal framework necessary for the implementation of environmental insurance;
- f) limited financial capacity of insurers to cover damages caused to the environment.

⁴¹ United Nations Environment Programme Finance Initiative (2022). *New risks, new opportunities: Harnessing environmental pollution liability insurance for a sustainable economy*. Geneva: UNEPFI, p. 8.

⁴² Swiss Re (2023). World insurance: stirred, and not shaken. *Sigma*, 3(2023), p. 38.

⁴³ World Economic Forum (2024). *The Global Risk Report 2024*, 19th Edition, Geneva: WEF, p. 8.

a) Inefficiency of the state in remediating environmental damage

One of the main challenges in the field of environmental protection is the inefficiency of state institutions in responding promptly and effectively to environmental disasters and their adverse consequences resulting from human activity. There is often a problem with the issuance of permits for projects that pose significant environmental risks, as well as a lack of coordination between different national and local authorities. There is also a lack of efficiency in addressing the consequences of environmental incidents, which often leads to further environmental degradation—providing an additional argument for the establishment and implementation of environmental insurance. By introducing mandatory environmental insurance through a public-private partnership model, the state could, in cooperation with insurers, compensate for the shortfall in funds needed for environmental remediation. This would enable more accurate allocation of resources and faster intervention in urgent environmental situations, thereby laying the foundation for a more systematic approach to environmental protection.

b) Lack of sufficient financial resources within companies to remedy the effects of environmental incidents (accidents)

Companies that cause environmental incidents often lack sufficient funds to remediate the damage or compensate affected communities and victims. Due to the complexity of assessing environmental disasters from both financial and operational aspects, many companies are unable to cover the costs of remediation and compensation. This represents a serious problem for environmental sustainability, as it often leads to the long-term neglect of corporate responsibility towards the environment. Mandatory environmental insurance could address this issue, as companies would be legally required to pay insurance premiums, thereby ensuring that insurers compensate the affected parties and reducing the risk of financial incapacity to remedy the environmental consequences of their activities.

c) Lack of a standardised methodology for determining the monetary value of environmental damage

Due to the variety of damage types—such as long-term impacts on biodiversity, water or soil contamination, and harm to human health—it is challenging to calculate accurately the actual costs of remediation and compensation. Different approaches and methodologies exist depending on the type of environmental incident. However, there is still no adequate methodology that would allow for consistent and precise valuation of damage, which is essential for determining insurance premiums, where the expected value of loss is the most dominant component. The implementation of environmental insurance could contribute to the development and standardisation of these methodologies, as insurance

companies would be motivated to design methods enabling accurate damage assessments in order to appropriately determine premiums and compensation amounts. This would allow them to develop a range of products covering specific environmental risks and, through mandatory environmental insurance that encompasses a broad base of policyholders, ensure access to coverage for all environmental polluters—both legal entities and individuals. Without a mandatory system, many of them would not meet the conditions for inclusion.

d) Lack of transparent statistics on natural resources and the state of the environment

There is currently a significant issue related to the lack of transparency and readily available data on the state of the environment and natural resources. Environmental information is often not collected in real time or is inadequately analysed, which hinders timely decision-making regarding environmental protection. Moreover, data on resources—such as water and energy—are not sufficiently integrated into broader environmental strategies. To implement environmental insurance, it is necessary to establish a national database on environmental resources and their current status, including records of environmental damage. Such a national environmental statistics system would enable more accurate monitoring of environmental risks and faster responses in the event of their materialisation or the occurrence of environmental damage.

e) Lack of an adequate institutional and legal framework necessary for the implementation of environmental insurance

It is necessary to establish institutional preconditions for the introduction of mandatory environmental insurance by creating a specific type of liability insurance for environmental damage. This represents the appropriate approach to implementing such insurance. Introducing mandatory environmental insurance for companies whose activities may seriously endanger the environment—air, soil, and water—requires the imposition of strict conditions regarding environmental protection measures. Legislation should mandate compulsory insurance for specific high-risk industries, such as the oil industry, mining, chemical production, and agriculture. By adopting appropriate regulations, companies are both obligated and encouraged to invest in environmental insurance.

Liability for environmental pollution in Serbia is regulated by the Law on Environmental Protection. According to the "polluter pays" principle, the polluter is responsible for the damage caused to the environment and bears the full cost of measures to prevent and reduce pollution, including the costs of damage assessment and remediation. The Law on Environmental Protection also prescribes mandatory insurance for polluters whose facilities or activities pose a

high risk to human health and the environment, covering liability for damage caused to third parties. Any person who suffers damage has the right to compensation, which can be claimed directly from the polluter or the polluter's insurer or financial guarantor if such entities exist. The Republic of Serbia reserves the right to claim compensation in cases where no other party is entitled to it.⁴⁴ However, the law does not specify which economic activities are subject to the requirement for mandatory liability insurance. As a result, there is a challenge in determining the entities to which the insurance obligation applies.⁴⁵ Additional legislative shortcomings concern the absence of essential elements in the mandatory insurance contract, which partly explains why this type of insurance is not available as a standalone product on the domestic insurance market. The Environmental Protection Act does not specify the risks covered by the insurance, prescribe a minimum sum insured, or define a mechanism for monitoring the implementation of mandatory insurance contracts.⁴⁶ In Serbia, environmental pollution liability insurance can only be arranged as supplementary coverage within general liability insurance. In the absence of precise legal regulations, the definition of the insured risk in environmental liability insurance is left to the autonomous regulation of insurance companies.⁴⁷ According to the General Terms and Conditions for Liability Insurance, if specifically agreed upon and subject to the payment of an additional premium, the policy includes coverage for property damage resulting from environmental pollution, including damage to land and water. This insurance coverage applies only if the pollution resulted from a sudden and unforeseen event that deviates from the regular course of business. Consequently, damages to the environment that arise gradually and as a result of continuous exposure are not covered, although such damages occur more frequently in practice than sudden ones.⁴⁸

Beyond establishing a clear legal framework, it is essential to develop supporting policies that foster the growth of environmental insurance. The state may provide subsidies or tax relief to companies that invest in environmental risk prevention

⁴⁴ Law on Environmental Protection, *Official Gazette of the Republic of Serbia*, No. 135/2004, 36/2009, 36/2009 – other law, 72/2009 – other law, 43/2011 - Constitutional Court decision, 14/2016, 76/2018 i 95/2018 – other law, articles 102-107.

⁴⁵ Molnar, D., & Koprivica, M. (2024). Osiguranje kao instrument upravljanja rizicima u rudarstvu – primer Srbije. In: *Ekonomski rast i ekonomska stabilnost*, Krstić, G., & Randelović, S. (eds.), Belgrade: Serbian Scientific Society of Economists, Faculty of Economics and Business, University of Belgrade, p. 150.

⁴⁶ Labudović Stanković (2012), op. cit., p. 1273.

⁴⁷ Molnar & Koprivica (2024), op. cit., p. 150.

⁴⁸ Šulejić, P. (2000). Zagađivanje životne sredine i osiguranje. *Pravni život*, 40(11), p. 473.

or choose to purchase environmental insurance. Moreover, raising awareness about the importance of environmental insurance is essential. Insurance companies and business operators should be trained in identifying environmental risks and implementing suitable insurance solutions.

f) Limited financial capacity of insurers to cover damages caused to the environment

Given that environmental pollution-related damages can be extremely large, the question arises as to whether insurers in the domestic market have sufficient capacity to provide coverage at an affordable premium. Pooling resources through the establishment of insurance pools can enable a more balanced distribution of risk, increased capacity to cover large environmental losses, and the maintenance of affordable premiums for policyholders. In this context, the example of France is particularly relevant. As early as 1989, France established a pollution liability insurance pool that brought together all insurers and reinsurers operating in the country to share risk jointly. The French experience demonstrates that broader participation by insurance companies, combined with strong public awareness of environmental risks, contributes to a higher uptake of pollution liability insurance at relatively lower premium levels.⁴⁹

**Toward a New Architecture for Environmental Insurance -
Introducing mandatory environmental insurance**

The introduction of mandatory environmental insurance constitutes a critical instrument for addressing the previously identified structural and regulatory challenges. Although prevailing perspectives often advocate for its application only in the context of large-scale environmental catastrophes, we contend that mandatory coverage should extend to all activities posing environmental risks, regardless of their frequency or intensity, insofar as they may endanger air, soil, or water quality. Such a policy would entail the imposition of stringent environmental protection requirements on companies engaged in environmentally hazardous operations. While the complete elimination of environmental risks and their consequences remains unattainable, mandatory environmental insurance provides the most robust and systematic mechanism for mitigating risks and promoting long-term environmental sustainability.

Institutional foundations must be established for the development of environmental insurance by introducing and designating it as a distinct category

⁴⁹ Zvezdov, I. M. (2020). The EU Legal and Regulatory Framework for Measuring Damage Risks to the Biodiversity of the Marine Environment. *Environmental Policy: An Economic Perspective*, p. 131.

of liability insurance for environmental damage. Environmental insurance would facilitate improved planning and remediation of ecological harm, as well as enable a more efficient allocation of responsibility among enterprises, insurers, and the state. Moreover, it would create a mechanism that incentivises companies to adopt preventive measures aimed at minimizing the likelihood of environmental incidents while also ensuring financial protection in the event of a disaster. The establishment of such insurance would require legal compliance with environmental standards and directives of the European Union.

Unlike traditional insurance models, which provide compensation after damage has occurred, environmental insurance adopts a proactive approach to managing environmental risks. It offers incentives for reducing the frequency and severity of such risks, thereby minimising potential losses and aligning with the principles of sustainable development. Environmental insurance encompasses the design and implementation of insurance products in a way that promotes sustainability. In light of the aforementioned challenges, the development of an effective environmental insurance system must rest on a sound institutional framework, firmly grounded in environmental protection principles and the broader agenda of sustainable development.

What could be additional elements of mandatory environmental insurance model for Jadar project?

Context: Sharp Findings from the Jadar Project

Misrepresentation of Jadar project Impact: Jadar project was publicly framed as a small, “invisible” mine. In reality, it spans over 2,000 hectares, involves daily use of 4 to 5 tons of underground explosives, and would generate up to 72 million tons of toxic tailings in 22,000 days of planned exploitation. Insurance must cover not only post-damage costs but the full environmental liability — land loss, contamination, cultural and biodiversity destruction, as well as social and medical risks.

Power Imbalance: Corporate voices dominate public discourse (80% of speaking time), while local and domestic expert voices are marginalised and re-contextualised. Insurance must factor in not just physical damages but the erosion of epistemic justice — protecting communal rights to self-representation in risk evaluation.

Delegitimisation of Resistance: Opposition is portrayed as irrational or foreign-influenced, while corporate interests are framed equally as national progress and interests. Environmental insurance must account for social impacts, including the

suppression of alternative development paths (agriculture, tourism, animal stocks etc.).

Neocolonial Extraction Patterns: While EU countries experiment with less-destructive lithium extraction, Serbia is offered outdated or high-risk methods, which shall be experimentally tested in the Jadar valley. Environmental insurance regimes must be decolonial, recognising asymmetries in risk exposure, technological access, social and environmental justice. The project frames extractivism as the only green transition path to the future, erasing alternatives. Environmental insurance must challenge this by embedding local temporality and value systems into how risk is defined and covered.

As environmental risks escalate due to extractivist development models, new governance tools are urgently needed. The Jadar Valley lithium project exemplifies the cascading ecological and social risks related to green transition. Life Cycle Assessment (LCA), traditionally used for environmental accounting, can now be repurposed as a predictive tool for environmental insurance, shifting from post-damage compensation to proactive risk prevention.

To translate these conceptual demands into operational mechanisms, environmental insurance must evolve into a proactive and systemic risk governance tool. This involves linking premium structures to measurable environmental performance, aligning financial instruments with long-term ecological resilience, and embedding equity principles into insurance design. The following recommendations outline the necessary elements of such a redefined model, tailored to the specific context of the Jadar Valley.

Expand Insurance to Prevention, and tie premiums to ecological behaviour - reward restoration, penalise degradation and negative externalities. This assumes public-private insurance pools, as well as internationalisation of risks through reinsurance. Blend of state and market funds - to insure high-risk, underregulated zones like the Jadar Valley.

Protect the life in Jadar - smallholder farmers and the ecosystem by linking environmental insurance with food security, land and population health.

Institutional Reform - Mandate environmental insurance, standardise the impact metrics via LCA method and software, and enforce transparency.

Democratise Access - Develop community microinsurance schemes that centre the needs of those most affected but least protected.

Life Cycle Assessment (LCA) as a Foundation for Environmental Insurance:

The Jadar LCA spans the full project lifecycle (40 years active, 100 years post-closure), offering metrics for long-term liability. It identifies critical risk vectors — especially water and waste management, which emerge in the most vulnerable system. LCA can serve in environmental insurance as:

- *Risk-based Premiums:* Water usage (150,000 liters/ton LCE) and contamination indicators (arsenic, boron) can be monetized as insurance risks.
- *Performance-Linked Incentives:* LCA scenarios (e.g., closed-loop systems) show drastic reductions in harm, justifying lower insurance costs for mitigation.
- *Uncertainty as Risk:* Unknowns in waste management behavior and emission factors can be insured against through adaptive, higher-premium policies.

LCA and environmental insurance are not just technical tools — they are political instruments. When wielded by inclusive coalitions, they can expose the hidden costs of extractivism, redistribute environmental risk, and protect both ecosystems and the communities that steward them. Furthermore, the environmental insurance premium can be designed to internalise the key *negative externalities* and *systemic risks* associated with the Jadar lithium mining project. The following impacts can be directly translated into quantifiable liabilities and thus form the basis for calculating the insurance premium.

Directly translatable risks for environmental insurance premiums:⁵⁰

1. Water resource depletion and contamination are significant concerns, with water depletion reaching 150,000 m³ per ton of LCE, which implies a premium charge per unit of water depletion, especially in a high-stress hydrological basin. Arsenic, boron, and sulfate pollution in wastewater create

⁵⁰ The data and categories in the text derive from multiple research sources on lithium mining and its impacts, starting from SANU monographs, RT corporative available and expert reports. Numerical values come from Life Cycle Assessment (LCA) studies that quantify the ecological footprint of Lithium Carbonate Equivalent (LCE), from extraction to final processing. Technical parameters are generated by industry reports documenting water consumption, waste generation, and pollutant emissions. Specific metrics like CTUh (comparative toxicity units for humans) and CTUe (ecotoxicity) come from standardised models such as USEtox, which enables comparative assessment of potential risks. Ecological assessments, carrying capacity analyses, and medical studies contribute to understanding health and ecosystem consequences. This comprehensive dataset serves as the foundation for calculating adequate insurance premiums that reflect the potential financial liabilities associated with the environmental risks of lithium mining.

additional risks, suggesting a risk-adjusted surcharge based on toxicity thresholds, especially for arsenic exceeding 0.01 mg/L (WHO guideline). Uncertainty in treatment efficacy also factors in, where higher uncertainty equals higher risk surcharge, especially for boron, which is difficult to remove.

2. Human and ecosystem toxicity present further challenges, with human toxicity potential ranging from 0.08–0.12 CTUh and freshwater ecotoxicity between 8,500–12,000 CTUe. This toxicity translates to premium implications based on projected health burden (DALYs, hospital visits, etc.) and biodiversity loss costs.
3. Air emissions contribute significantly to environmental impact, with global warming potential of 18–22 t CO₂-eq per ton of LCE, as well as SO_x, NO_x, and PM emissions causing acidification and respiratory health impacts. These can be priced using carbon market values, acidification health burden models, and PM_{2.5}-related morbidity data.
4. Land use change and irreversible transformation, involving land transformation of 250–300 m² per ton of LCE, create premium implications related to irrecoverable soil fertility loss, biodiversity offset costs, and long-term productivity loss of fertile agricultural land.
5. Tailings and waste management risks are considerable, with processing tailings of 18–20 tons per ton of LCE and wastewater sludge of 2–3 tons per ton of LCE, leading to premium considerations based on potential leakage, acid mine drainage (AMD), and post-closure remediation needs.
6. Post-closure liability includes a 100-year monitoring period within system boundaries, suggesting an annualised premium to cover perpetual risks from leaching, structural failures, and water table contamination.
7. Socio-cultural and agricultural disruption impacts existing rural livelihoods and food systems, with premium implications including compensation funds for agricultural losses, displacement, or social unrest (using shadow pricing or local economic dependency metrics).

Monte Carlo Simulation Outputs (e.g., 95% CI for CTUh and CTUe) can be used to set risk buffers or premium caps. Co-product allocation (Li vs. B) must be accounted for when allocating impact responsibility—critical if insurance applies only to the lithium fraction. Process modifications (closed-loop water, dry-stack tailings, advanced arsenic removal) reduce insurance costs, which can be used to incentivise cleaner practices via premium discounts. A mandatory environmental insurance scheme for cases similar to the Jadar project should integrate technical risk metrics, socio-environmental accountability, and long-term liability through a lifecycle-based premium structure, ensuring not only post-damage compensation but also proactive risk governance and environmental justice.