



OPEN ACCESS

EDITED BY

Yen-Chiang Chang,
Dalian Maritime University, China

REVIEWED BY

Anooja Ali,
REVA University, India
Xiangxin Xu,
Shanghai Jiao Tong University, China

*CORRESPONDENCE

Yu Ning
✉ ningyusysu@163.com

RECEIVED 16 April 2025

ACCEPTED 07 July 2025

PUBLISHED 23 July 2025

CITATION

Ning Y (2025) Advancing EIA framework
for deep-sea mining: a critical review of
current regulations and proposals.
Front. Mar. Sci. 12:1612889.
doi: 10.3389/fmars.2025.1612889

COPYRIGHT

© 2025 Ning. This is an open-access article
distributed under the terms of the [Creative
Commons Attribution License \(CC BY\)](#). The
use, distribution or reproduction in other
forums is permitted, provided the original
author(s) and the copyright owner(s) are
credited and that the original publication in
this journal is cited, in accordance with
accepted academic practice. No use,
distribution or reproduction is permitted
which does not comply with these terms.

Advancing EIA framework for deep-sea mining: a critical review of current regulations and proposals

Yu Ning^{1,2*}

¹School of Law, Guangzhou University, Guangzhou, China, ²Southern Marine Science and Engineering
Guangdong Laboratory (Zhuhai), Zhuhai, China

On June 25, 2021, Nauru informed the Council of International Seabed Authority that its sponsored entity Nauru Ocean Resources Inc. intended to apply for approval of a plan of work for exploitation in the international seabed area and requested the Council to complete the adoption of relevant regulations, triggering the “two-year rule”. This has intensified the urgency to finalize the Exploitation Regulations as the current draft regulations remain insufficient to address the environmental challenges posed by mining activities. Deep-sea mining may have an irreversible impact on the marine environment, with disputes centred on how to effectively implement environmental impact assessment to improve environmental protection. The current regulatory texts, including the 2024 Revised Consolidated Text, exhibit significant limitations, particularly in the areas of environmental risk assessment, alternatives, cumulative impact assessment, and stakeholder participation within the environmental impact assessment framework. It highlights the need for clear review standards and quantitative models for environmental risk assessment, well-defined scopes and review mechanisms for alternatives, precise definitions and processes for cumulative impact assessment, and robust stakeholder engagement mechanisms. These recommendations are essential for developing a comprehensive legal mechanism that can effectively address the environmental challenges associated with deep-sea mining activities, thereby contributing to the sustainable management of the resources in “the Area”.

KEYWORDS

EIA, environmental risk assessment, alternatives, cumulative impact assessment, stakeholder

1 Introduction

On June 25, 2021¹, the President of the Republic of Nauru (referred to as “Nauru”) informed the Council of International Seabed Authority (referred to as “ISA”) that Nauru Ocean Resources Inc. (NORI), a Nauruan sponsored entity, intended to apply for approval of a plan of work for exploitation in the international seabed area (referred to as “the Area”), and requested the Council to complete the adoption of rules, regulations, and procedures necessary to facilitate such approval within two years pursuant to section 1, paragraph 15, of the Annex to the 1994 Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea (referred to as “1994 Agreement”) (ISA, 2021). This application triggered the “two-year rule”². Upon receiving the application, the Authority expedited the discussions on the formulation of relevant regulations. Nevertheless, the relevant regulations have not been officially promulgated as of yet, and the official version still remains the “Draft Regulations on Exploitation of Mineral Resources in the Area” of 2019 (referred to as “2019 Draft Exploitation Regulations”, ISBA/25/C/WP.1) (ISA, 2019). To facilitate the official release of the “Exploitation Regulations”, the ISA issued Revised Consolidated Text of the Draft Exploitation Regulations (referred to as “2024 Revised Consolidated Text”, ISBA/30/C/CRP.1) summarizing the negotiation progress in 2024 to enable further targeted negotiations. NORI indicated that it would commence the work plan for mining in “the Area” in 2025. The issue of balancing the interests of resource exploitation and environmental protection has once again become the focus of discussion. Constructing a relatively comprehensive, balanced among all stakeholders, and effectively enforceable legal system for environmental impact assessment (referred to as “EIA”) has emerged as an important task for the Authority to address the current challenges.

2 Development of the EIA framework in “the Area”

In accordance with the Convention and the 1994 Agreement, the ISA has undertaken work since 2014 to develop regulations for the exploitation of mineral resources in the Area (International Seabed Authority, 2025). From the discussion of financial terms related to mining in the Area in 2014, to the drafting of a framework in March 2015, and then to the first working draft in 2016, a new draft exploitation regulation has been issued annually based on the opinions of stakeholders. The provisions on environmental protection have been continuously refined and strengthened, and the elements of EIA, the content of the environmental impact report, and the structural arrangements for the functions and powers of the ISA have become more rational.

The 2019 Draft Exploitation Regulations provided comprehensive stipulations for EIA, clarifying its purpose as the evaluation and mitigation of potential impacts of mining activities on the marine environment. The assessment process encompasses preliminary evaluation, public participation, review, and approval stages. It also underscores the significance of environmental management and monitoring plans, mandating contractors to regularly review and update the assessment content and, if necessary, adjust plans of work to ensure that exploitation activities align with the requirements for marine environmental protection. Applicants must comprehensively identify the potential risks of mining activities to the marine environment in the Environmental Impact Statement, focus on addressing key environmental concerns, and propose targeted mitigation measures based on the Best Available Scientific Evidence and Precautionary Approach.³ Additionally, the draft highlights the assessment of cumulative impacts, requiring an evaluation of the potential cumulative impacts of the proposed activities on other known activities within the area, as well as on ecosystem functions and biodiversity.⁴ In terms of scientific uncertainty, the draft explicitly acknowledges the limitations of scientific knowledge and mandates the reduction of uncertainty through ongoing monitoring and research.⁵ Furthermore, the draft places special emphasis on the broad participation of stakeholders, requiring applicants to engage in stakeholder consultations to ensure that their key concerns and comments are fully considered.⁶

The negotiations on the 2019 Draft Exploitation Regulations were further advanced through informal working groups, intersessional working groups and “Friends of the President” by the ISA Council. The Council issued 2024 Revised Consolidated Text and the Compilation of Proposals for the Draft Exploitation Regulations (ISBA/30/C/CRP.3). The majority of delegations supported the conduct of rigorous EIAs for deep-sea mining activities to ensure effective protection of the marine environment and to promote the common heritage interests of humanity.

1 The Permanent Mission of Nauru, after consultations with the members of the Authority, had made the decision to defer the effective date of the notification to 9 July 2021, rather than 30 June as originally communicated.

2 According to paragraph 15 of Section 1 of the Annex to the 1994 Agreement, if a State intending to apply for approval of plans of work for exploitation, the Council shall complete the adoption of such rules, regulations and procedures within two years of the request, otherwise the Council shall none the less consider and provisionally approve such plans of work based on the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 (referred to as “the Convention”), Exploration Regulations, 2019 Draft Exploitation Regulations and any other rules, regulations and procedures which have adopted provisionally until a new draft has been adopted by the Council or exploitation regulations adopted by the Assembly. As of February 2025, six contractors had conducted EIAs according to the relevant regulations, especially Exploration Regulations and 2019 Draft Exploitation Regulations.

3 Regulations 2, 44 and 47 of the 2019 Draft Exploitation Regulations.

4 Annex IV of the 2019 Draft Exploitation Regulations.

5 Regulations 2 and 44 of the 2019 Draft Exploitation Regulations.

6 Regulations 11, 44 and Annex IV of the 2019 Draft Exploitation Regulations.

Disagreements among states were primarily centered on the specific implementation details of EIAs, including the scope of assessment, methodologies, the extent of public participation, and the coordination with existing international law. Some delegations, such as Indonesia, argued that EIAs should take into account cumulative impacts and interactions with other activities.⁷ Other delegations maintained that EIAs should focus on the direct impacts of mining activities on the marine environment and avoid overcomplicating the assessment process.⁸ The majority of delegations supported the comprehensive identification of environmental risks and emphasized the application of the precautionary principle and the ecosystem approach.⁹ Most delegations also highlighted the importance of broad public participation in the EIA process and suggested that Contractors should fully consider the comments of stakeholders and explain how such the comments are addressed in the EIA.¹⁰ Several delegations further underscored the importance of Regional Environmental Management Plans (REMPs) in EIAs and the need for Test Mining during the EIA process. While there was a general consensus on the necessity of EIAs for deep-sea mining, differences remained regarding their specific implementation. Future negotiations will need to resolve these differences and develop a comprehensive, transparent, and effective EIA framework to protect the marine environment and promote the sustainable development of deep-sea mining.

3 The limitations of the EIA in the current regulatory texts

The 2024 Revised Consolidated Text attaches greater significance to the role of supervision and inspection in EIA, emphasizes consultation with stakeholders, and has a clearer procedural arrangement than the previous draft. It also more conspicuously reflects a comprehensive consideration of technology and the interests of contractors. Nevertheless, there are still numerous limitations:

7 Regulations 46(3)(i) bis and Regulation 46(4)(a) alt in Compilation of Proposals for the Draft Exploitation Regulations (ISBA/30/C/CRP.3).

8 In the 2024 Revised Consolidated Text, provisions on cumulative impacts that were previously scattered throughout various clauses have been removed. Instead, these are now addressed under “Holistic cumulative impact assessment and issues to be addressed” in Annex IV, Article 10ter. Additionally, a specific definition for “Cumulative Environmental Effect” has been provided in the Schedule and the term “cumulative” has been removed from the definition of “Environmental Effect” that was included in the 2019 version.

9 Draft regulation 47. bis Alt and the relevant comment in the 2024 Revised Consolidated Text.

10 Regulation 93bis in Compilation of Proposals for the Draft Exploitation Regulations (ISBA/30/C/CRP.3).

3.1 Environmental risk assessment

While ISA has formulated relatively detailed guidelines for environmental risk assessment, its explanation of the standard “cost and benefit of risk reduction are seriously disproportionate” remains vague. It states that “the reasonable practicability of risk reduction measures shall be kept under review in the light of new knowledge and technology developments and Good Industry Practice, Best Available Techniques and Best Environmental Practices” (ISA, 2022). However, this interpretation fails to provide applicants with a clear cost-benefit ratio, making it difficult for applicants to design a specific environmental risk assessment program. Moreover, the regulatory texts of the Authority lack a clear criterion for the “uncertainty” of such risks. An excessive focus on continuously reducing “remaining uncertainty” may overemphasize environmental protection at the expense of commercial development principles, thereby significantly diminishing contractors’ incentives to conduct mining activities in “the Area”.

3.2 Alternatives

Alternatives are a key component of EIA, with the primary goal of informing decision-makers and the public about the potential lowest levels of environmental impact or the best options among different courses of action. This enables decision-makers to make choices based on more comprehensive scientific information. The 2024 Revised Consolidated Text represents a significant improvement over the 2019 Draft Exploitation Regulations on EIA, explicitly requiring applicants to consider the no-action alternative in their alternatives. However, the text still lacks clear provisions on the design process, specific criteria, and review procedures for alternatives. Although the Draft Standard and Guidelines for the Environmental Impact Assessment Process (ISBA/27/C/4) touch on alternatives, it similarly fails to regulate these key aspects. This omission may allow applicants or contractors significant subjectivity and arbitrariness in selecting alternatives, posing challenges for the International Seabed Authority in its regulatory role and hindering effective mitigation of the environmental impacts of mining activities in “the Area”. More environmentally sound alternatives being overlooked or informally eliminated before the formal analyses in EIA, which can undermine the goals of EIA — to encourage more environmentally sound and publicly acceptable actions (Steinemann, 2001).

3.3 Cumulative impact assessment

When each project is considered in isolation, its environmental impact may seem minimal. However, when combined, these impacts can have a significant effect on the environment. In the context of mining activities in “the Area”, which are fraught with scientific uncertainties, failing to account for cumulative impacts can lead to irreversible environmental damage. Yet, the regulatory

texts of ISA do not provide specific and workable procedures for cumulative impact assessment.

Firstly, the 2019 Draft Exploitation Regulations and the three Exploration Regulations have not defined “cumulative impacts” clearly. Although the 2024 Revised Consolidated Text has defined “cumulative environmental effect” in the Schedule¹¹, it has deleted all provisions about cumulative impacts in the EIA process, even in the environmental impact statement of the Annex IV. Moreover, the cumulative impacts are not explicitly included in the definition of EIA. These factors may lead to the failure of the applicant to grasp the evaluation of the cumulative impacts of the plan of work in the EIA process. Secondly, while the 2024 Revised Consolidated Text requires applicants to consider both temporal and spatial impacts in their cumulative impact assessments, it does not specify the exact spatial scope that needs to be evaluated (ISA, 2025). Such unclear regulations may lead applicants to overlook the cumulative effects of projects in their assessments. Thirdly, ISA regulations do not outline specific steps for cumulative impact assessment. The practice of cumulative impact assessment is complex because of the need to consider multiple sources of change, alternate pathways of accumulation, and temporally and spatially variable effects (Spaling, 1994). Although the Draft Standards and Guidelines for the Environmental Impact Assessment Process attempts to address this deficiency by outlining key elements and evaluation criteria for cumulative impacts and expanding the dimensions of cumulative impact assessment, these criteria are included in the “guidelines” section. According to ISA’s determination of the legal status of guidelines, this content does not have legal binding force.

3.4 Stakeholders

Some provisions of the EIA implementation procedures do not yet meet the requirements of the transparency principle, particularly in the collection and incorporation of stakeholders’ opinions. This undermines the effective implementation of public opinions and ultimately jeopardizes the balance between mining activities in “the Area” and environmental protection. The Council then decided to invite written comments from Council members, non-Council members of the Assembly, as well as observers and stakeholders of the ISA, but premised solely on comments received from Council members, the ISA Secretariat issued an updated version of the draft regulations in December 2019 as a

¹¹ The Recommendations for the Guidance of Contractors for the Assessment of the Possible Environmental Impacts arising from Exploration for Marine Minerals in the Area (ISBA/25/LTC/6/Rev.1, hereinafter referred to as the “Recommendations”) defines “cumulative impacts” as “Impacts resulting from incremental changes caused by other past, present or foreseeable actions”. The phrase “incremental changes” emphasizes the temporal accumulation of impacts over time but overlooks the cumulative effects of different projects occurring simultaneously in different or overlapping spatial areas. This inaccuracy was corrected in the 2024 Revised Consolidated Text.

‘conference room paper’, which currently forms the basis for text negotiations at the Council (Singh, 2021). As a result, the current text overlooks many opinions from stakeholders.

Public participation in EIA faces two main obstacles: (1) Identification of Stakeholder Eligibility: There are no clear provisions regarding the scope of stakeholders, the criteria and procedures for determining their eligibility, or the remedies available for eligibility disputes. (2) Barriers to Stakeholder Comments Expression: Although the 2024 Revised Consolidated Text places greater emphasis on stakeholder participation than the 2019 Draft Exploitation Regulations, requiring consultation with stakeholders throughout the entire EIA process and providing specific consultation requirements for directly affected stakeholders, it still has limitations. The text mandates that applicants disclose all written comments received from stakeholders. This allows ISA to review whether and to what extent applicants have considered stakeholder interests or whether their rejection of such opinions is justified. However, it gives no further information on how the submissions were considered nor to what extent their content was included in the framework, and implementing Art. 6(9) of Aarhus requires at least a declaration on the submissions received and the relevance of their content, explaining how the responses were reviewed and were used (or not) in the final decision (Lallier and Maes, 2016). However, there is no option for an appeal after the decision of the ISA, as the Seabed Disputes Chamber of the International Tribunal for the Law of the Sea has no jurisdiction to handle cases regarding exploration or exploitation activities that are brought before the court by a natural person or a juridical person who is not directly involved in those activities (Willaert, 2020).

4 Suggestions for the robust EIA framework in “the Area”

The EIA of mining in “the Area” is a complex challenge that requires a scientifically rigorous and robust legal framework. This involves establishing clear criteria for the review of environmental risks, scrutinizing the scientific validity of alternatives, and clarifying the necessity, methodology, and scope of cumulative impact assessment to accurately evaluate the spatial and temporal dimensions of ecological effects. Moreover, the framework must clearly delineate the rights and mechanisms for stakeholder participation, ensuring their meaningful engagement to enhance the transparency and legitimacy of the EIA process. Addressing these interrelated issues is essential for developing an effective EIA framework that can adequately address the environmental challenges posed by the mining activities in “the Area”.

4.1 Environmental risk assessment

4.1.1 Setting the review standards for risks

Environmental risk assessment is fundamentally a multi-dimensional evaluation of natural values, and as such, it

inherently involves economic, ethical, and philosophical considerations, making it essential to establish value criteria—that is, evaluation standards—as a measure for the assessment itself (Qian, 2010). It should determine the acceptable risk standards according to different mineral types and the degree of ecosystem vulnerability, and these standards are related to the environmental thresholds. Currently, given the limited understanding of deep-sea ecosystems and geological environments, these standards must initially rely on robust baseline data and draw from comparable industry standards. They should then be continuously updated and refined as technology advances and our knowledge deepens, particularly through adaptive management of mining activities. These standards should encompass not only the natural environment but also multi-dimensional values such as human health and socio-economic and cultural aspects. Additionally, in setting these standards, it is crucial to balance the green mining technologies between developed and developing countries to avoid creating green barriers that could impede developing countries' participation in mining activities in “the Area”. This standard should not only reflect the value of the natural environment but also encompass multi-dimensional values related to human health,

socio-economic conditions, and culture. Additionally, in setting these standards, it is important to balance the gap in green mining technologies between developed and developing countries to avoid creating green barriers that could hinder developing countries' participation in mining activities.

4.1.2 Develop a quantitative model for risk indicators

After setting the overall review criteria, it is also necessary to develop a quantitative model for risk indicators within this framework. Despite the many scientific uncertainties associated with mining in “the Area”, it is still possible to identify key environmental risk assessment indicators based on different mineral types, mining technologies, and the richness of ecosystems. A quantitative model for risk indicators can be developed for applicants or contractors to refine according to specific circumstances. The various adverse effects have different scales in terms of time and space, which must be incorporated into a proper environmental risk assessment (Jorgensen and Fath, 2011). Therefore, the quantitative model for risk indicators should primarily include the following three dimensions (Figure 1): (1)

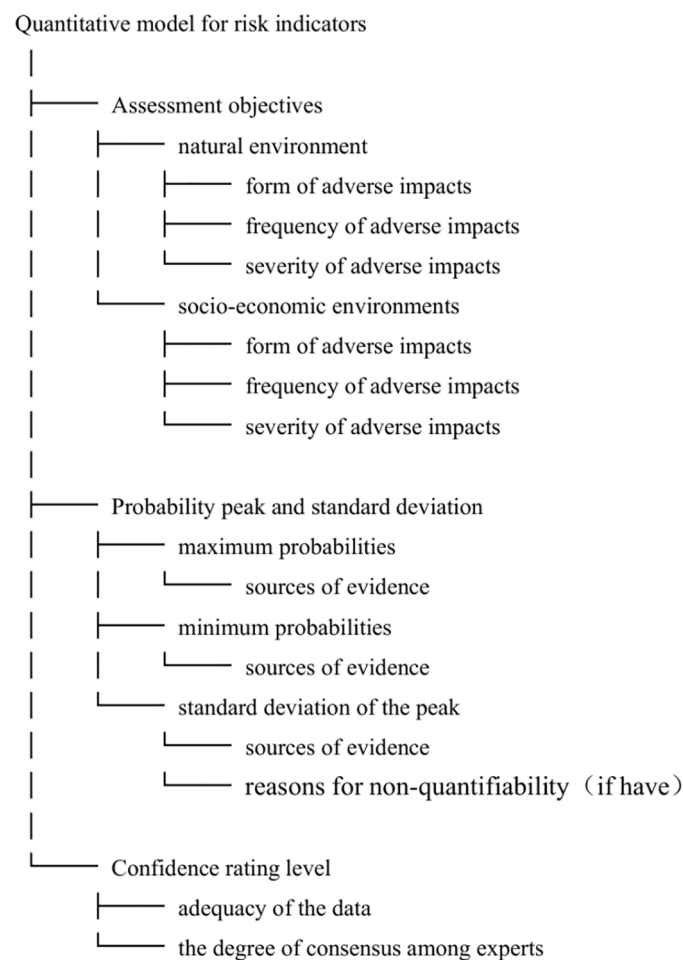


FIGURE 1
Quantitative model for risk indicators.

Assessment objectives. The focus of environmental risk assessment is the form, frequency, and severity of adverse impacts on the environment caused by human activities, including both natural and socio-economic environments. A comprehensive environmental risk assessment should not only consider what kind of harm may occur and its severity but also evaluate whether such harm is likely to occur frequently or occasionally and the probability of its occurrence. (2) Probability peak and standard deviation. Based on the latest available knowledge and best available technologies, assess the maximum and minimum probabilities of each risk occurring, calculate the standard deviation of the peak, and specify the sources of evidence used in the assessment. If it is not possible to quantify the probability, the scientific reasons for this inability should be clearly explained. (3) Confidence rating level of the basis for risk assessment. The need to assign a confidence rating to the basis of risk assessment judgments stems from the presence of numerous uncertainties. The so-called confidence rating level refers to the adequacy of the data used in the risk assessment and the degree of consensus among experts in the field. For example, if a risk judgment is supported by reliable data and achieves a high degree of expert consensus, the confidence level of the assessment basis is the highest; conversely, it is the lowest. Therefore, the confidence rating level best reflects whether an environmental risk assessment has been conducted thoroughly using the best available technologies and good industry practices. It also reflects the degree of community acceptance, representing a shift from purely objective scientific rationality to community rationality.

4.2 Alternatives

4.2.1 Define the reasonable scope of "Alternative"

The number of potential alternatives for a project is theoretically limitless, but in the circumstance of EIA, the alternatives must be finite. It is essential that all reasonable alternatives are considered, and that each alternative within the same tier is meaningfully connected yet distinct from the others. The crux lies in the interpretation of "reasonableness". The reasonable range is dictated by the purpose and need statement: The range of alternatives that must be considered need not extend beyond those reasonably related to the purposes of the project (Steinemann, 2001). As the regulatory body, the Authority should fully consider the reasonable scope of alternatives and provide applicants with clear criteria for developing these alternatives. Failure to do so not only confuse applicants and increases costs but also prevents the public and regulatory authorities from effectively reviewing whether the submitted alternatives are "reasonable" and "comprehensive". The alternatives considered should include sufficient detail to facilitate the risk assessment of planned impacts and potential unplanned or accidental impacts (Durden et al., 2018). Where the application of Best Environmental Practice does not deliver acceptable results, additional or alternative measures may be required and Best Environmental Practice redefined accordingly (ISA, 2017).

4.2.2 Establish a review and feedback mechanism for "alternative"

Firstly, alternative options stem from optimization under scientific uncertainty. Therefore, when designing alternative options during the scoping phase, it is essential to widely solicit opinions from stakeholders, particularly by establishing an independent expert review system to leverage the role of independent experts in scientifically reviewing these alternatives. Secondly, the Authority should establish effective communication and feedback mechanisms among applicants, stakeholders, independent experts, and review bodies. The specific reasons for applicants' acceptance or rejection of opinions from stakeholders, independent experts, and review bodies should be thoroughly documented and submitted to the review body for assessment to determine whether further modifications to the alternatives are necessary. This also helps avoid knowledge gaps caused by information asymmetry and ensures that alternative options can be promptly revised and improved. Lastly, if applicants or contractors make significant changes at any stage of the environmental impact assessment process, a re-review and feedback of the alternative options must be conducted to ensure they comply with good industry practices and the best available technologies.

4.3 Cumulative impact assessment

4.3.1 Clarify the specific assessment process of "cumulative impacts"

Cumulative impact assessments is the process of systematically analyzing and assessing cumulative environmental change: a perturbation may follow single or multiple pathways and involve additive or interactive processes, and controlling factors such as assimilative capacity, thresholds, and dynamic variability regulate the accumulation of incremental environmental changes (Spaling, 1994). The design of the cumulative impact assessment process should fully consider the following factors: (1) Identify specific spatial impact criteria. Appropriate spatial scales may be at the community, watershed, airshed, or ecosystem level. Spatial cumulative impacts must take into account the potential spread of different impact sources. For example, an oil spill from a mining machine can be widely dispersed by ocean currents to other areas, and plumes generated by propeller disturbances can affect not only surface ecosystems but also deep-sea ecosystems several kilometers away. Public availability of environmental data from various projects aids in assessing spatially overlapping impacts. (2) Identify specific temporal impact criteria. There needs to be a clear definition of how far back to trace "past activities" and how far forward to project "potential future activities". Temporal determination should be based on the environmental carrying capacity of the area and existing baseline data, with the time span covering all environmental impacts that cannot be restored within that period. (3) Identify the impact sources and assess content. Different mining methods, scales, and equipment technologies can introduce various types and degrees of impact sources. Additionally,

the types of affected resources—such as the atmosphere, water bodies, or biological communities—must be considered. (4) Identify the thresholds for cumulative impacts. The environmental carrying capacity of the area is key to sustainable development and the value of environmental impact assessments. When cumulative impacts exceed this threshold, alternative options, mitigation measures, or project disapproval should be considered on a case-by-case basis. In setting thresholds, the “weakest link” principle should apply, meaning the most vulnerable resource in the ecosystem should determine the threshold. (5) Examine the various cumulative impacts comprehensively. Cumulative impacts can be temporal, spatial, additive, or interactive. When assessing cumulative impacts, it is essential to consider all potential accumulation comprehensively. The Authority must establish a consensus standard based on scientific data to assess comprehensive forms of cumulative impacts.

4.3.2 Establish a review and feedback mechanism for “cumulative impact assessment”

Cumulative impact assessments have much potential for managing cumulative effects through better siting and phasing of development, demand reduction and other behavioural changes, and particularly through setting development consent rules for projects (Therivel and Ross, 2007). It should be initiated at the scoping phase, rather than waiting until the comprehensive impact assessment phase. The Authority should promptly review the cumulative impact assessment report during the scoping phase. Based on the review and feedback, the Contractor should adjust the project plan, including site selection and implementation phases, and conduct new cumulative impact assessments until the Authority’s impact thresholds and acceptable risk standards are met. If the Contractor disagrees with the Authority’s review results, they may lodge an objection within a reasonable timeframe, providing scientific rationale to the Authority, which will then organize independent experts for a re-review.

4.4 Stakeholders

4.4.1 Define the reasonable scope of “stakeholders”

Given that “the Area” and its resources are the common heritage of mankind, environmental damage to this region directly affects the interests of all humanity. Therefore, from a normative perspective, all of humanity, including future generations, should be considered stakeholders and participate in the environmental impact assessment process for mining activities in “the Area”. However, practicality demands that all rules be realistically feasible, both in practice and economically. The degree of stakeholding is key to determining the scope of stakeholders. The environment of “the Area” is highly complex and uncertain. The identification of stakeholder eligibility can refer to the 2012 CBD voluntary guidelines and the definition of “stakeholders” in the Aarhus Convention, taking into account factors such as the specific mining location, mining methods, degree of knowledge uncertainty, and environmental risk levels.

To ensure orderly participation of stakeholders and avoid repetition in the expression of opinions, it is advisable to follow the practices of the United Nations Environment Programme and Agenda 21 by categorizing stakeholders and requesting all stakeholders to accredit themselves under another of the nine major groups that is closest to their area of activity (UNEP, 2020). The effective participation of environmental organizations should also draw on this approach. It not only avoids redundant expressions of similar or identical interests but also facilitates stakeholder management. This includes identifying stakeholders at each assessment stage and enables communication among different stakeholder groups, as well as lodging complaints when their opinions are not properly addressed.

4.4.2 Establish a remedy mechanism for the rights of “stakeholders”

When stakeholders’ right to participate is mishandled and there is no remedy mechanism, the distorted rights cannot be corrected, and public participation mechanism cannot be effectively implemented. In the process of constructing the legal framework for environmental impact assessments in “the Area”, administrative and judicial remedies could be established, drawing on precedents from the Rio Declaration and the Aarhus Convention.

First, the Authority should establish the administrative remedy procedures. Firstly, if the potential stakeholder has legitimate grounds to believe that its rights to access environmental information or participate in procedures have not been properly exercised, he may lodge a complaint with the Legal and Technical Commission (LTC) or the Council. Upon receiving such a complaint, the LTC or Council is obligated to conduct a substantive review within a reasonable timeframe, rectify the error or provide a detailed explanation as to why the entity was not recognized as a “stakeholder”. Secondly, if a stakeholder deems that his comments have not been reasonably taken into account, or if the Council has overruled the LTC’s subsequent negative opinion in a way that contradicts his interests, he has the right to appeal to the Council. Upon receiving such an appeal, the Council should conduct a substantive review within a reasonable timeframe, correct the error or provide a detailed clarification of the reasons why the stakeholder’s comments have not been considered. Finally, an accountability mechanism for decision-making should be established. This means holding decision-makers responsible for their actions. Certain penalties or responsibilities for environmental damage compensation should be imposed for the human errors in the determination of the stakeholder’s status, the acquisition of information, and the project approval process.

Second, the Authority should establish the judicial remedy procedures. After exhausting the above administrative remedies, if the potential stakeholder still believes that his legitimate rights and interests have not been reasonably remedied, he may bring a lawsuit before an international judicial body. Firstly, it is necessary to address several key issues: who has the right to file which kind of lawsuit, the timeliness of the lawsuit, how to handle cases where a party is not a qualified subject, and the litigation procedures and time limits. Secondly, judicial remedy procedures should be straightforward

and affordable. The procedures should not be overly complicated or expensive, as this would reduce the likelihood of stakeholders initiating the process. Conversely, litigation costs should not be so low as to encourage frivolous lawsuits. Therefore, an appropriate judicial cost should be set in reference to general international judicial practice. Thirdly, judicial procedures that are independent and expeditious should be provided for stakeholders, including environmental organizations, to challenge such a decision, act or omission by the public authority in question (UNEP, 2013). The Seabed Disputes Chamber of the International Tribunal for the Law of the Sea has no jurisdiction to handle cases regarding exploration or exploitation activities initiated by a natural person or a juridical person not directly involved in those activities, which means that environmental organizations are unable to contest an approval of possibly harmful activities in “the Area” before an international judge (Willaert, 2020). However, the important role of environmental organizations in effectively protecting the environment of the “Area” cannot be overlooked. Finally, the capacity of international judges to handle relevant environmental cases should be enhanced. Where conditions permit, guidelines for adjudicating typical cases should be gradually developed. The duty of judges should be to conduct judicial review on whether the actions or omissions of the public authority are legally correct, and therefore appropriate review standards should be established in order to prevent inconsistent judgments in similar cases (European Commission, 2018).

5 Conclusion

The burgeoning interest in commercial exploitation within the international seabed area, exemplified by Nauru Ocean Resources Inc.’s application and the impending activation of the “two-year rule”, underscores the critical need for a robust and comprehensive regulatory framework to govern deep-sea mining activities. While ISA has made commendable progress in advancing the 2024 Revised Consolidated Text, significant lacunae persist within the extant regulatory regime, particularly concerning the EIA process.

A meticulous analysis of the current regulatory texts reveals several critical deficiencies that impede effective environmental stewardship. The lack of clarity regarding risk reduction standards and the ambiguous treatment of “uncertainty” in environmental risk assessments present substantial obstacles for applicants and may inadvertently skew the balance towards commercial expediency at the expense of environmental preservation. Furthermore, the absence of well-delineated procedures for evaluating alternatives and cumulative impacts undermines the fundamental objective of the EIA—to inform decision-making through rigorous scientific analysis. The lack of clear guidelines on stakeholder identification, participation, and rights remedy limits the effectiveness of public consultation and engagement. This omission not only hinders the transparency of the decision-making process but also undermines the legitimacy of the EIA outcomes, as the diverse interests and concerns of stakeholders may not be adequately considered.

As deep-seabed mining activities continue to evolve, ongoing research and adaptive management approaches will be essential for

refining the EIA framework. This includes clarifying and continuously updating the standards for risk assessment, as well as clarifying the necessity, methodology, and scope of cumulative impact assessment, with the integration of new scientific knowledge and technological advancements. Additionally, defining the reasonable scope of alternatives and establishing rigorous review and feedback mechanisms are essential for ensuring comprehensive and scientifically valid EIA processes. The development of administrative and judicial remedy mechanisms is necessary to address potential mishandling of stakeholder rights and to ensure the effective implementation of public participation mechanism. The sustainable governance of deep-sea mining hinges on the development of a comprehensive, scientifically robust, and legally enforceable EIA framework that can balance environmental protection with responsible resource exploitation for the equitable benefit of all.

Author contributions

YN: Supervision, Writing – review & editing, Validation, Project administration, Data curation, Conceptualization, Investigation, Writing – original draft, Funding acquisition, Methodology, Formal analysis, Software, Resources, Visualization.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. The fieldwork is supported by the following project: The Guangdong Provincial Philosophy and Social Science Fundamental Project, China (Grant No. GD24YFX09).

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher’s note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Durden, J. M., Lallier, L. E., Murphy, K., Jaeckel, A., Gjerde, K., and Jones, D. (2018). Environmental Impact Assessment process for deep-sea mining in "the Area." *Mar. Policy* 87, 194–202. doi: 10.1016/j.marpol.2017.10.013
- European Commission. (2018). *Citizen's Guide to access to Justice in Environmental Matters* (Luxembourg: Publications Office of the European Union). Available online at: <https://www.clientearth.org/media/npkhntuw/env-18-004-guide-en-web.pdf>.
- International Seabed Authority. (2025). *The Mining Code: Draft Exploitation Regulations*. Available online at: <https://isa.org.jm/mining-code/draft-exploitation-regulations> (Accessed June 10, 2025).
- ISA. (2017). *A Discussion Paper on the Development and Drafting of Regulations on Exploitation for Mineral Resources in the Area (Environmental Matters)* (Kingston, Jamaica: International Seabed Authority). Available online at: <https://www.isa.org.jm/wp-content/uploads/2022/04/DP-EnvRegsDraft25117.pdf>.
- ISA. (2021). *Letter dated 30 June 2021 from the President of the Council of the International Seabed Authority addressed to the members of the Council*. ISBA/26/C/38. (Kingston, Jamaica: International Seabed Authority). Available online at: <https://www.isa.org.jm/documents/isba-26-c-38/>.
- ISA. (2019). Draft regulations on exploitation of mineral resources in the Area. ISBA/25/C/WP.1. (Kingston, Jamaica: International Seabed Authority). Available online at: <https://www.isa.org.jm/documents/isba-25-c-wp-1/>.
- ISA. (2022). Draft guidelines on the tools and techniques for hazard identification and risk assessments. ISBA/27/C/8. Available online at: <https://www.isa.org.jm/documents/isba-27-c-8/>.
- ISA. (2025). Draft regulations on exploitation of mineral resources in the Area, Revised Consolidated text. ISBA/30/C/CRP.1. (Kingston, Jamaica: International Seabed Authority). Available online at: <https://www.isa.org.jm/documents/isba-30-c-crp-1/>
- Jorgensen, S. E., and Fath, B. D. (2011). *Fundamentals of Ecological Modelling: Applications in Environmental Management and Research*. 4th edition (Netherland: Elsevier).
- Lallier, L. E., and Maes, F. (2016). Environmental impact assessment procedure for deep seabed mining in the area: Independent expert review and public participation. *Mar. Policy* 70, 212–219. doi: 10.1016/j.marpol.2016.03.007
- Qian, H. W. (2010). The Technical Nature of Environmental Risk Assessment (in Chinese). *Energy Environ. Prot.* 5, 1–4.
- Singh, P. A. (2021). The two-year deadline to complete the International Seabed Authority's Mining Code: Key outstanding matters that still need to be resolved. *Mar. Policy* 134, 104804. doi: 10.1016/j.marpol.2021.104804
- Spaling, H. (1994). Cumulative effects assessment: Concepts and Principles. *Impact Assess.* 12, 231–251. doi: 10.1080/07349165.1994.9725865
- Steinemann, A. (2001). Improving alternatives for environmental impact assessment. *Environ. Impact Assess. Rev.* 21, 3–21. doi: 10.1016/S0195-9255(00)00075-5
- Therivel, R., and Ross, B. (2007). Cumulative effects assessment: Does scale matter? *Environ. Impact Assess. Rev.* 27, 365–385. doi: 10.1016/j.eiar.2007.02.001
- UNEP. (2013). *Access to information, public participation, and access to justice in environmental matters: Engaging national governments in the conversation* (Amman, Jordan: West Asia Regional Consultative Meeting). Available online at: <https://www.unep.org/resources/report/access-information-public-participation-and-access-justice-environmental-matters>.
- UNEP. (2020). *Handbook for Stakeholder Engagement*. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/32831/stakeholder_handbook_EN.pdf?sequence=11 (Accessed March 25, 2025).
- Williaert, K. (2020). Public participation in the context of deep sea mining: Luxury or legal obligation? *Ocean Coast. Manage.* 198, 105368. doi: 10.1016/j.ocecoaman.2020.105368