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Article Title

Aligning Technical Standards for In-Situ Resource Utilization with the Principles of Non-Appropriation and Benefit Sharing: Implications for Indonesia's Regulatory Sovereignty

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ABSTRACT

In-situ resource utilization (ISRU) on celestial bodies raises legal questions concerning operational safety, equal access, protection of the space environment, and benefit sharing. This article examines how safety zones, interoperability, and contamination prevention align with the principles of non-appropriation and benefit sharing, and the implications for Indonesia's regulatory sovereignty. This prescriptive doctrinal legal study employs statutory, conceptual, and comparative approaches, supported by an expert interview concerning the relevant policy context. The findings indicate that alignment among the three technical parameters remains partial because internationally agreed operational criteria of general application have yet to be established. Safety zones require risk-proportionate access restrictions without exclusive control over operational areas. Interoperability requires the acceptance of technologies offering equivalent functionality, while contamination prevention is governed by Article IX of the OST. Shared benefits may be realized through opportunities for access and use, protection of scientific investigations, information exchange, and capacity building. Financial contributions require a valid legal basis or agreement. Law Number 21 of 2013 provides a legal basis for regulating commercial activities, supervision, registration, responsibility, and international cooperation, although ISRU-specific requirements require further elaboration. The article proposes a three-layer assessment model integrating technical characteristics, international legal obligations, and national regulatory authority. The model operates through domestic regulation and multilateral diplomacy without asserting territorial sovereignty over celestial bodies.

Keywords: *Benefit Sharing; ISRU; Non-Appropriation; Regulatory Sovereignty; Space Law.*

INTRODUCTION

In-situ resource utilization (ISRU) enables materials found on celestial bodies to be used in producing water, oxygen, fuel, and other resources required for space missions. Processing lunar water ice, for example, may reduce the need to transport supplies from Earth. ISRU encompasses prospecting, extraction, processing, utilization of extracted resources, and waste management, each involving distinct operational risks. Water-ice deposits in permanently shadowed regions (PSRs) of the Moon are among the resources requiring specific safety arrangements. ISRU operations may involve fixed installations, vehicle routes, material storage facilities, and the release of regolith dust, which could interfere with facilities and scientific investigations conducted by other parties. These operational characteristics require technical standards consistent with international legal obligations governing the use of outer space and the protection of other States' interests (Dallas et al., 2021; McKeown et al., 2022; Hubbard et al., 2024).

The legality of ISRU activities must be assessed in light of the relationship between the freedom of exploration and use of outer space under Article I of the OST and the prohibition of national appropriation under Article II of the OST. Byers and Boley (2023) explain the relationship between the freedom to use outer space, the prohibition of territorial appropriation, and the obligation to give due regard to the interests of other States. The legal issues include distinctions among resource deposits within celestial bodies, extracted materials, and the areas where operations take place. Recognizing rights over extracted materials under national legislation

requires a separate assessment of their effect on other States. Meanwhile, securing an operational site over an extended period may restrict other States' opportunities to use the same area. The legality of extraction activities, recognition of rights over extracted resources, and use of operational areas must therefore be assessed under the legal provisions governing each matter (Kim, 2018; Zannoni, 2020; Svec, 2022).

The three technical parameters of ISRU involve different legal considerations. Safety zones concern the geographical extent and duration of access restrictions necessary to protect personnel, spacecraft, and facilities. Interoperability concerns the ability of communication, navigation, data-exchange, and equipment systems to function together or operate compatibly. Technical requirements recognizing only particular systems may restrict the participation of other operators even when their technologies provide equivalent safety functions. Contamination prevention concerns the obligation to avoid harmful contamination of celestial bodies and to give due regard to the interests of other States under Article IX of the OST. These parameters require a distinction between standards implementing existing international obligations and technical requirements whose enforceability depends on an additional legal basis (Zwart et al., 2023a).

The freedom to use outer space must be examined together with the obligation to consider the benefits and interests of all States. Article I of the OST provides that the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries without discrimination. This provision informs assessments of opportunities for scientific investigations, information sharing in accordance with applicable requirements, capacity building, and international cooperation. In ISRU operations, restrictions on operational areas may affect other States' access to scientific research sites. Interoperability requirements may also affect participation opportunities, while contamination prevention relates to environmental protection and preserving opportunities for future scientific investigations. Article I of the OST does not establish a universally applicable royalty percentage or a mandatory formula for distributing financial profits. Such mechanisms require rules identifying the legal basis for contributions, obligated parties, beneficiaries, and administrative arrangements. Assessments based on non-appropriation must therefore be complemented by an examination of benefit-sharing implementation (Deplano, 2023; Yap et al., 2023).

ISRU regulation has developed through instruments with different legal statuses. The OST establishes international obligations for its States Parties, while the Artemis Accords (2020) express political commitments among participants on interoperability, resource utilization, and preventing interference with space activities. The Working Group on Legal Aspects of Space Resource Activities within the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) has considered draft principles concerning space resource activities. The United States and Luxembourg have enacted provisions recognizing rights over extracted resources, while Japan and

the United Arab Emirates have developed rules governing resource activities and their implementation. The Artemis program and cooperation under the International Lunar Research Station initiative also demonstrate differing national approaches to space resource utilization. The distinct legal status of these instruments requires separate assessments of treaty obligations, national legislation, political commitments, and State practice (Zwart et al., 2023b; Vylegzhanin et al., 2025).

Indonesia regulates space activities through Law Number 21 of 2013. The Law addresses commercial activities, governmental guidance and oversight, security and safety, registration, responsibility and compensation, insurance, environmental preservation, and international cooperation. Government Regulation Number 7 of 2023 regulates national space technology capabilities. The institutional functions of the National Research and Innovation Agency are governed by Presidential Regulation Number 78 of 2021, as amended by Presidential Regulation Number 95 of 2025. Exercising national regulatory authority over ISRU requires identifying the legal nexus connecting activities, operators, and space objects to Indonesia. Such authority must be distinguished from claims of sovereignty over celestial bodies, which are prohibited under Article II of the OST. Previous studies have examined the need to regulate space mining and adapt Indonesia's national legal framework (Suryaatmadja et al., 2020; Putro et al., 2025).

Previous research has addressed various legal issues arising from space resource utilization. Studies of safety zones have examined access restrictions associated with long-term lunar mining operations (McKeown et al., 2022). Research on lunar water-ice mining and environmental impact assessment has identified regulatory needs arising from operational characteristics and risks (Dallas et al., 2021; Hubbard et al., 2024). Studies of benefit sharing have examined competing interpretations of benefits for all States and alternative distribution mechanisms (Xu & Su, 2022; Deplano, 2023). In Indonesia, research on space mining and national legal reform has identified the need for greater regulatory certainty in commercial space activities (Suryaatmadja et al., 2020; Putro et al., 2025). Research concerning developing countries in Southeast Asia has also addressed differences in technological capabilities and approaches to the Artemis Accords (2020) (Nugraha et al., 2026). Building on this literature, this analysis examines the relationship between the three technical parameters of ISRU and the two OST principles, along with their implications for Indonesia's regulatory authority and diplomatic position. It contributes legal criteria for aligning technical standards and an assessment model integrating operational characteristics, international obligations, and national authority.

The study addresses two legal questions. First, how can safety zones, interoperability, and contamination prevention in ISRU activities align with the principles of non-appropriation and benefit sharing, while accounting for operational risks, freedom of use, and the interests of other States? Second, what implications

does such alignment have for Indonesia's regulatory sovereignty through the exercise of national authority and participation in developing international principles within COPUOS? These questions establish the study's objectives: to formulate the legal basis and limits governing the application of ISRU technical standards and to develop a legal framework for Indonesia's regulatory authority. The analysis distinguishes implementing existing international obligations from developing new legal rules.

METHOD

This prescriptive doctrinal legal study employs statutory, conceptual, and comparative legal approaches (Qamar & Rezah, 2020). The statutory approach is used to interpret international space law and national provisions governing space activities, legal subjects, and space objects. The conceptual approach examines non-appropriation, benefit sharing, jurisdiction, international responsibility, and the legal status of technical standards. The comparative approach analyzes United States and Luxembourg legislation on recognizing rights over extracted resources, licensing, and supervision. Japanese and United Arab Emirates regulations provide additional comparisons concerning operational plans and the regulation of space resources.

Primary legal materials include the OST, the Liability Convention (1971), the Registration Convention (1974), and Indonesian laws and regulations governing space activities. Indonesia's status as a party to these treaties is examined through Law Number 16 of 2002, Presidential Decision Number 20 of 1996, and Presidential Decision Number 5 of 1997. Treaty interpretation follows Article 31 and Article 32 of the Vienna Convention (1969). The Moon Agreement (1979) and the UNCLOS (1982) are used for limited comparison of approaches to governing shared resources. This analysis accounts for differences in subject matter and scope of application. Secondary legal materials comprise books and scholarly articles on space resource law, operational sustainability, duties of cooperation, technical standards, and the development of national space law.

Indonesia's diplomatic documents submitted within COPUOS, Space Benefits Declaration (1997), the Artemis Accords (2020), the Hague Building Blocks (2019), and documents of the Working Group on Legal Aspects of Space Resource Activities are examined according to their respective legal status. The review of legal materials and negotiating documents covers developments through September 30, 2026, including the consolidated draft principles discussed that year. The analysis distinguishes the law as it stands (*lex lata*) from the law as it ought to be developed (*lex ferenda*). This distinction determines whether technical standards implement treaty obligations, constitute requirements enforceable under national regulatory authority, or represent proposed rules requiring further agreement (Sampara & Husen, 2016).

Supporting data were obtained through an online semi-structured interview with an expert from the National Research and Innovation Agency on September 17, 2026. The interview statements were organized into ten themes concerning equitable benefits, national interests, regulatory developments, technological capabilities, policy priorities, institutions, financing, and cooperation. Each theme was compared with official documents and classified as "supported," "partially supported," or "not yet verified." These categories indicate how strongly documentary evidence supports the expert's statements. Indonesia's official positions are established from diplomatic documents, while interpretations of legal obligations and State authority are based on primary legal materials.

The analysis applies grammatical, systematic, and teleological methods of interpretation to the relationships among legal provisions (Irwansyah, 2020). The assessment of subsequent practice follows Article 31(3)(b) of the Vienna Convention (1969), which concerns subsequent practice establishing the agreement of the parties regarding treaty interpretation. The first stage of analysis relates ISRU activities and risks to the freedom to use outer space, the prohibition of appropriation, environmental protection, and benefit sharing. The second stage determines the legal nexus between activities and Indonesia by examining the applicability of national law, licensing, supervision, registration, jurisdiction, responsibility, insurance, and cooperation. Comparative legislation and diplomatic documents are then used to identify the limits of regulatory authority and areas requiring further regulation.

RESULTS AND DISCUSSION

A. Application of ISRU Technical Standards and the Legal Limits of the Non-Appropriation Principle

The legal assessment of ISRU technical standards requires distinctions among activities, subjects, objects, and their legal consequences. The interview with an expert from the National Research and Innovation Agency yielded ten themes covering equitable benefits, international regulatory developments, Indonesia's interests, technological capabilities, national priorities, institutions, financing, and cooperation. The review of official documents indicates differing levels of support for these themes. The obligation to consider the interests of all States is established in Article I of the OST, while Indonesia's 2024 diplomatic contribution addresses the need for regulation capable of adapting to technological developments. The assertion that space navigation has a higher national priority than ISRU is not supported by an official document establishing such a hierarchy. Table 1 presents the relationship between the expert's statements and the official documents.

Table 1. Assessment of Themes from the National Research and Innovation Agency Expert Interview Against Official Documents

No.	Theme and Main Statement	Comparative Document	Assessment Finding
1	Equitable benefits: ISRU profits may be concentrated among States with advanced technological capabilities	Article I of the OST	Partially supported; a legal basis for benefits to all States exists, but the actual distribution of profits has not been established
2	International instruments: specific ISRU regulations remain under development	Draft principles within COPUOS	Partially supported; negotiations are ongoing, while the effectiveness of implementation cannot yet be assessed
3	National interests: space technology capabilities influence policy direction	Indonesia's statements in 2023 and 2024	Partially supported; the official statements do not explain all considerations underlying national policies
4	Indonesia's interests: space resource regulation is strategically significant	Indonesia's diplomatic documents	Partially supported; an official diplomatic position is available, but plans for particular facilities have not been verified
5	Technological development: regulation must accommodate technological advances	Indonesia's 2024 contribution	Supported; the document addresses regulatory adaptability to technological developments, or future-proofing
6	National priorities: navigation is considered more important than ISRU	National planning documents	Not yet verified as an officially established order of priorities
7	Institutions and financing: interagency coordination and financial support are required	Law Number 21 of 2013 and diplomatic documents	Partially supported; an institutional legal basis exists, but dedicated ISRU financing has not been established
8	Benefit sharing: all States have interests in the use of outer space	Article I of the OST	Supported; the provision does not establish a universal royalty obligation
9	The 1996 Declaration: the instrument does not establish a specific binding mechanism for distributing profits	Space Benefits Declaration (1997)	Supported; the Declaration does not prescribe financial distribution according to a fixed percentage
10	Cooperation: benefits may be implemented through agreements, including memoranda of understanding (MoUs)	Space Benefits Declaration (1997) and Indonesia's 2024 contribution	Partially supported; the legal effects of cooperation depend on its substance and the parties' intentions

Source: Author's analysis of the expert interview conducted on September 17, 2026, and relevant official documents.

ISRU encompasses five stages involving distinct primary legal considerations. Prospecting concerns freedom of exploration and communicating information about activities. Extraction requires risk management and safety protection at operational sites. Processing requires coordination among facilities and interoperability. Using extracted resources raises questions about rights to materials, while waste management raises obligations to prevent contamination. Environmental obligations may apply across several stages, just as interoperability may be required throughout an operation. These distinctions correspond to the

need to regulate lunar water-ice mining according to operational characteristics and associated risks (Hubbard et al., 2024). Table 2 presents the relationship between each stage, the applicable provisions, and the legal assessment.

Table 2. Relationship Between ISRU Stages, OST Provisions, and Criteria for Legal Alignment

Stage	Primary Legal Issue	OST Provisions and Assessment Criteria	Assessment Finding
Prospecting	Surveys and information	Articles I, IX, and XI of the OST; freedom of exploration and communication of information under applicable requirements	Generally aligned, provided the relevant obligations are fulfilled
Extraction	Safety zones	Articles I, II, IX, and XII of the OST; risk-based access restrictions without territorial appropriation	Potentially inconsistent when restrictions exceed legitimate safety requirements
Processing	Interoperability and use of facilities	Articles I, VI, and IX of the OST; operational safety and opportunities to use functionally equivalent systems	Additional regulation is needed to prevent unlawful restrictions on participation
Utilization of extracted resources	Rights over extracted materials	Articles I, II, and VI of the OST; distinction between extracted materials, deposits, and operational sites	Recognition of rights over extracted resources remains subject to differing interpretations of international law
Waste management	Contamination	Article IX of the OST; prevention of harmful contamination, with supervision of national activities under Article VI of the OST	A general obligation exists, but specific technical criteria require further elaboration

Source: Author's analysis based on the OST and the operational characteristics of ISRU.

Safety zones must be distinguished from exclusive control over operational areas. Article I of the OST guarantees freedom to explore and use celestial bodies, whereas Article II prohibits national appropriation through claims of sovereignty, use, occupation, or any other means. Byers and Boley (2023) explain how these principles shape the legal limits of outer space utilization. In areas with limited water-ice deposits, long-term extraction and processing facilities may restrict access to sites other parties also need. Such risks increase when an operator maintains control over access throughout its operations without periodically reassessing safety requirements (McKeown et al., 2022; Hubbard et al., 2024).

Based on these legal provisions and operational characteristics, the alignment of safety zones can be assessed against five criteria. First, their geographical extent must be proportionate to identifiable safety risks. Second, access restrictions must last only as long as operational needs require and end when the underlying safety justification no longer applies. Third, information concerning activities and restrictions must be communicated in accordance with Article XI of the OST. Fourth, consultations must be conducted when circumstances involving potentially harmful interference arise under Article IX of the OST. Fifth, other States' access rights must be respected under the applicable provisions,

including the arrangements governing visits under Article XII of the OST. These criteria derive from interpreting several OST obligations in light of operational risks. The OST itself does not prescribe numerical limits on the geographical extent or duration of safety zones. Section 11 of the Artemis Accords (2020) and the Hague Building Blocks (2019) provide examples of coordination, notification, and restrictions justified by safety requirements. Because these instruments do not bind all OST States Parties, unilateral implementation cannot establish universally applicable operational criteria.

Interoperability concerns the ability of different technical systems to perform the functions required for joint operations. Compatible communication, navigation, data-exchange, and supporting systems may reduce operational interference. Nevertheless, requirements recognizing only one technological design may restrict operators using alternative systems. Section 5 of the Artemis Accords (2020) establishes interoperability as a commitment among participants, while Article I and Article IX of the OST provide the basis for assessing nondiscriminatory use and due regard for other States' interests. The acceptance of technologies may be assessed according to functional equivalence, safety requirements, reliability, and the ability to operate together. Technical requirements imposed on operators must have a valid legal basis or agreement. Transparent specifications and opportunities to demonstrate technological equivalence may reduce participation restrictions unrelated to legitimate safety requirements (Xu & Su, 2020).

Contamination prevention is specifically addressed by Article IX of the OST. This provision requires States to avoid harmful contamination of celestial bodies and adverse changes to Earth's environment resulting from the introduction of extraterrestrial matter. In ISRU operations, regolith excavation, water-ice processing, material transport, and residue disposal create different risks to the environments of celestial bodies, facilities, and scientific investigations. Environmental impact assessments can identify potential consequences before operations commence, while monitoring provides information about their effects during implementation (Dallas et al., 2021). Preventive obligations may be implemented through risk assessment, control of material releases, monitoring, waste management, and facility closure. Technical thresholds and compliance procedures require an appropriate regulatory basis (Zwart et al., 2023a). Assessments of legal violations must take account of the meaning of harmful contamination under the applicable provisions, the nature of the impacts, and preventive obligations. These obligations remain relevant before environmental damage occurs.

Resource ownership requires a distinction among deposits remaining within celestial bodies, extracted materials, and operational areas. Article II of the OST prohibits national appropriation of celestial bodies, while recognizing private-law rights over extracted resources raises separate legal questions. Arguments

supporting commercial utilization sometimes invoke usufruct, a right to use property and enjoy its benefits without acquiring ownership of the underlying property, to distinguish resource extraction from territorial control. Conversely, approaches that limit the recognition of rights through national legislation emphasize outer space as a resource open to common use (*res communis omnium*) and question the legal basis for asserting such rights against other States. The principle that no one can transfer more rights than they possess (*nemo that quod non habet*) also features in debates concerning the legal basis for granting rights over space resources (Kim, 2018; Zannoni, 2020; Svec, 2022).

These competing arguments indicate that prohibiting territorial sovereignty does not, by itself, resolve questions about ownership of extracted resources. National legislation may recognize rights within the domestic legal system, while the effects of those rights in relation to other States must be assessed under international law. Distinguishing rights over extracted materials, the use of facilities, and control of operational sites is necessary to identify the object and legal consequences of each right (Anderson et al., 2018; Guyomarc'h, 2023). The distinction between economic commons and legal commons further shows that a resource's economic value does not determine its legal status (Tepper, 2019). A limited comparison with the classification of geographical features under the law of the sea illustrates the importance of distinguishing physical modifications to an object from determining its legal status under the applicable legal regime (Widiastuti & Musyarri, 2026).

Developments in State practice must be assessed according to the source and legal status of the relevant conduct. Article 31(3)(b) of the Vienna Convention (1969) recognizes subsequent practice establishing the agreement of the parties regarding treaty interpretation. National legislation, commitments under the Artemis Accords (2020), and corporate activities may inform assessments of developing approaches to space resource regulation. Identifying State practice requires examination of the attribution of conduct to States and the acceptance of that practice by the parties to the treaty (Liu & Tronchetti, 2019; Zwart et al., 2023b; Lively, 2024). Article VI of the OST requires authorization and continuing supervision of national space activities conducted by nongovernmental entities. Within the scope of lawful national authority, operators may be subject to technical standards through licensing requirements, but their applicability to other parties depends on the legal source of the relevant obligation. Accordingly, the alignment of ISRU technical standards with the non-appropriation principle remains partial. General treaty obligations exist, but operational criteria governing safety zones, the acceptance of functionally equivalent technologies, and contamination standards have not been uniformly established for all States.

B. Implementation of the Benefit-Sharing Principle through ISRU Technical Standards and Space Cooperation

Implementing the benefit-sharing principle requires assessing the benefits of outer space utilization for all States, including those without the technological capabilities necessary to conduct extraction. Article I of the OST provides that exploration and use shall be carried out for the benefit and in the interests of all countries without discrimination. The provision also promotes cooperation in scientific investigations. Implementation of this obligation must be distinguished from each State's actual capacity to utilize space resources. Competing interpretations of benefit sharing demonstrate that opportunities for use, scientific cooperation, capacity building, and economic benefits may require different implementation mechanisms (Deplano, 2023). Approaches to governing shared resources, or commons, provide a basis for comparing forms of participation and benefit distribution by operational characteristics and applicable legal arrangements (Yap et al., 2023).

Space Benefits Declaration (1997) establishes principles of international cooperation that take account of the needs of developing countries and equitable terms of cooperation. The Declaration does not prescribe a particular percentage of financial profits as a universal legal obligation. Its negotiating history reflects differences among States concerning access to the benefits of space activities and practicable forms of cooperation (Benkö & Schrogl, 1997). By comparison, Article 11 of the Moon Agreement (1979) addresses the common heritage of mankind and the establishment of an international regime governing the exploitation of lunar resources. Part XI of UNCLOS (1982) provides a distinct institutional framework for managing resources in the international seabed Area. The International Seabed Authority's experience offers comparative insights into institutional competence, contribution obligations, and distribution mechanisms. Its relevance to celestial resources remains limited by differences in subject matter, scope, and States' participation in the respective legal regimes (Koch, 2018; Yun, 2020).

Nonmonetary benefits are directly related to safety zones, interoperability, and contamination prevention. For safety zones, communicating information on operational locations, activities, and interference risks can help other States plan activities in adjacent areas. Information-sharing obligations remain subject to Article XI of the OST. For interoperability, transparent functional requirements and opportunities to test equivalent technologies can facilitate participation by States with differing technological capabilities. To prevent contamination, protecting scientific investigation sites and exchanging monitoring results under applicable rules may preserve research opportunities for other States. Information disclosure and technology utilization must comply with applicable obligations, agreements between the parties, and intellectual property rights. The three parameters

demonstrate that benefits may be shared through access, participation, protection of scientific activities, and technical cooperation.

Capacity building for developing countries may be implemented through training, joint research, knowledge exchange, access to scientific data, and technological cooperation. Article 73 through Article 75 of Law Number 21 of 2013 govern international cooperation in space activities, including technological capabilities, technology utilization, knowledge transfer, technology transfer, and human resource capacity building. Cooperation arrangements may specify objectives, participating parties, information use, the utilization of research results, and the protection of intellectual property rights. In ISRU, developing capabilities for safety risk assessment, environmental monitoring of celestial bodies, and interoperability is directly relevant to operational needs. Such cooperation may be implemented through treaties or other valid arrangements, subject to the obligations and interests of the parties concerned.

Financial benefit-sharing mechanisms require rules establishing the legal basis of contributions, obligated parties, contribution amounts, administrators, beneficiaries, and accountability for fund management. Xu and Su (2022) examine voluntary and mutually agreed approaches to benefit sharing, with developing countries' interests in mind. A proposed space resources fund provides another institutional option for connecting commercial activities with capacity building and benefit distribution (McKeown et al., 2025). The Hague Building Blocks (2019) address capacity development, information exchange, technological cooperation, and the possible establishment of an international fund as forms of benefit sharing, without proposing mandatory monetary distribution as a general rule.

Criddle and Fox-Decent (2026) examine duties of cooperation under international law, providing a basis for distinguishing an obligation to cooperate from an obligation to achieve a particular distributive outcome. Article I of the OST requires benefits for all countries but does not establish a universally applicable royalty percentage. Financial contributions may be established through international agreements, contracts valid under the applicable law, or special regulatory arrangements supported by lawful authority. Bilateral, regional, and multilateral cooperation may produce different legal consequences. Likewise, an MoU's legal effect depends on its substance and the parties' intentions. Accordingly, benefit sharing can most readily be developed through nonmonetary arrangements grounded in existing cooperation frameworks, whereas financial mechanisms require separate agreements and legal provisions. Alignment with the principle of shared benefits does not yet extend to a uniform distribution mechanism applicable to all ISRU activities.

C. Adequacy of Indonesia's National Regulatory Framework and the Limits of Its Authority over ISRU

Indonesia's regulatory sovereignty over ISRU relates to its authority to regulate and supervise activities, space activity operators, and objects with a legal nexus to Indonesia. Article VI of the OST establishes States' international responsibility for national activities in outer space, including requirements for authorization and ongoing supervision of activities conducted by nongovernmental entities. Article VIII of the OST governs the jurisdiction and control of the State of registry over registered space objects and their personnel. Byers and Boley (2023) examine the relationship between State responsibility, the freedom of use, and due regard for the interests of other States. Marboe (2015) also discusses the role of national space law in implementing States' international obligations. Such regulatory authority differs from claims of sovereignty over celestial bodies, which are prohibited by Article II of the OST. Under Indonesian law, Article 4 and Article 5 of Law Number 21 of 2013 provide a basis for determining the legal connection between spacecraft, space activities, and Indonesia.

Article 5 of Law Number 21 of 2013 establishes the Law's scope of application based on several legal connections. These include space activities conducted within or from Indonesia's sovereign territory or jurisdiction, activities undertaken for or on behalf of Indonesia, the involvement or participation of Indonesian nationals or legal entities, and activities of foreign parties that have obtained authorization. Article 37 section (1) of the Law permits commercial space activities by legal entities established under Indonesian or foreign law, while Article 37 section (2) delegates further regulation of their requirements and procedures to a Government Regulation. These provisions establish a basis for determining the legal nexus between operators and Indonesia. Operational requirements for licensed entities, proof of legal connections, and the scope of supervision still require further elaboration within existing statutory authority. Establishing specific ownership rights over resource deposits or extracted materials also requires a separate legal basis (Suryaatmadja et al., 2020; Putro et al., 2025).

Article 5 and Article 76 section (1) of Law Number 21 of 2013 must be interpreted systematically in conjunction with Article VI of the OST. Article 5 determines the applicability of national law, while Article 76 section (1) governs the international responsibility of the Government of Indonesia for space activities within the scope of its sovereignty or jurisdiction. Article VI of the OST, meanwhile, refers to national activities in outer space when establishing States' international responsibility. These wording differences require consideration of the relationships among operators, operational locations, authorizing States, launching States, and States of registry. These relationships may be determined by examining the legal nexus connecting each activity to Indonesia. In multinational missions, one State may exercise licensing authority over an operator while another

retains jurisdiction and control over a registered space object. The involvement of an Indonesian legal entity may also require national supervision when a launch takes place from another State's territory. The principal issue is therefore not the absence of legal connections under Indonesian law, but the need for operational criteria governing how those connections identify and exercise authority.

The international responsibility of States for national space activities must be distinguished from liability for damage caused by space objects. Article VI of the OST governs international responsibility for national activities, whereas Article VII of the OST and the Liability Convention (1971) govern launching States' liability for damage. Article II of the Liability Convention (1971) establishes absolute liability for damage caused by space objects on the surface of Earth or to aircraft in flight. Article III establishes fault-based liability for specified damage involving another launching State's space object elsewhere than on the surface of Earth. Under Indonesian law, Article 76 of Law Number 21 of 2013 distinguishes the Government of Indonesia's international responsibility from the compensation obligations of space activity operators. Article 77 section (1) establishes absolute liability, whereas Article 77 section (2) applies fault-based liability to specified damage occurring in outer space between space activity operators. Article 77 section (3) provides for the determination of liability in that relationship according to agreements between the parties. Article 81 addresses joint and several liability, while Article 84 establishes third-party liability insurance requirements, except for government institutions.

In ISRU operations, regolith ejecta, disruptions to communication systems, or damage to another party's facilities may raise questions concerning proof of fault and causation. Safety-zone standards, notification procedures, environmental monitoring, and interoperability requirements may serve as relevant standards of care where they correspond to applicable risks and obligations. Violations of such standards must be assessed together with the circumstances of the incident and evidence of damage and causation under the applicable liability provisions. Article 83 of Law Number 21 of 2013 delegates further regulation of responsibility and compensation to a Government Regulation. The specific regulatory need arising from ISRU concerns developing compliance standards and evidentiary criteria for establishing fault, rather than creating a separate basis of liability unrelated to existing provisions. Greater legal certainty concerning operational risks also affects the financing of commercial activities (Janikowski, 2025).

Registration of space objects has legal consequences distinct from licensing and the determination of launching-State liability. Article VIII of the OST governs the jurisdiction and control of the State of registry over registered space objects. Article II of the Registration Convention (1974) governs registration, including determining the State of registry when more than one launching State is involved.

Article IV of the Convention specifies the information to be furnished to the Secretary-General of the United Nations. Under national law, Article 71 section (1) of Law Number 21 of 2013 establishes registration obligations for space objects with relevant launching connections to Indonesia. Article 71 section (2) governs information contained in the register of spacecraft, while Article 72 addresses the submission of information for international registration. An ISRU mission may involve landers, mining vehicles, processing modules, and transport spacecraft owned or operated by different entities. Each object's connection with the relevant State of registry must be determined under the applicable provisions. Registration establishes a basis for jurisdiction and control over space objects, not territorial control over resource-bearing areas.

The adequacy of national regulation must be assessed according to the authority established for each field of space activity. Article 41 of Law Number 21 of 2013 governs governmental guidance and oversight through regulation and control. Article 42 establishes norms, standards, guidelines, and criteria, along with control measures that include licensing and certification. Article 43 letter (d) directs the efficient and sustainable utilization of space-related natural resources while preserving environmental functions. Article 51 and Article 52 address space security and safety. Article 8 letter (e) prohibits activities capable of causing pollution or environmental damage on Earth or in outer space. Article 87 governs environmental preservation, while Article 88 concerns protecting Earth's environment. Prevention of harmful contamination of celestial bodies must also comply with Article IX of the OST. The ISRU-specific regulatory issue concerns criteria for prevention, monitoring, residue control, and assessment of impacts on celestial bodies. Distinctions between civil liability and contractual obligations may be illustrated through a limited comparison with banking law (Manga & Dianti, 2023), while the relationship between restrictions on economic activities and international obligations may be considered through a limited comparison with national investment policy (Simbolon, 2023).

Table 3. Adequacy of Indonesia's National Law in Addressing ISRU Requirements

Issue	Indonesian Legal Basis	Assessment Finding
Commercial activities	Article 5 and Article 37 of Law Number 21 of 2013	A legal basis exists; criteria concerning operators' legal nexus, licensing requirements, and supervision of extraction activities require further elaboration
Standards and supervision	Article 41 through Article 43 and Article 51 through Article 52 of the Law	General authority exists; specific technical standards must be established under the relevant regulatory powers
Responsibility and liability	Article 76 through Article 83 of the Law	A legal basis exists; standards of care, fault, causation, and agreements among operators require further specification

Issue	Indonesian Legal Basis	Assessment Finding
Insurance	Article 84 of the Law	Third-party insurance requirements exist; the scope of ISRU-specific risks requires further assessment
Environment	Article 8 letter (e), Article 87, and Article 88 of the Law	Environmental protection provisions cover Earth and outer space; specific criteria for contamination of celestial bodies require further regulation
Registration	Article 4, Article 5, Article 71, and Article 72 of the Law	The relationships among space objects, spacecraft, operators, and States of registry require clarification
Benefit-sharing cooperation	Article 73 through Article 75 of the Law	A legal basis exists for international cooperation and capacity building
Rights over extracted materials	Article 3 and Article 37 of the Law	Commercial space activity provisions do not expressly establish ownership rights over extracted materials

Source: Author's analysis based on Law Number 21 of 2013 and related regulations.

A comparison of national legislation reveals differences between recognizing rights over extracted resources and regulating operational conduct. In the United States, the CSLCA (2015, Title IV, 51 U.S.C. § 51303), recognizes specified rights of covered entities over resources obtained, subject to applicable law and relevant international obligations. This provision must be distinguished from the broader United States licensing framework for space activities. Luxembourg Space Resources Law (2017) recognizes the possibility of resource ownership and provides requirements concerning authorization, operations, supervision, and operator liability (Tronchetti & Liu, 2021; Vylegzhanin & Krokhina, 2025). Japan Space Resources Act (2021) connects space resource activities with operational plans, authorization, and recognition of rights. The United Arab Emirates has also developed relevant regulations through UAE Space Sector Law (2023) and UAE Space Resources Regulations (2025).

Table 4. Comparison of United States and Luxembourg Space Resource Regulations

Aspect	United States	Luxembourg	Relevance for Indonesia
Rights over extracted resources	CSLCA (2015, 51 U.S.C. § 51303) recognizes rights over resources obtained	Article 1 of Luxembourg Space Resources Law (2017) permits ownership of space resources	Ownership of extracted resources must be distinguished from control over deposits or operational areas
Licensing	CSLCA (2015, Title IV) does not regulate the entire mission licensing system	Article 2 and Article 3 of Luxembourg Space Resources Law (2017) govern written authorization requirements	Commercial activity requirements must be elaborated within the delegation under Article 37 section (2) of Law Number 21 of 2013
Supervision	Governed by applicable federal law	Article 12 and Article 15 of Luxembourg Space Resources Law (2017) address authorization conditions and supervision	Competent authorities and continuing supervision must be clearly determined

Aspect	United States	Luxembourg	Relevance for Indonesia
Risk and liability	CSLCA (2015, Title IV) does not contain the complete liability and insurance framework governing space activities	Article 10 and Article 16 of Luxembourg Space Resources Law (2017) address operational risks and operator liability	National regulations must comply with Article 76 through Article 84 of Law Number 21 of 2013

Source: Author's analysis based on United States and Luxembourg legislation.

The assessment indicates that Indonesian law already provides a general legal basis for commercial activities, technical regulation, safety, registration, responsibility, insurance, environmental preservation, and international cooperation. Three specific regulatory needs arise directly from ISRU's characteristics: criteria for establishing operators' legal nexus and supervisory obligations, standards of care for assessing fault, and contamination-prevention standards for celestial bodies. Requirements for commercial activities may be elaborated under Article 37 section (2) of Law Number 21 of 2013. Responsibility and compensation are regulated by delegation under Article 83 of the Law, while safety, environmental, and registration requirements must be established under their respective sources of authority. Recognition of specific rights over extracted materials requires a separate legal basis. Following the integration of the former National Institute of Aeronautics and Space into the National Research and Innovation Agency, the allocation of research, technological, licensing, and supervisory functions must comply with Presidential Regulation Number 78 of 2021, as amended by Presidential Regulation Number 95 of 2025, and other applicable institutional provisions. Indonesia's national framework is therefore only partially adequate at the operational regulatory level, rather than lacking space law entirely.

D. Indonesia's Diplomacy within COPUOS and the Exercise of Regulatory Sovereignty in Two Domains

Indonesia's position within COPUOS reflects developing countries' interests in access, shared benefits, legal certainty, and multilateral regulation of space resources. Indonesia's statement before the COPUOS Legal Subcommittee on March 21, 2023, emphasized the need for a transparent and inclusive international regulatory framework. Its written contribution submitted on November 15, 2024, addressed definitions of space resources, non-appropriation, sustainability, benefit sharing, and supervision of nongovernmental entities. The contribution also addressed the need for regulations that can adapt to technological developments. Attention to equal access and capacity building aligns with developing countries' interests in developing space resource activities (Nugraha et al., 2026). Indonesia's diplomatic interests therefore include operational safety, protection of scientific investigations, opportunities for use, and shared benefits for States with different technological capabilities.

As of September 30, 2026, negotiations within the Working Group on Legal Aspects of Space Resource Activities remained at the stage of drafting principles proposed for recommendation. Discussions during 2026 addressed consolidated draft principles concerning compliance with international law, freedom of access, non-appropriation, safety, environmental protection, information exchange, and cooperation. The drafts also addressed the relationship between resource extraction and the OST's prohibition on appropriation. Their status as proposed recommendations differs from obligations already established by international treaties. The same distinction applies to the Artemis Accords (2020) and national regulations, each with its own scope of application. Research on the possibility of developing a common approach among BRICS countries demonstrates variation in national approaches to celestial resources (Vylegzhanin et al., 2025). In multilateral negotiations, Indonesia may propose principles addressing safety, freedom of use, and the interests of States without extraction capabilities.

Analyzing the three ISRU parameters provides specific grounds for Indonesia's diplomatic agenda. For safety zones, international principles should address the geographical extent and duration of risk-based restrictions, activity notification, consultation under Article IX of the OST, and protecting other States' opportunities for use. For interoperability, standards may be developed based on system performance and functional equivalence, provided the systems meet applicable safety requirements. To prevent contamination, regulation should address environmental risk assessment, impact monitoring, protection of scientific investigations, residue management, and facility closure. The three parameters are also connected with benefit sharing through arrangements governing access, information exchange, research cooperation, and capacity building. Financial contribution mechanisms require separate provisions governing obligations and administration.

Within domestic regulation, internationally agreed principles may inform requirements for operational plans, reporting changes in risk, appropriate technology use, activity reports, and supervision after operations are completed. These requirements must be established according to the authority of the relevant institutions and through appropriate regulatory instruments. Fundamental matters concerning rights, obligations, licensing, and supervision must be distinguished from technical specifications requiring adjustment as technology develops. Detailed technical standards may be established through implementing instruments where the relevant authority exists. This distinction corresponds to Indonesia's approach to future-proofing and the incremental regulatory approach reflected in the Hague Building Blocks (2019). It permits safety requirements to be adapted without unilaterally altering the legal basis of existing obligations.

Indonesia's regulatory sovereignty is examined through three interconnected layers of legal assessment. The first identifies the subjects, objects, operational stages, and technical risks of ISRU. The second assesses activities against applicable international legal obligations while distinguishing those obligations from political commitments and draft recommendations. The third determines the legal nexus between activities and Indonesia and identifies national authority to grant authorization, supervise activities, and regulate their consequences. The results of these three layers are applied within two domains. The domestic domain concerns regulating activities under national authority, while the multilateral diplomatic domain concerns Indonesia's participation in developing international principles. These relationships are illustrated in Figure 1.

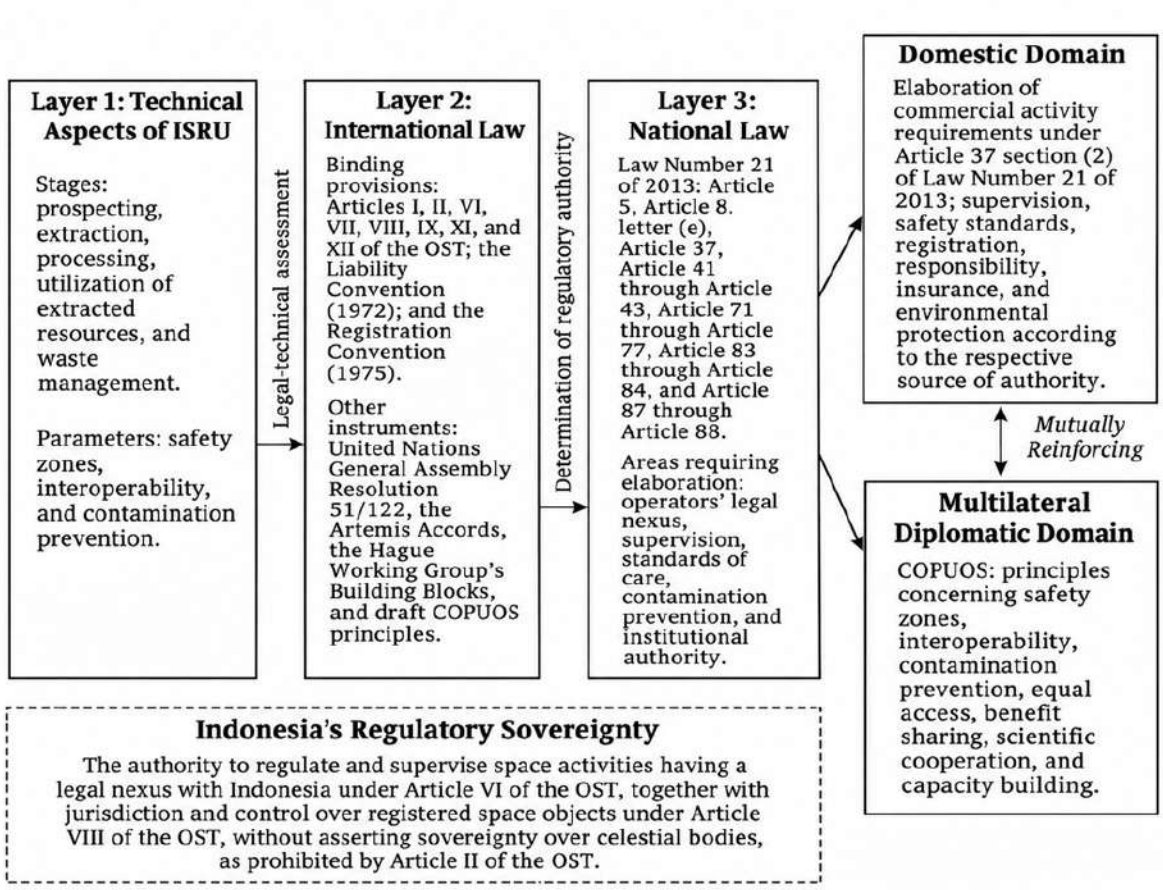

Figure 1. Model for Aligning Three Layers of Assessment and Two Domains of Indonesia's Regulatory Sovereignty.

The relationship between the two domains determines how international obligations are implemented through national authority and how Indonesia participates in developing common international rules. In the domestic domain, licensing, reporting, supervision, and environmental protection requirements must rest on a valid legal basis. In the diplomatic domain, Indonesia may propose criteria governing safety zones, interoperability, the protection of celestial bodies, and benefit sharing for multilateral consideration. Implementing both domains

also requires coordination among the research functions of the National Research and Innovation Agency, the diplomatic responsibilities of the Ministry of Foreign Affairs, and other institutions according to their respective authority. The legal effect of negotiated outcomes depends on the instrument's form and the agreement of participating States. Indonesia's regulatory sovereignty is therefore exercised through lawful national regulatory authority and participation in international norm development, rather than territorial control over celestial bodies.

CONCLUSIONS AND SUGGESTIONS

The alignment of ISRU technical standards with the principles of non-appropriation and benefit sharing remains partial. Articles I, II, and IX of the OST establish a legal basis for assessing freedom of use, the prohibition of national appropriation, and the prevention of harmful contamination. Nevertheless, safety zones, interoperability, and contamination standards have not been governed by uniformly applicable international operational criteria. Safety zones require risk-proportionate restrictions limited to operational needs, accompanied by information sharing and consultations under the applicable provisions, while respecting other States' access. Interoperability requires accepting functionally equivalent technologies that meet lawful safety requirements. Contamination prevention requires assessing risks to the environments of celestial bodies and to scientific investigations. Benefit sharing may be implemented through access opportunities, research cooperation, information exchange, and capacity building. The distribution of financial profits requires a separate legal basis or agreement governing contribution obligations and their administration.

For Indonesia, the implications concern determining authority over activities, space activity operators, and space objects with a legal nexus to Indonesia. Article 5 of Law Number 21 of 2013 governs the applicability of national law, while Article 76 section (1) of the Law governs the international responsibility of the Government of Indonesia within the specified scope. These provisions must be interpreted systematically alongside Article VI of the OST. National law already provides a general basis for regulating ISRU, but further elaboration is required in three areas: criteria establishing the legal nexus between operators and Indonesia, standards of care for assessing fault, and contamination prevention standards for celestial bodies. Licensing and supervision must also be distinguished from the jurisdiction of the State of registry, the status of the launching State, and liability for damage. The three-layer assessment model integrates technical characteristics, international obligations, and national regulatory authority. Its findings apply to domestic regulation and multilateral diplomacy.

National legal development should focus on elaborating requirements for commercial activity under Article 37 section (2) of Law Number 21 of 2013. Relevant

matters include classifying ISRU activities, determining operators' legal nexus and licensing requirements, and establishing supervisory obligations appropriate to mission characteristics. Technical standards may serve as standards of care under the applicable provisions. Responsibility and compensation must comply with Article 76 through Article 83 of the Law, while third-party insurance is governed by Article 84 of the Law. Environmental and registration requirements must be established under their respective legal bases. Recognition of specific rights over extracted materials requires a separate legal basis consistent with international obligations. Institutional functions following the integration of the former National Institute of Aeronautics and Space into the National Research and Innovation Agency must also comply with the applicable regulations. At the international level, Indonesia should develop proposals concerning operational safety, technological functional equivalence, protection of celestial environments, research cooperation, and capacity building.

Implementing these recommendations requires clarifying interagency authority, developing risk-based operational requirements, and coordinating the National Research and Innovation Agency's technical research with Indonesia's diplomatic interests within COPUOS. Doctrinal legal research provides a basis for interpreting legal norms and determining authority, while establishing safety distances, contamination thresholds, and the economic feasibility of benefit-sharing mechanisms requires further technical and empirical research. Future studies should also examine how responsibility is allocated in multinational ISRU missions and how financial contributions are structured in agreements among States. These findings may inform regulatory proposals that accommodate technological developments, the interests of all States, and legal certainty.

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