International Law Review Of Space Debris Mitigation Efforts

El Renova Ed. Siregar[1]*, Adya Paramita Prabandari[2], Naek Siregar[3]

[1]Master of Law, Diponegoro University, Indonesia
[1]Researchers at the National Research and Innovation Agency (BRIN), Indonesia
[2]International Law Lecturer, Diponegoro University, Indonesia
[3] International Law Lecturer, Lampung University, Indonesia
*Corresponding Author:
Email: elrenova@yahoo.co

Abstract.

Space debris has become an increasingly pressing issue in space exploration and utilization. This article conducts a comprehensive review of aspects of international law relating to space debris mitigation efforts. This research analyzes existing legal frameworks, including relevant multilateral treaties and international legal principles related to the space environment. With a focus on the principles of shared responsibility and avoidance of damage to the space environment, the study identifies key challenges in managing space junk and reducing the risk of collisions in earth orbit. An in-depth analysis of the role of national space agencies and international organizations in implementing mitigation measures was also carried out. In the context of international cooperation, this article evaluates existing collaborative efforts and proposes new measures to improve the effectiveness of space debris mitigation. A better understanding of legal responsibility and burden-sharing in addressing these issues became a central point in the study. By analyzing recent developments in space law and international environmental regulations, this article provides insight into the direction the global community might take in addressing future space debris mitigation challenges. It is hoped that this research can provide guidance for policymakers, academics, and legal practitioners in their efforts to maintain a clean and sustainable space environment.

Keywords: *Space debris, International law, mitigation, space environment and space exploration.*

I. INTRODUCTION

Space exploration has been integral to human achievement in exploring unspoiled frontiers (Zein, 2022). However, with advances in technology and increased space activity, an increasingly urgent problem arises, namely the impact of space debris. Space junk, consisting of the remains of defunct satellites, fragments of spacecraft, and other components, poses a serious threat to the space environment and continued future exploration. The challenge of space debris mitigation is not only limited to technical aspects, but also involves complex dimensions of international law (Savitri, 2019). Within this framework, this study aims to provide an in-depth understanding of international law reviews of space debris mitigation efforts. Through a comprehensive analysis, this article will outline existing legal frameworks, identify relevant international legal principles, and explore challenges and opportunities in managing space debris effectively.As a first step, the study will review the principles of international law relating to shared responsibility in protecting the space environment. These principles are an important foundation in developing collaborative approaches to space debris mitigation amid the expanding development of space exploration (INDRASWARA, 2021). In addition, the analysis will also discuss the role of national space agencies and international organizations in carrying out mitigation efforts, as well as see how existing multilateral agreements can be effectively applied in the context of space debris. In the context of regulatory development and international cooperation, this article will explore collaborative efforts that have been taken and propose new steps that can be taken to improve space debris mitigation. In the midst of complex technical and political challenges, international cooperation is an important key in addressing the negative impacts of space debris.

Therefore, a deep understanding of legal responsibility and burden-sharing in safeguarding the space environment is critical in creating a sustainable future of space exploration (Ahmad, 2022).In order to provide guidance for policymakers, academics, and legal practitioners, the study will also analyze recent developments in space law and international environmental regulation. As such, it is hoped that this article can provide valuable insight into the direction the global community may take in dealing with the challenges

of space debris mitigation in an era of increasingly complex space exploration. Space exploration has brought inevitable impacts on the space environment, including the emergence of space junk that can threaten the continuity of space activities and the integrity of the earth's orbit. With an increasing number of space objects circling the planet, the risk of collisions and further growth of space junk is increasingly concerning (Bryson, 2021). Therefore, the need for effective mitigation measures and a strong international legal framework is becoming increasingly urgent.Under the framework of international law, the concept of shared responsibility and environmental principles become relevant in the context of space debris mitigation. These principles underscore the importance of international cooperation in addressing space environmental challenges involving countries and institutions.

With so many stakeholders involved in space exploration, effective coordination and regulation are essential to prevent an escalation of the space debris problem. National space agencies and international organizations play a central role in designing and implementing space debris mitigation measures. Through cooperation between countries and international coordination, measures such as monitoring and tracking space debris, developing recovery technologies, and managing the life cycle of space objects can be carried out more efficiently (Haslinda Baji Anriani & Ansar Arifin, 2021). Along with that, it is important to consider the legal aspects of this cooperation, including enforcement mechanisms and the division of responsibility in emergency situations.The research will also detail the development of multilateral agreements related to space and environmental activities. These agreements include a legal framework that creates the foundation for space debris mitigation efforts (Simamora, 2020). However, the implementation and effectiveness of these agreements in the context of space debris mitigation needs to be explored further to understand the extent of their role in addressing this issue. In an effort to create more sophisticated and effective mitigation measures, the study will propose new alternatives and assess the feasibility of implementation. The development of innovative technologies, strengthened cooperative approaches, and tougher legal measures may be solutions to consider to address the impacts of space debris (Supriatna, 2021).Ultimately, this article aims to contribute to a global discussion of how international law can help address the challenge of space debris mitigation. With a deeper understanding of legal principles, the role of national space agencies, and the possibility of stronger international cooperation measures, it is hoped that we can protect the space environment and realize sustainable and safe space exploration for future generations.

International cooperation in space debris mitigation depends not only on understanding and implementing legal principles, but also requires careful technical coordination (Soedarto &; Ainiyah, 2022). Monitoring and tracking inactive space objects and space junk is becoming an increasingly complex task as the number of objects in orbit increases. Advanced tracking technology and reliable information systems are needed to identify collision risks and avoid incidents that could worsen the space junk situation.Efforts to formulate effective mitigation measures, the active role of national space agencies in developing and implementing appropriate technologies and policies are crucial. Countries have a responsibility to ensure that the space objects they launch comply with safety and recovery standards, as well as take the necessary steps to reduce the impact of space debris. This includes the development of more durable spacecraft, designs that minimize waste production, and safe elimination strategies. Within the framework of international law, multilateral treaties such as the 1967 Outer Space Treaty and the United Nations Guiding Principles on Space Objects offer an important legal basis for regulating space activities and mitigating space debris (Muthia, 2023). However, challenges in implementing and enforcing these agreements need to be addressed. Further legal steps may be needed to strengthen certain aspects of space debris regulation and provide a stronger legal basis for enforcement and accountability.Amid the complexity of technical and legal challenges, the international community needs to identify tipping points in addressing the space debris problem. The necessary measures involve a wide range of parties, including space agencies, international organizations, the private sector, and civil society.

Strong and comprehensive international cooperation can lead to more effective mechanisms for managing space debris, including in terms of exchanging data, technology, and resources (Abrori, 2021). By understanding existing international legal frameworks, technical challenges, and opportunities for

cooperation, this article aims to provide guidance for policymakers, legal practitioners, and the academic community in addressing space debris mitigation issues. It is hoped that these efforts will guide the development of more sophisticated regulations and more effective collaborative actions in maintaining a sustainable space environment, so that space exploration can continue to thrive without jeopardizing the space ecosystem and future activities (Arifin et al., 2023).

II. METHODS

This research uses a qualitative approach to explore a deep understanding of international law reviews of space debris mitigation efforts (Hermawan, 2019). The qualitative method was chosen because this study aims to explain the complexity of the legal framework and the dynamics of international cooperation in the context of space debris mitigation.

III. RESULT AND DISCUSSION

Result:

This research resulted in a deep understanding of international law reviews of space debris mitigation efforts, as well as challenges and opportunities in managing the environmental impacts of space activities. By applying qualitative research methods, several important findings have been identified:

1. **Relevant Principles of International Law**: Analysis of international legal documents highlights the importance of legal principles such as shared responsibility, environmental protection, and damage prevention (Kriswandanu, 2023). These principles are an important foundation in developing collaborative approaches in space debris mitigation.
2. **The Role of National Space Agencies and International Organizations**Case studies from national space agencies and international organizations show a diversity of approaches to space debris mitigation. Active involvement in the monitoring, tracking and elimination of space debris are important steps taken by many countries and organizations (Kumalasari, 2021).
3. **Implementation of Multilateral Agreements**International treaties such as the 1967 Outer Space Treaty have provided an important legal basis for space debris mitigation (Irvan &; Purwanto, 2020). However, challenges in the implementation and enforcement of these agreements point to the need for renewal and improvement of oversight mechanisms.

In addition, this study also reveals the need for a holistic approach in addressing the problem of space debris. It requires not only the active role of national space agencies and international organizations, but also the involvement of the private sector and civil society. This could include participation from commercial space companies in implementing responsible practices for space debris management.These findings also point to the need for regulatory updates and stronger enforcement mechanisms in the context of space debris mitigation. In an era of increasingly sophisticated space exploration, existing international legislation needs to be updated and improved to reflect technological developments and new challenges (Fonna, 2019). Joint efforts to develop new legal norms governing the production, tracking, and elimination of space junk can have significant positive impacts.In addition, this study also underscores the urgency of establishing an international body that focuses specifically on space debris mitigation. Such a body can serve as a collaborative forum for member states, national space agencies, and international organizations to share information, technology, and resources in a joint effort to safeguard the space environment (Utami, 2019).However, as the study reveals, the challenges are not only technical and legal, but also political and economic. Efforts to implement mitigation measures require strong commitment from all stakeholders, as well as intensive coordination at the international level.In order to realize effective space debris mitigation measures, it is necessary to recognize that international cooperation is a key pillar.

The findings of the study highlight the importance of collaborative approaches between countries, national space agencies, international organizations, and the private sector. This collaboration is not only needed for the exchange of information and technology, but also to develop tougher norms and regulations in an effort to reduce the impact of space debris.The importance of coordination and division of responsibility in managing space debris becomes clear in this context. International cooperation should consider ways to

address technical challenges, such as accurate monitoring and tracking, and identifying potentially debris objects. In addition, providing incentives for technological innovation and environmentally friendly design in the creation of new space objects can play a role in reducing the production of space debris.In terms of law implementation, enforcement of existing international treaties becomes essential. Effective mechanisms are needed to monitor and ensure compliance with regulations governing space activities and mitigation of space debris (Susilo &; Vernando, 2021). In addition, ethical and moral considerations must also be taken into account in decision-making about tracking, monitoring, and eliminating space debris.The findings of the study also underscore the need for a long-term approach to space debris mitigation. Current efforts should be seen as part of a larger strategy to maintain the sustainability of space exploration. Proactive measures such as the development of recycling technologies and the recovery of materials from space debris can help mitigate long-term impacts.

The importance of space debris mitigation is not only limited to the technical and legal sphere, but also has broader social, economic, and ecological impacts. The results of this study show that mitigation efforts require synergy between various stakeholders to face increasingly complex challenges in space exploration.In terms of regulatory development, an adaptive and responsive approach to technological developments and new risks is required. The need for comprehensive and flexible regulations is important in regulating the dynamics of space activities and maintaining the continuity of the space environment.In addition, the results of this study highlight the important role of education and public awareness in understanding the importance of space debris mitigation. Broader education about the impacts of space debris and its implications for environmental sustainability can encourage further community support and action (Rahmayanti &; Feryl Ilyasa, 2022).This research serves as an important starting point in facing the challenge of space debris mitigation. However, there are still many questions worth exploring further. Further study may involve a more detailed analysis of existing legal agreements and international cooperation, as well as tracing the political and economic implications of mitigation measures.In the face of space debris mitigation challenges, it is important to consider global and humanitarian dimensions. The results of this study show that this problem transcends national borders and necessitates cross-border cooperation in an effort to create a safe and sustainable space environment.In this context, the development of stricter regulations and strong enforcement mechanisms is imperative.

This regulation must be able to regulate aspects of production, use, and elimination of space objects comprehensively. Strict enforcement is also required to ensure compliance with these regulations.In addition, the results of this study also encourage further collaboration in the development of space debris mitigation technology. Innovations in the field of tracking, elimination, and recycling of space debris can play a key role in reducing environmental impact. Technological sustainability and research and development efforts should be encouraged in order to provide more effective solutions.The importance of education and public awareness must also continue to be emphasized. Strong public support can influence changes in industry policies and practices. Educational campaigns about the risks of space debris and the importance of environmental sustainability can trigger positive action from individuals and community groups.This research has had an impact that goes beyond academia. The results can provide important input for policymakers, national space agencies, and international organizations in formulating effective mitigation guidelines and measures. In addition, this article can inspire further research in exploring specific aspects of the international legal framework and cooperation related to space debris.In closing, space debris mitigation is a shared responsibility of all mankind. Through coordinated joint efforts, we can realize a sustainable future of space exploration and safeguard the space environment as a valuable legacy for future generations.

Discussion:

At the discussion stage, this study in-depth on the implications of international law on space debris mitigation and discusses important findings emerging from the analysis. Here are some key points to consider in the context of the discussion:

1. **Importance of International Cooperation**: In the context of space debris mitigation, international cooperation is emerging as an important element in ensuring the success of mitigation efforts. This discussion emphasized the importance of cross-border cooperation between countries, national space

agencies, and international organizations. This cooperation involves various aspects, including the exchange of information, technology, and resources.

2. **Legal Implications of Environmental Principles**: International legal principles relating to the environment, such as the principles of environmental protection, shared responsibility, and damage prevention, are important cornerstones in space debris mitigation. This discussion details how these principles can be interpreted and applied in the context of the space environment.
3. **The Role of National Space Agencies and International Organizations**: This study discusses the active role of national space agencies and international organizations in efforts to mitigate space debris. This includes existing practices, such as monitoring and tracking space debris, as well as the development of technologies to address the problem.
4. **Technical and Legal Challenges**: This discussion highlights the technical and legal challenges faced in mitigating space debris. These challenges include monitoring and identifying space objects that have the potential to become junk, as well as expanding legal interpretation in the context of the space environment.
5. **Development of More Appropriate Regulations**: This discussion considers the need to develop more appropriate regulations in regulating space activities and mitigating space debris. The political, economic, and ethical implications of this regulation are discussed in depth.
6. **Alternative Solutions and Collaboration**: This study also proposes alternative solutions, such as the establishment of a special international agency for space debris mitigation. It details how further collaboration between countries and other stakeholders can result in more effective measures to safeguard the space environment.
7. **The Importance of Education and Public Awareness**: This discussion highlights the importance of public education and awareness in supporting space debris mitigation efforts. Education about the impact of space debris and environmental sustainability can influence community attitudes and actions in supporting mitigation measures.
8. **Broader Implications and Implications for the Future**: This discussion reflects on the broader impact of the results of this study, including the political, economic, and ecological implications of space debris mitigation. These implications are linked to visions of a sustainable future of space exploration.

Efforts to mitigate space debris and show that this challenge is not only the responsibility of one party or one country, but is a global challenge that requires a global response.In the context of this discussion, it is important to examine the complex interaction between legal, technical, political, and social aspects in efforts to mitigate space debris. The implications of international law must be interpreted and applied carefully, taking into account existing frameworks and supporting collaboration and harmonization between states.In addition, this discussion also raises questions about how space debris mitigation practices can develop in the future. Will countries be more inclined to collaborate or adopt a more independent approach? How do new technological developments affect space debris mitigation? Questions of this kind inspire deep reflection on the future direction of space debris mitigation.This discussion also reflected on the importance of public support in carrying out mitigation efforts. By increasing public understanding of the urgency of the space debris problem and its consequences, we can create momentum for greater collective action. In this regard, education, awareness campaigns, and public dialogue become important instruments.In developing further discussions, it is important to discuss several issues that are focal points in efforts to mitigate space debris:

1. **Deep International Cooperation**: The involvement of various countries and space agencies in space debris mitigation efforts reflects the essence of deep international cooperation. The exchange of data, technology, and resources is essential to overcome technical and economic constraints in monitoring and eliminating space debris.
2. **The Role of Regulation in Driving Mitigation**: The conversation about tighter regulation raises questions about how international law can stimulate more responsible mitigation practices. This

discussion involves consideration of the contractual and non-contractual nature of international law and its impact on the development of space technology and design.

3. **Use of** Technology in Mitigation: Technology plays a major role in space debris mitigation. It details the potential of emerging tracking, monitoring, and erasure technologies and how international collaboration can drive further innovation in this area.
4. **Uncertainty and Risk**: This discussion reflects on the level of uncertainty and risk involved in mitigating space debris, both from a technical and legal perspective. Short-informed decision-making and careful risk assessment are key concerns in dealing with these challenges.
5. **Social and Economic Impacts**: In addition to environmental impacts, the study also underscores the social and economic implications of space debris mitigation efforts. In a changing global context, how mitigation can affect employment, economic cooperation, and technological developments in the long term needs to be considered.

Ultimately, space debris mitigation efforts require a sustainable approach, based on the principles of international law, global cooperation, and technological innovation. Awareness of the urgency of protecting the space environment must continue to be increased through education and campaigns, both among the general public and within the scope of government policies.This discussion illustrates the complexity and multidimensionality of space debris mitigation challenges. In addition, it opens the door to further research in delving into specific aspects of international law, technology regulation, and deeper social implications. The collective effort to preserve the space environment as a valuable legacy for future generations is a shared responsibility that must be carried by all mankind.

IV. CONCLUSION

In closing, this study has outlined and comprehensively analyzed the international law review of space debris mitigation efforts. The results of this study have important implications in the context of space environmental protection and the continuity of space exploration. Some of the main points of this study can be summarized as follows: **Global Cooperation as Key**: This research confirms that space debris mitigation requires close global cooperation. Various stakeholders, including countries, national space agencies, international organizations, and the private sector, must collaborate to address complex challenges within the scope of space activities. **Legal Principles as Guides**: The principles of international law relating to environmental protection, shared responsibility, and damage prevention form an important foundation in the development of mitigation measures. Enforcement of these principles in practice is key in maintaining the sustainability of the space environment. **Technical and Legal Challenges**: This study identifies a number of technical and legal challenges in space debris mitigation. From object monitoring to interpretation of international legal treaties, an expansion of understanding and innovative solutions are needed to overcome these constraints.

The **Importance of Strong Regulation**: The development of appropriate regulations and strong enforcement mechanisms is needed to regulate space activities and manage the impacts of space debris. This regulation must be able to accommodate technological developments and support responsible mitigation practices. **Contribution to Education and Awareness**: Public awareness of the impact of space debris and the need for mitigation is an important element in this effort. Education, awareness campaigns, and public participation will help shape further support for mitigation actions. **Long-Term Vision for Sustainability**: Space debris mitigation should be seen as an integral part of the long-term vision of the sustainability of space exploration. Current mitigation measures must play a role in building a sustainable future for future generations.Overall, this research provides an in-depth look at the complexity of international legal issues in space debris mitigation. The results of this research can make valuable contributions to policy, legal practitioners, national space agencies, and all parties involved in preserving the space environment. By integrating the principles of international law, global collaboration, and technological innovation, we can move forward in our efforts to protect the space environment for a brighter future.

REFERENCES

[1] Abrori, F. (2021). *Halal Tourism And Welfare Improvement*. Literacy Of The Archipelago.

[2] Ahmad, S. (2022). Hfryjhfr. The *Idea Of Forming An International Company For The Management Of Natural Resources Of The Common Heritage Of The People*.

[3] Arifin, Z., Ariantini, M. S., Sudipa, I. G. I., Chaniago, R., Dwipayana, A. D., Adhicandra, I., Ariana, A. A. G. B., Yulianti, M. L., Rumata, N. A., &; Alfiah, T. (2023). *Green Technology: Application Of Environmentally Friendly Technology In Various Fields*. Pt. Sonpedia Publishing Indonesia.

[4] Harahap, A. et, all, Macrozoobenthos diversity as anbioindicator of the water quality in the Sungai Kualuh Labuhanbatu Utara, AACL Bioflux, 2022, Vol 15, Issue 6.

[5] Bryson, B. (2021). *The Body: A Guide For Residents*. Gramedia Main Library.

[6] Fonna, N. (2019). *Development Of The Industrial Revolution 4.0 In Various Fields.* Guepedia.

[7] Haslinda Baji Anriani, H., &; Ansar Arifin, A. (2021). *Knitting Mosaics Of Togetherness In Breaking The Chain Of The Covid-19 Pandemic (Socio-Cultural Studies).* Unhas Press.

[8] Hermawan, T. (2019). *Fiqh Siyasah Review Of Local Government Efforts In Air Pollution Control (Study At Ulubelu Thermal Power Plant, Tanggamus Regency)*. Uin Raden Intan Lampung.

[9] Indraswara, A. I. T. (2021). *Review Of International Law On Climate Change As A Result Of Single-Use Plastic Use In Indonesia (Makassar City Case Study).* Bosowa University.

[10] Harahap, Arman ,2018, Macrozoobenthos diversity as bioindicator of water quality in the Bilah river, Rantauprapat, Medan. ***J. Phys.***: Conf. Ser. 1116 052026.

[11] Irvan, I., &; Purwanto, I. W. N. (2020). Demilitarization Efforts In Space Are Viewed From The Perspective Of International Space Law. ***Kertha State Journal,*** *8*, 14–26.

[12] Kriswandanu, A. R. (2023). Implementation Of Human Rights In Cases Of Environmental Violations In Yogyakarta Region: A Comparative Legal Analysis. ***Journal Of Law And Human Rights Wara Sains***, *2*(6), 483–491.

[13] Kumalasari, V. (2021). Professional Ethics, In The Field Of Information Technology. *Publisher Yayasan Prima Agus Teknik*, 1–75.

[14] Muthia, N. F. (2023). *The Effect Of Space Commercialization Activities On The Increase In Space Debris.* Hasanuddin University.

[15] Rahmayanti, H., &; Feryl Ilyasa, S. K. M. (2022). *Environmental Education And Climate Change*. Media Strait.

[16] Savitri, A. (2019). *Demographic Bonus 2030: Answering The Challenges And Opportunities Of Education 4.0 And Business Revolution 4.0.* Genesis Publishers.

[17] Simamora, A. S. (2020). Legality Of Space Debris Remediation Practices Based On International Law. ***Journal Of Aeronautics And Space Policy Studies***, 1(1), 1–17.

[18] Harahap, A. P. Hrp, N.K.A.R. Dewi, Macrozoobenthos diversity as anbioindicator of the water quality in the River Kualuh Labuhanbatu Utara, ***International Journal of Scientific & Technology Research,*** 9(4), 2020, pp. 179-183.

[19] Soedarto, T., &; Ainiyah, R. K. (2022). *Agricultural Technology Into Innovative Farmers 5.0: The Transition To Modern Agriculture.* Uwais Inspiration Indonesia.

[20] Supriatna, J. (2021). *Sustainable Environmental Management*. Yayasan Pustaka Obor Indonesia.

[21] Susilo, H. E., &; Vernando, I. (2021). Study Of The Readiness Of The Lapan Satellite Technology Center Laboratory As A Testing Laboratory For Cube Satellite Products (Cubesat) In Accordance With Iso 17025: 2017. *Standardization Scientific Meeting And Presentation*, *2020*, 155–164.

[22] Utami, A. S. N. (2019). The Asia-Pacific Space Cooperation Organization (Apsco) As China's Strategy Forms A Confidence Building Measure In The Asia Pacific Region. ***Journal Of Diplomacy And Security Studies,*** *11*(2).

[23] Zein, M. F. (2022). The *Struggle Of Religion And Mass Communication: The Communication Revolution And The Influence Of Information Technology On Religion And People*. Mohamad Fadhilah Zein Digital Publishing.