

Bolstering Science and Technology Collaboration: Indonesia and China's Marine Technology Initiative

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Abstract

The research examined the bilateral cooperation framework concerning the advancement of marine technology, knowledge exchange, and capacity enhancement between Indonesia and China. This research aimed to analyze the legal and institutional dimensions of the initiative, particularly regarding technology transfer, capacity building, intellectual property protection, joint resource management, and environmental sustainability. This research applied normative legal research by analyzing relevant legal instruments, policy documents, bilateral cooperation frameworks, and academic literature. The findings show that the initiative is multifaceted, offering opportunities for scientific cooperation and maritime capacity development while also presenting challenges related to governance, benefit-sharing, technological asymmetry, and implementation effectiveness. The research further identifies the importance of joint coordination mechanisms, technology roadmaps, environmental safeguards, and dispute-resolution frameworks in supporting effective cooperation. It concludes that the Indonesia and China Marine Technology Initiative may contribute to sustainable marine technology development, provided that its implementation ensures balanced benefits, substantive technology transfer, environmental protection, and respect for maritime governance principles within the broader ASEAN maritime cooperation context.

Keywords: bilateral technology collaboration, capacity building, marine technology initiative, sustainability

Introduction

Marine technology cooperation has become an important part of contemporary maritime governance, particularly for archipelagic states that depend on sustainable ocean management, technological capacity, and regional maritime stability. In light of this tremendous potential, maritime powers such as China and Indonesia are progressively resorting to marine technology to unlock its mysteries and exploit its resources. The Indonesia-China Marine Technology Initiative, a bilateral accord established to enhance scientific and technological cooperation between the two nations, is a driving force behind this undertaking (Migliaccio et al., 2022).

Both Indonesia and China exhibit distinct advantages and strategic concerns within maritime affairs. Indonesia, being the largest archipelagic country globally, is characterized by its extensive coastline of 99,000 kilometers and more than 17,000 islands, which are replete with abundant resources and biodiversity (Khomsin, 2022). Indonesia's "Global Maritime Fulcrum" initiative seeks to position the nation as a pivotal center for maritime commerce and technological advancement. In contrast, China is recognized as an international frontrunner in technological advancements and has a rapidly growing demand for offshore resources (Alverdian, 2022). The "Belt and Road Initiative" emphasizes infrastructure development and maritime connectivity, making it an ideal partner for Indonesia's maritime aspirations.

The initiative covers several areas, including joint research, technology transfer, capacity building, environmental monitoring, and sustainable resource management. Submersibles developed in collaboration can investigate the enigmatic depths, whereas sophisticated aquaculture systems have the potential to bolster food security and sustainability. Joint endeavors to leverage ocean energy and conduct oceanographic research could yield substantial benefits for both countries (Shaheen & Panhwar, 2022). The agreement facilitates the transfer of technology and knowledge through technology transfer agreements, academic exchanges, and collaborative research endeavors. An open exchange of expertise promotes the development of new ideas, expedites technological progress, and guarantees that both countries benefit from the collective knowledge of the other (Gunawan et al., 2024). Programs for Mutual Capacity Development and Training recognize that proficient personnel are crucial to advancing marine technology. The initiative places significant emphasis on capacity development and training initiatives (Gunawan & Rizqy Pane, 2024). These programs equip scientists, engineers, and technicians from both nations with the specialized knowledge and skills necessary to operate and innovate in the marine industry. As a result, a new generation of maritime specialists will emerge (Suryadi et al., 2022). At the implementation level, strengthening this capacity is essential so that Indonesia does not merely become a technology user, but also develops the absorptive capacity to adapt, standardize, and pursue further innovation in line with local needs, for example, in eastern Indonesia and in disaster-prone waters.

This cooperation raises governance concerns related to intellectual property, benefit-sharing, environmental safeguards, and joint resource management. The agreement should establish transparent and equitable mechanisms to ensure that collaboration-generated

innovations are mutually beneficial while safeguarding the intellectual property rights of both nations. Joint resource management is crucial in ensuring the sustainable use of shared maritime resources, including fisheries and underwater resources. The agreement must delineate comprehensive frameworks for collaborative resource management that uphold the principles of sovereignty, responsible utilization, and conservation. Marine technology must be pursued to prioritize environmental sustainability (Jorgenson & Fink, 2023).

Solid environmental safeguards and sustainability protocols should be integrated into the agreement to prevent marine technology initiatives from contributing to ecosystem degradation or pollution. Beyond technical and environmental considerations, the governance dimension must also be understood within the region's geopolitical context, especially where marine data, seabed mapping, and research activities intersect with territorial sensitivities, permitting requirements, and security perceptions. With a forward-looking perspective, the Indonesia-China Marine Technology Initiative exhibits tremendous potential to shape the maritime innovation landscape in the region (Caruso et al., 2022).

The Indonesia-China Marine Technology Initiative represents a substantial stride in reciprocally benefiting from and advancing collectively from the immense potential of the maritime domain. This collaborative endeavor achieved favorable results by employing strategic problem-solving, establishing efficient implementation mechanisms, and prioritizing sustainable practices (Aprilia, 2023). By linking the Global Maritime Fulcrum agenda and the Belt and Road Initiative in a more operational manner, while taking regional stability implications into account, this collaborative approach can be positioned not merely as a technology project, but as an instrument for building maritime capacity, strengthening resource governance, and advancing sustainable maritime stability. Although the Indonesia-China Marine Technology Initiative is often presented as a technical and developmental cooperation, it also raises broader academic questions concerning maritime governance, science diplomacy, technology transfer, and sustainable resource management.

The central problem is not merely whether Indonesia and China cooperate in marine technology, but how such cooperation is governed, how knowledge and technology are transferred, and how the initiative addresses asymmetry, environmental sustainability, intellectual property, and regional maritime sensitivities. Existing studies on Indonesia-China relations have largely focused on infrastructure investment, trade, the Belt and Road Initiative, maritime security, and geopolitical tensions in the South China Sea. Meanwhile, studies on maritime governance in Southeast Asia often emphasize legal regimes, resource management, and environmental protection. However, limited attention has been given to marine technology cooperation as a mechanism of science diplomacy and regional maritime governance. In particular, the literature has not sufficiently examined how the Indonesia-China Marine Technology Initiative combines technology transfer, capacity building, intellectual property protection, environmental safeguards, and institutional coordination within one bilateral framework.

This research examines how the Indonesia-China Marine Technology Initiative functions as a mechanism of science diplomacy and maritime governance, particularly in

relation to technology transfer, capacity building, environmental sustainability, intellectual property protection, and regional maritime cooperation. Furthermore, the objective of this article is to analyze the legal, institutional, and policy dimensions of the Indonesia-China Marine Technology Initiative. Specifically, the research examines three aspects: first, the mechanisms of technology transfer, knowledge sharing, and capacity building; second, the governance challenges related to intellectual property, joint resource management, and environmental sustainability; and third, the broader implications of the initiative for regional maritime governance and science diplomacy in ASEAN. This research contributes to existing literature by moving beyond a descriptive account of Indonesia-China marine cooperation. It offers an analytical reading of marine technology cooperation as a governance instrument that links science diplomacy, technology transfer, sustainability, and regional maritime stability. Thus, the research provides a more focused understanding of how bilateral technology cooperation may support Indonesia's maritime capacity while also generating legal, institutional, and geopolitical challenges.

Literature Review/Analytical Framework

As part of the analysis of the Indonesia-China Marine Technology Initiative, the research focuses on understanding both the advantages and potential difficulties associated with the initiative. This assessment entails a comprehensive investigation of specific projects included in the bilateral agreement. The primary focus is on the collaborative development and deployment of marine technology, which provides infrastructure for renewable energy sources, aquaculture systems, and underwater vehicles (Badriyah et al., 2023). Furthermore, the literature review delves into the mechanisms included in the agreement to facilitate knowledge sharing and technology transfer between research entities in Indonesia and China. Additionally, the review examines the provisions for mutual capacity building and training programs that are designed to improve the skills of researchers and technicians in both countries (Sharan et al., 2023).

A key focus is how the initiative intends to counteract difficulties and impediments. Accordingly, the literature review examines the safeguards and methods incorporated into the agreement to protect intellectual property resulting from collaborative research. In addition, it assesses how the initiative successfully navigates joint resource management of shared maritime resources while protecting each nation's sovereign rights. Moreover, the evaluation investigates the environmental sustainability measures that are included in the agreement. It does so by analyzing impact assessments and sustainability procedures to guarantee responsible exploration and usage of resources (Panjwani et al., 2023).

In the course of the initiative's progression, the literature review focuses on techniques for implementation and future directions. The research investigates collaborative coordination process and funding structures built to enable the smooth project execution of projects. The research expands to include both elements in the agreement to highlight the role technology roadmaps and collaborative research and development plans play in directing future objectives (Augustine & Chouinard, 2022). The framework that is established for

monitoring progress and evaluating outcomes is also discussed. Additionally, the review addresses the methods for conflict resolution that are incorporated into the agreement. These theories include viewpoints on collaborative research, technology transfer, intellectual property protection, environmentally friendly practices, and effective coordinating mechanisms. This framework aims to provide a complete understanding of the possible impact and implications of the initiative for future cooperation attempts in marine technology between Indonesia and China (Miller et al., 2022).

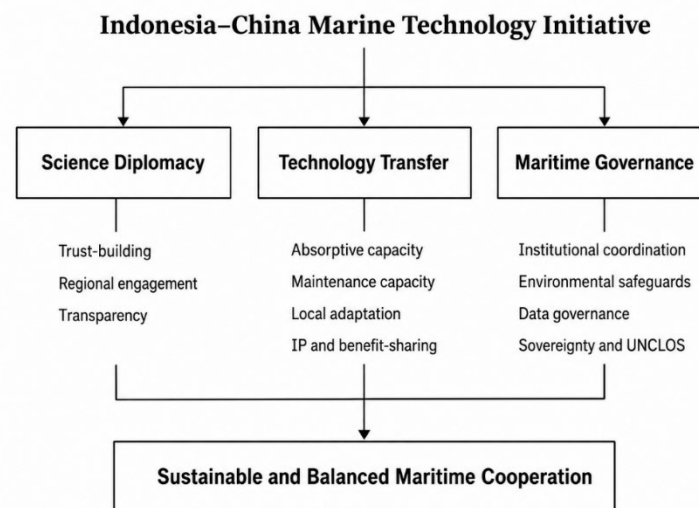


Figure 1. Analytical Framework of the Indonesia-China Marine Technology Initiative (Authors, 2026)

This research applies three interrelated analytical frameworks: science diplomacy, technology transfer, and maritime governance (see Figure 1). These frameworks are used to examine the Indonesia-China Marine Technology Initiative not merely as a technical cooperation project, but as a broader governance arrangement involving knowledge, authority, resources, and strategic interests. First, science diplomacy is used to analyze how marine research and technology cooperation may function as a diplomatic instrument. From this perspective, cooperation in oceanographic research, environmental monitoring, and marine technology development can contribute to confidence-building and regional engagement. However, science diplomacy is effective only when cooperation is transparent, mutually beneficial, and not perceived as an instrument of strategic influence. Second, technology transfer and absorptive capacity are used to evaluate whether Indonesia gains substantive technological capability from the initiative.

Technology transfer should not be measured only by the existence of training programs, workshops, or academic exchanges. It should be assessed by whether Indonesian institutions can learn, operate, maintain, modify, and further develop the transferred technology. This framework is important because Indonesia and China do not possess equal technological and financial capacity. Third, maritime governance is used to assess the institutional, legal, and environmental dimensions of the initiative. This includes coordination mechanisms,

environmental safeguards, intellectual property protection, data governance, joint resource management, and respect for sovereignty. From this perspective, the initiative must be evaluated in terms of whether it supports sustainable maritime development while protecting Indonesia's maritime jurisdiction and policy autonomy.

Research Method

This research employs a normative legal research method combined with qualitative document-based policy analysis. The research examines the legal, institutional, and policy dimensions of the Indonesia-China Marine Technology Initiative, particularly in relation to technology transfer, capacity building, intellectual property protection, environmental sustainability, and joint maritime resource governance. The data used in this study consist of secondary legal and policy materials (Tan, 2021). These include bilateral cooperation documents, relevant national regulations and policy frameworks, academic literature, institutional reports, and credible media sources concerning Indonesia-China maritime cooperation, marine technology development, the Belt and Road Initiative, Indonesia's Global Maritime Fulcrum, and regional maritime governance in ASEAN. The materials are selected based on three criteria. First, the sources must be directly relevant to Indonesia-China marine technology cooperation or broader maritime governance. Second, the sources must address at least one of the study's core analytical themes: technology transfer, capacity building, intellectual property, environmental sustainability, institutional coordination, or joint resource management. Third, the sources must be authoritative, consisting of legal instruments, government or institutional documents, peer-reviewed academic works, or credible policy analyses.

The data are analyzed using qualitative content analysis and legal interpretation. The analysis was conducted by identifying recurring legal and policy themes, comparing the initiative's stated objectives with its governance mechanisms, and evaluating the implications of the cooperation for sustainable maritime governance and science diplomacy. This method enables the study to assess the initiative not merely as a technical cooperation project, but as a legal and institutional arrangement with broader implications for Indonesia-China relations and regional maritime governance.

Analysis

Comparative Analysis of Similar Bilateral Agreements

A prominent illustration of such cooperation can be found in the joint endeavor between Indonesia and China to design, manufacture, and implement marine technology (D. Zhang et al., 2022). The collaboration has the potential to fundamentally transform numerous facets of marine research, including infrastructure for renewable energy, aquaculture systems, and subaqueous vehicles. Furthermore, the analysis examines particular initiatives in the

bilateral agreement, emphasizing their importance and potential ramifications for both nations and the international community (Meinig et al., 2019).

Autonomous underwater vehicles (AUVs) are among the most significant areas of the Indonesia-China Marine Technology Initiative because they support seabed mapping, oceanographic research, and environmental monitoring. Moreover, AUVs constitute one of the concrete forms of marine technology cooperation under the Indonesia-China Marine Technology Initiative. AUVs are relevant because they can support seabed surveys, oceanographic data collection, marine biodiversity observation, and environmental monitoring. For Indonesia, this technology is important to strengthen marine research capacity, especially in areas where conventional monitoring and underwater exploration remain limited. However, AUVs' cooperation should not be viewed merely as a technical achievement. Because AUVs are closely connected to seabed mapping, oceanographic data collection, and resource identification, they may generate sensitive maritime data with scientific, economic, and strategic value. Therefore, the key issue is not only whether Indonesia gains access to AUV technology, but also whether Indonesia controls the data collected, participates in data processing, and develops the capacity to operate, maintain, and adapt the technology independently.

This issue is particularly important because the cooperation takes place within an asymmetric technological relationship. China has stronger industrial and technological capacity in advanced marine technologies, while Indonesia seeks to develop its domestic maritime research and innovation capability. If Indonesia only receives access to AUV equipment or operational training without acquiring the ability to operate, repair, modify, and process data independently, the cooperation may create technological dependency rather than genuine capacity building. Thus, these benefits depend on whether Indonesia has access not only to the equipment, but also to the data, software, maintenance knowledge, and technical capacity required to use the technology independently (Noguchi & Maki, 2021).

The partnership between Indonesia and China also encompasses advancing sophisticated aquaculture systems (Brantner & Khatib, 2021). Aquaculture is indispensable to reducing pressure on natural fish populations and ensuring sustainable seafood production. The two nations strive to advance aquaculture technology through collaborative efforts, enhancing operational effectiveness and ecological sustainability (Naylor et al., 2021). One possible area of cooperation is integrated aquaculture, which combines fish farming with the cultivation of algae and other marine organisms. Such systems may contribute to sustainable production, but their effectiveness depends on local adaptation and institutional capacity (Boyd et al., 2020). The key issue is whether aquaculture cooperation strengthens Indonesia's domestic capacity or creates dependence on external technology. If integrated aquaculture systems rely heavily on imported equipment, software, feed technology, technical standards, or foreign maintenance services, Indonesia may become dependent on Chinese technological inputs. Therefore, the success of aquaculture cooperation should be measured not only by production output, but also by the extent to which Indonesian researchers, local industries, and coastal communities are involved in technology adaptation, operation, and further innovation.

Marine renewable energy cooperation should be assessed not only from its contribution to the clean energy transition, but also from its financing structure, ownership model, local content, and depth of technology transfer (Hakim et al., 2025). If China provides the major technological components, financing, and engineering expertise, while Indonesia primarily provides project locations, regulatory access, and market opportunities, the cooperation may produce unequal long-term benefits (Wang et al., 2020). In such a situation, China may gain commercial expansion and strategic technological presence, while Indonesia may remain dependent on external technology, spare parts, maintenance systems, and technical standards (DeCastro et al., 2019). Therefore, the effectiveness of marine renewable energy cooperation depends on whether it strengthens Indonesia's domestic technological capacity. This requires the involvement of Indonesian engineers, universities, research institutions, state-owned enterprises, and local industries in project design, installation, operation, maintenance, and further innovation. The cooperation should also include clear local content requirements, mechanisms for knowledge transfer, joint research arrangements, and training programs that extend beyond operational use. Without these elements, Indonesia may benefit from access to renewable energy infrastructure but may not acquire the engineering knowledge necessary to develop marine renewable energy independently in the long term.

The collaboration also emphasizes environmental monitoring, conservation endeavors, and specific initiatives. Both nations acknowledge the significance of conserving marine ecosystems and biodiversity. Through this endeavor, collaborative research and monitoring programs shall be instituted to monitor alterations in aquatic ecosystems and evaluate the impacts of human activities (Di Franco et al., 2020). For example, the collaboration involves the deployment of sensor-equipped autonomous monitoring vessels that collect real-time data on ocean temperature, acidity, and pollutant levels. The collected data can provide valuable insights into the impacts of climate change on marine ecosystems, thereby offering guidance for conservation initiatives. One notable aspect of this collaboration is the enhancement of capabilities and the transfer of knowledge. Given its technological prowess, China is well-positioned to assist Indonesia in developing its marine technology capabilities. Using training programs, technology transfer initiatives, and knowledge sharing, Indonesian scientists and researchers will be better equipped to participate more actively in marine research and technology development (Song et al., 2021). This provision of the accord not only confers advantages upon the two participating nations but also fosters the expansion of knowledge and development of capabilities on a global scale. It inspires scientific community collaboration and advocates for the sustainable and responsible utilization of marine resources (Kumar et al., 2021).

The bilateral agreement delineates a series of projects that serve as tangible manifestations of both countries' dedication to the progression of scientific understanding, the advocacy for ecological sustainability, and the exploitation of the marine environment's potential for societal advantage (Ansori et al., 2019). As these initiatives advance, they possess the potential to revolutionize marine science, aquaculture, renewable energy, and environmental preservation, thereby serving as a paradigm for global collaboration in science and technology (Meinig et al., 2019). The Indonesia-China Marine Technology Initiative exemplifies the potential for scientific and technological progress through global cooperation.

An essential element of this collaboration involves fostering the exchange of knowledge and the transmission of technology between research institutions and companies based in Indonesia and China. The exchange of knowledge and resources is crucial for achieving the initiative's maximum potential (Dheani, 2020). The agreement facilitates the establishment of cooperative research initiatives that unite specialists, engineers, and scientists from both nations. By collaborating on research endeavors, Chinese and Indonesian institutions combine their expertise, infrastructure, and resources to address intricate challenges in marine technology (Subroto et al., 2020). This collaborative strategy expedites the development of novel solutions. For instance, Indonesian counterparts and Chinese research institutions renowned for their innovations in marine technology work together to design and develop state-of-the-art underwater vehicles. By participating in this knowledge exchange process, Indonesian researchers can acquire insights into recent technological developments while contributing their local expertise (G. Liu et al., 2021).

Indonesian institutions benefit from exposure to technological progress in China, particularly in renewable energy infrastructure and AUVs. On the contrary, Chinese institutions learn about Indonesia's distinctive marine ecosystems and obstacles, enhancing their understanding and potential (Mathrani & Edwards, 2020). Technology transfer mechanisms facilitating the exchange of tangible assets, including software and hardware, are incorporated into the agreement. Chinese corporations with specialized knowledge in marine technology share their expertise with Indonesian counterparts, enabling the latter to produce, manage, and maintain cutting-edge marine equipment. For example, China could support the dissemination of AUV manufacturing technology to Indonesian enterprises, thereby promoting the domestic fabrication of such vehicles. This initiative enhances Indonesia's technological prowess and fosters economic expansion by cultivating a domestic marine technology sector (K. Zhang et al., 2022).

Educational exchanges are promoted to cultivate future marine technology professionals. Chinese academic institutions provide opportunities for Indonesian scholars and researchers to pursue their studies and conduct research, reciprocating for Chinese researchers in Indonesia (Gupron et al., 2021). In addition to establishing a reservoir of proficient practitioners, this practice guarantees the perpetuation of technology transfer and knowledge sharing beyond the original agreement (Azzopardi, 2020). Educational exchanges should therefore be evaluated based on measurable outcomes, such as whether Indonesian researchers obtain access to laboratories, technical documentation, joint publications, prototype development, and long-term research collaboration. Without such outcomes, educational exchanges may remain symbolic and may not significantly reduce Indonesia's technological dependence.

The agreement expedites the progression of marine technology by capitalizing on the respective advantages of both nations; as a result, research institutions, corporations, and the scientific community stand to gain. Knowledge transfer, research collaborations, and technology transfer mechanisms are integral elements that drive innovation in marine technology and promote the sustainable development of marine resources locally and globally (Song et al., 2021).

Challenges and Obstacles

Collaborative research initiatives, such as the Indonesia-China Marine Technology Initiative, play an indispensable role in advancing science and technology. However, intellectual property concerns frequently arise when multiple parties collaborate on innovative projects (Ding et al., 2020). Such agreements incorporate protective measures and systems to safeguard intellectual property from collaborative research, promoting confidence and ensuring an equitable allocation of advantages. This analysis examines the precise mechanisms and safeguards mandated in the Indonesia-China agreement (Maddusila, 2022). A fundamental element of the agreement is establishing unambiguous proprietorship and intellectual property rights. The agreement stipulates that all intellectual property produced as a result of the collaborative research shall be possessed jointly by the participating institutions or companies from Indonesia and China. This guarantees that each participant is vested in the research's results. For instance, if the collaboration yields jointly developed a marine technology innovation, such as an AUV, the agreement will explicitly delineate shared the rights and ownership. This prevents prospective conflicts and establishes an environment conducive to fair cooperation (Liu, 2022).

The agreement includes clauses prohibiting disclosure and ensuring non-disclosure to safeguard confidential intellectual property. These provisions require all participants in the collaborative research to maintain the confidentiality of any personal information or trade secrets. Strict confidentiality agreements bind institutions and researchers from both nations, prohibiting the illicit distribution or sharing of proprietary information. This protects valuable intellectual property and fosters a collaborative environment where both parties can operate with trust (Gao & Wang, 2022). A framework for licensing and commercializing intellectual property produced through collaborative research is incorporated into the agreement. The agreement grants Indonesian and Chinese entities the authority to license or commercialize any intellectual property generated throughout the project (F. Ali & Haapasalo, 2023). For instance, if the collaboration yields a novel marine technology innovation, Chinese and Indonesian entities may investigate the possibility of licensing the technology to external entities or commercializing it for the benefit of both countries. This guarantees that the intellectual property is economically viable and practically usable (Chen, 2022).

Disputes about intellectual property are delineated in the agreement through distinct mechanisms for resolution. These mechanisms are designed to promote equitable and transparent conflict resolution. The deal specifies alternative dispute resolution methods, including arbitration, mediation, and others. The primary objective of these mechanisms is to prevent protracted and expensive legal disputes and foster mutually beneficial resolutions that safeguard the interests of all involved parties (Diakonova & Pechegina, 2022).

To mitigate concerns about the transfer of knowledge and the development of capabilities, the agreement incorporates stipulations concerning the transmission of technologies and training. Participants from China and Indonesia can access training programs designed to facilitate knowledge and technology transfer. For example, if the collaboration results in the development of a novel marine technology, joint educational

initiatives might be formed to instruct technicians and researchers from both nations on the technology's proper functioning, maintenance, and progression. This ensures that the intellectual property is utilized to the mutual advantage of both parties.

In promoting fairness in allocating advantages, the agreement might incorporate benefit-sharing mechanisms of intellectual property. These mechanisms delineate how any royalties or revenues derived from the commercialization of intellectual property shall be distributed among the participating institutions or businesses. For instance, if a marine technology that was developed collaboratively achieves commercial success, the agreement might assign a specific proportion of the revenue generated to each participant in the partnership. This promotes the equitable allocation of economic advantages (Ahmad et al., 2023).

The agreement may mandate periodic intellectual property audits to uphold principles of transparency and accountability. The custody, utilization, and safeguarding of intellectual property resulting from collaborative research are evaluated using these audits. Audits are a protective measure to detect and prevent unauthorized utilization or theft of intellectual property. They help enforce the agreement's stipulations and guarantee that collaborative research yields advantages for all involved parties (Deng et al., 2021).

The Indonesia-China Marine Technology Initiative demonstrates a severe commitment to intellectual property issues by incorporating extensive safeguards and mechanisms to manage them effectively. These measures aim to safeguard intellectual property, guarantee equitable ownership and rights, streamline the licensing and commercialization processes, and establish dispute resolution mechanisms (I. Ali & Sulistiyono, 2020). The agreement cultivates a cooperative atmosphere in which Indonesia and China can advance marine technology while protecting their interests and advocating for the ethical use of intellectual property.

Furthermore, the collaboration is for the mutual benefit of both nations and the international community (Soedarman et al., 2020). The Indonesia and China Marine Technology Initiative is a significant step forward in international collaboration for marine research and technology. This initiative seeks to enhance scientific knowledge and address the complexity of joint resource management in shared maritime areas while respecting each nation's sovereign rights. Thus, this research investigates how the agreement addresses the management of shared resources and incorporates environmental sustainability measures to guarantee responsible exploration and use of resources (Ifatari et al., 2020).

The agreement seeks to balance sovereign rights and shared interests concerning joint resource management. At the outset, the agreement makes it clear that it acknowledges the sovereignty of both China and Indonesia over the marine regions under their respective countries' control (Fangkun & Xiaoyan, 2020). It emphasizes the need to adhere to international law, particularly the United Nations Convention on the Law of the Sea (UNCLOS) when delineating maritime boundaries. Each nation is dedicated to settling disagreements by the principles of the UN Convention on the Law of the Sea (Tamada, 2020). This agreement aims to provide procedures for joint resource management in regions where

maritime boundaries cross or where resources are shared. To prevent illegal fishing, environmental damage, and other unlawful activities, these techniques include coordinated patrols, data sharing, and cooperative surveillance (Humphries et al., 2020). The agreement outlines principles for the distribution of resources and cooperation. By this provision, Indonesia and China are granted equal rights to access and use maritime resources shared between the two countries, including fish stocks and mineral resources. It is necessary to establish resource management committees, which are made up of representatives from both nations, to monitor the equitable allocation of these resources and ensure that they are used sustainably (Lestari et al., 2022).

Methods for conflict resolution are included in the agreement to resolve potential issues concerning resource management. Regarding resolving disagreements, both nations have agreed to engage in peaceful negotiation, mediation, or arbitration. This ensures that any problems regarding the exploitation of resources are settled in an amicable manner and in accordance with international law. Environmental sustainability measures are being implemented to ensure responsible exploration and utilization (Sabri et al., 2022). By mandating the completion of exhaustive Environmental Impact Assessments (EIAs) for all projects using marine technology and resource extraction, the agreement places significant importance on the responsibility to preserve the environment. The purpose of these evaluations, which are carried out jointly by specialists from Indonesia and China, is to examine the potential environmental repercussions that could be caused by the proposed activities (S. Lee et al., 2022). The impact on marine ecosystems, water quality, and local communities is all considered in these EIAs.

It is essential for determining potential dangers and for directing decision-making to reduce negative impacts. Sustainability norms are incorporated into the agreement to ensure responsible exploration and exploitation of resources. These standards include specific guidelines for environmentally responsible fishing practices, the protection of sensitive marine habitats, and the prevention of pollution. In addition to following these guidelines, China and Indonesia have committed to incorporating them into their respective resource management procedures (Han, 2021). Joint research and monitoring projects provide additional support for environmental sustainability. The purpose of collaborative research projects is to evaluate the health of marine ecosystems, monitor the effects of human activities, and track changes in biodiversity. Both nations can arrive at well-informed judgments emphasizing conservation and sustainability through exchanging information and research results (Abad-Segura et al., 2021).

Furthermore, this agreement establishes conservation areas and marine protected zones in exceptionally environmentally fragile locations. These areas have been designated to protect vital habitats and species that are particularly threatened (Cashion et al., 2020). The extraction of resources and the conduct of commercial activities in these zones are subject to restrictions to reduce the disturbance caused to these delicate ecosystems. Indonesia and China have agreed to facilitate technology transfer for sustainable resource management. This development is driven by their commitment to environmental sustainability. The sharing of technologies such as advanced fisheries management systems, pollution control measures,

and renewable energy solutions enhances each party's capacity to support responsible exploration and use of marine resources (Hariyanti, 2021).

The Indonesia and China Marine Technology Initiative exemplifies a well-rounded strategy for managing shared resources and preserving the environment. In addition to respecting each nation's sovereign rights, the agreement sets transparent processes for distributing shared resources and resolving conflicts (Rogers et al., 2021). Through the implementation of stringent EIAs, sustainability protocols, research, monitoring, and conservation initiatives, it places a significant emphasis on environmental sustainability. Indonesia and China are advancing marine research and technology by incorporating these measures into their collaboration and establishing a model for the responsible and sustainable usage of resources in maritime areas shared by both countries (Adedoyin et al., 2020).

Thus, the discussion applies the three analytical frameworks introduced earlier. From a science diplomacy perspective, the implementation of the Indonesia-China Marine Technology Initiative should be assessed based on whether it strengthens trust, transparency, and constructive maritime engagement. From a technology transfer perspective, the initiative should be evaluated by whether it improves Indonesia's absorptive capacity and reduces technological dependence. From a maritime governance perspective, the initiative should be assessed through institutional coordination, environmental safeguards, data governance, resource management, and respect for sovereignty.

Implementation and Future Directions

Effective joint coordination processes and financial structures are needed for the Indonesia and China Marine Technology Initiative. This is necessary to guarantee the successful execution of projects that include collaboration between the two countries. These methods and structures make decision-making easier, supervise resource distribution, and monitor project implementation (Angelov, 2021). To strengthen the practical dimension of these findings, the governance and funding instruments described in the agreement can be read alongside the initiative's project themes already identified in this manuscript, namely the development of AUVs, integrated aquaculture systems, offshore wind and wave energy infrastructure, and sensor-based environmental monitoring platforms. These project clusters provide concrete "implementation lenses" through which joint coordination mechanisms, budgeting decisions, and technology roadmaps can be assessed (Łągiewska, 2024).

The initiative provides for joint coordination committees to support planning, project selection, and oversight of implementation. However, their effectiveness depends on whether Indonesia and China have balanced decision-making authority within these committees (Zhu et al., 2021). For example, within an AUV-oriented workstream, a joint committee would not only select research priorities but also standardize technical specifications (e.g., sensors, imaging payloads, data protocols) and allocate responsibilities for design, testing, deployment, and maintenance. Similarly, in environmental monitoring projects using autonomous vessels, joint committees would be expected to coordinate data-sharing rules,

calibration standards, and deployment schedules to ensure interoperability and scientific validity. For instance, a coordination committee might be assigned to select specific research projects in the marine technology field to ensure they align with the aims both countries share. However, the effectiveness of these committees depends on whether decision-making authority is balanced between Indonesia and China. Given China's stronger technological and financial capacity, there is a risk that project priorities may be shaped more by Chinese institutional and industrial interests than by Indonesia's long-term maritime capacity needs. Therefore, joint committees should not only coordinate projects but also ensure equal participation, transparent agenda-setting, and Indonesian involvement in technical decision-making.

The initiative also requires funding arrangements to support collaborative research and technology development. Funding arrangements should be critically assessed because financial contributions may influence bargaining power. If China provides a larger share of financing, equipment, or technical infrastructure, Indonesia may have a weaker influence over project design, procurement choices, and technology standards. This could create financial and technological dependency. Therefore, funding mechanisms should include transparency, shared budget control, local procurement opportunities, and safeguards to ensure that Indonesia is not merely a project location or technology market (Hall & Bonanomi, 2021). Essential aspects of the agreement include the creation of efficient technology roadmaps as well as strategies for collaborative Research and Development (R&D). They provide a strategic framework for determining priorities and directing research and development efforts toward common goals (D. Lee et al., 2020). However, if China provides a larger share of financing, equipment, or technical infrastructure, Indonesia may have weaker influence over project design, procurement, and technology standards.

Technology roadmaps are important for identifying research priorities and long-term technological targets (Winkowski, 2020). However, roadmaps should not only list future projects or technological targets. Roadmaps should include measurable indicators of technology transfer, such as Indonesian participation in research design, access to technical documentation, local maintenance capacity, software and data-processing access, joint ownership of research outputs, and the ability to adapt technology to Indonesian maritime conditions. Without such indicators, technology roadmaps may remain planning documents without guaranteeing substantive capacity building. Within marine technology, collaborative R&D plans may clarify project scope, objectives, budget, and institutional responsibilities. The key issue is whether Indonesian institutions participate as equal research partners or merely as project implementers.

Additionally, they outline the duties and responsibilities of every entity participating in the process. An example would be a collaborative research and development plan to build an underwater data transmission system. This plan would contain the research objectives, technical requirements, budget allocation, and the duties of both the Chinese and Indonesian research teams. Strategies like these ensure that research and development efforts are well coordinated and effective (Mason et al., 2020). The same logic can be extended to the integrated aquaculture initiatives described earlier: R&D plans can operationalize

sustainability objectives by defining performance indicators (e.g., nutrient cycling efficiency, environmental footprint, production stability), assigning responsibilities for field trials, and establishing procedures for environmental compliance (Shevchuk et al., 2025).

The agreement incorporates disagreement-resolution methods and monitoring frameworks to assess progress and evaluate outcomes, ensuring the integrity of the joint effort and to address potential disagreements that may arise later. If problems emerge during project implementation, the agreement establishes defined processes for resolving disputes. The resolution of disputes is often facilitated by using these mechanisms, which typically comprise procedures such as negotiation, mediation, or arbitration. These procedures guarantees that differences or conflicts are resolved quickly and amicably, avoiding disruptions to collaboration and ensuring Indonesia and China maintain a spirit of cooperation in their relationship (Sabri et al., 2022).

A collaborative project's progress and results can be evaluated with the help of monitoring frameworks built for this purpose. Regular reporting, data sharing, and performance reviews are all components of these frameworks, designed to monitor the progress. For instance, a monitoring framework for a project that focuses on the conservation of marine biodiversity would require both countries to produce periodic progress reports on species population trends, efforts to safeguard habitats, and the impact of conservation measures (Gunawan & Arumbinang, 2021). When it comes to the implementation of projects, these frameworks encourage transparency and accountability (Granikov et al., 2022). In addition, monitoring instruments may be linked to the agreement's sustainability commitments by ensuring that EIAs are completed, mitigation steps are documented, and compliance with conservation areas or protected zones is auditable, particularly in areas where resource use and ecological sensitivity intersect (Arumbinang et al., 2021).

Overall, the Indonesia and China Marine Technology Initiative uses a comprehensive collection of mechanisms for joint coordination, funding structures, technology roadmaps, collaborative research and development plans, processes for conflict resolution, and monitoring frameworks (Sari et al., 2024). These methods and structures play a crucial part in assuring the project's successful implementation, guiding the study's priorities, resolving conflicts, and evaluating progress in the partnership (Tritto, 2021). Both nations can successfully manage the complexities of international marine technology collaboration by developing clear protocols and frameworks. This allows them to accomplish their shared goals of advancing science and technology while simultaneously navigating the complexities of cooperation (Österblom et al., 2020).

Comparative Analysis of Similar Bilateral Agreements

The Indonesia-China Marine Technology Initiative can be better understood when compared with other bilateral arrangements in marine science and technology cooperation, such as the Japan-South Korea marine technology cooperation, the United States-Canada ocean technology collaboration, the Russia-Norway Arctic research and technology arrangement, and the Australia-New Zealand oceanographic research cooperation (see Table

1). These comparisons show that the Indonesia-China initiative has several distinctive features, particularly in relation to its broad technological scope, sustainability commitments, governance mechanisms, and capacity-building orientation. However, there are several challenges, especially concerning technological asymmetry, institutional capacity, and the need for more balanced benefit-sharing (Tritto, 2021).

Table 1. Comparative Framework of Bilateral Marine Technology Agreements (Authors, 2026)

Aspects	Indonesia-China	Japan-South Korea	US-Canada	Russia-Norway	Australia-New Zealand
Technology capacity	Asymmetrical	More balanced	Balanced or high capacity	Strategic-sensitive	Relatively balanced
Governance	Developing framework	Institutionalized	Strong institutional framework	Resource-sensitive	Trust-based cooperation
Technology transfer	Risk of dependency	More reciprocal	Advanced cooperation	Limited by security concerns	Research-oriented
Maritime sensitivity	High	Moderate	Low-moderate	High	Low
Main concern	Dependency, data, sovereignty	Reciprocity	Coordination	Arctic geopolitics	Environmental governance

Compared with the marine technology cooperation between Japan and South Korea, the Indonesia-China initiative places stronger emphasis on environmental sustainability and development-oriented technology cooperation. The inclusion of sustainability protocols, environmental impact assessments, and resource management mechanisms demonstrates that the initiative is concerned not only with technological advancement but also with responsible exploration and environmental protection. Nevertheless, the Japan-South Korea context involves two countries with relatively advanced technological capacity, making cooperation more reciprocal. By contrast, the Indonesia-China initiative operates within a more asymmetrical relationship, as China possesses stronger technological and industrial capabilities, while Indonesia seeks to strengthen its maritime technological base. Therefore, the sustainability and capacity-building commitments in the Indonesia-China initiative need to be assessed not only by their formal existence, but also by whether they generate concrete technological learning and institutional strengthening for Indonesia (Aung et al., 2020).

The comparison with the United States-Canada ocean technology collaboration also highlights important differences. The United States and Canada generally cooperate within a highly institutionalized and legally structured framework, supported by strong research institutions and relatively balanced technological capacity. In contrast, the Indonesia-China initiative gives greater attention to collaborative resource management, technology roadmaps, and dispute resolution mechanisms in a context where institutional and technological capacities are less balanced (Anwar, 2020). This makes the governance dimension particularly important. While the initiative provides mechanisms for joint coordination and resource allocation, its effectiveness depends on whether Indonesia and China have equal influence in determining project priorities, managing data, and distributing benefits. Without transparent decision-making and measurable indicators of technology

transfer, such mechanisms may become procedural rather than genuinely collaborative (Putera et al., 2022).

The Russia-Norway Arctic research and technology arrangement offers another useful point of comparison. Arctic cooperation is strongly shaped by resource sensitivity, environmental vulnerability, and geopolitical concerns. Similarly, the Indonesia-China initiative also involves sensitive maritime issues, although in a different regional context. The Indonesia-China initiative covers a broader range of marine technology fields, including autonomous underwater vehicles, integrated aquaculture, marine renewable energy, and sensor-based environmental monitoring. This wider scope gives the initiative significant potential to support Indonesia's maritime development (K. Zhang & Shen, 2023). However, some technologies, especially underwater vehicles and seabed-mapping instruments, may also generate sensitive maritime data. Therefore, the Indonesia-China initiative requires clear safeguards on data ownership, data access, and data use, particularly because cooperation takes place in a region affected by maritime sovereignty concerns and South China Sea sensitivities.

The Australia-New Zealand oceanographic research cooperation differs from the Indonesia-China initiative because it is generally based on high levels of trust, geographic proximity, and relatively compatible institutional systems. Cooperation between Australia and New Zealand is often focused on scientific research, oceanographic data sharing, and environmental management. By comparison, the Indonesia-China initiative combines scientific cooperation with broader development, investment, and strategic considerations. This makes the Indonesian case more complex. While the initiative includes mechanisms for resource allocation, funding structures, working groups, and technology transfer, these mechanisms need to be evaluated in terms of their practical implications. In particular, the initiative should ensure that Indonesia is not merely a recipient of technology or a project location, but an active participant in research design, technology adaptation, data governance, and long-term innovation (Wiloso et al., 2022).

Overall, the comparative analysis shows that the Indonesia-China Marine Technology Initiative is distinctive because of its comprehensive scope and its attempt to combine marine technology development, sustainability, resource governance, and capacity building within a single bilateral framework. However, compared with other bilateral agreements involving more technologically balanced partners, the Indonesia-China initiative faces a greater challenge in ensuring reciprocity and equitable benefit-sharing (Brigham & Gamble, 2022). Its success should therefore not be measured only by the number of projects, committees, or cooperation mechanisms established, but by whether the initiative strengthens Indonesia's absorptive capacity, protects maritime data and sovereignty, supports environmental sustainability, and reduces long-term technological dependence (Sandy & Inayati, 2022).

These comparative features are particularly visible when the initiative is assessed through its concrete project clusters, such as autonomous underwater vehicle development, integrated aquaculture, offshore renewable energy, and sensor-based environmental monitoring. In these areas, governance, sustainability commitments, and capacity-building

objectives can be evaluated through observable outputs and operational practices. Therefore, the Indonesia-China initiative should be treated not merely as a broad statement of bilateral cooperation, but as a governance arrangement whose effectiveness depends on implementation quality, institutional balance, and the extent to which Indonesia gains substantive technological and strategic benefits (Hariadi et al., 2022).

Conclusions

The Indonesia-China marine technology effort has produced many notable discoveries and potential benefits for scientific cooperation. Joint development activities have implemented innovative aquaculture systems, subsurface propulsion systems, and maritime energy infrastructure. Indonesian nautical competence and Chinese technology prowess blended well in these projects. The agreement has enabled a vibrant exchange of information and technologies, benefiting research institutions and enterprises in both nations. Recent collaborative training and exchange programs have greatly improved the scientific capacities of technicians and researchers on both sides by teaching new skills. Despite these advancements, intellectual property administration still needs improvement. However, the agreement includes extensive protections for both parties' ideas, creating a trusting, collaborative environment. Joint resource management, another complicated agreement area, requires delicate navigation to reconcile sovereign rights and common goals. The initiative's strict exploration and resource use standards show its environmental sustainability. In planning, the effort has effective coordination procedures, collaborative committees, and clear funding channels. Proactive technological roadmaps and research and development plans guide future scientific research endeavors. The project also has resilient conflict resolution processes and a comprehensive activity management system to track progress and overcome unexpected challenges.

Furthermore, the Indonesia-China effort is unique in its scope, depth of cooperation, and fair division of benefits and responsibilities. This milestone in worldwide marine technology partnerships shows how strategic collaboration can promote sustainable marine resource management and scientific growth. At the ASEAN level, the initiative may provide a useful reference for strengthening regional cooperation in marine science, technology transfer, capacity building, environmental monitoring, and sustainable maritime resource governance. At the same time, its implementation highlights the need for ASEAN member states to promote transparent technology partnerships, equitable benefit-sharing, protection of maritime data, and respect for national sovereignty. Indonesia can therefore use the experience gained from this bilateral initiative to support wider ASEAN mechanisms for science diplomacy, joint marine research, and sustainable maritime governance, while ensuring that cooperation with external partners remains consistent with ASEAN interests and regional stability.

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