POLICY & SOCIAL REVIEW

Policy & Social Review, Vol. 1 No. 2, pp. 81-89, December, 2021
ISSN 2798-3560 (Print), ISSN 2798-2297 (Online)
https://journal.inspire-kepri.org/index.php/PSR
DOI: https://doi.org/10.36256/psr.v1i2

Space Debris Governance: A Perspective of International Law

Chusnul Qotimah Nita Permata[1], Nur Barokah Uswatun Khasanah[2]

[1]Faculty of Law, Semarang State University, Semarang, Indonesia

ARTICLE INFO

Article History

Submitted: 30 June 2021
Revised: 1 November 2021
Accepted: 2 December 2021
Available online: 31 Desember 2021

Correspondence

Chusnul Qotimah Nita Permata
Email: chusnulqotimahnitapermata@gmail.com

ABSTRACT

The issue of space debris is discussed in international forums such as UNCOUPOS, ESA, and ITU as an effort to deal with space debris, as well as the formation of special international organizations such as IADC. International mechanisms that are used as guidelines for countries in carrying out space activities have resulted from this collaboration and researches carried out by international forums, both in the form of regulations and implementation standards. The purpose of this study is to analyze the efforts to handle space debris governance from an international law perspective. This research used a descriptive method. Our study suggests that the international mechanism in handling space debris is a form of liberalization, in which it must be realized that cooperation is a manifestation of the rationality of the international community that this handling is of common interest. The handling of space debris does not look at national borders and the assumption that international institutions play a more important role than countries is an incorrect assumption.

Keywords: Space Debris; Governance; International Law; International Institutions

Introduction

Space issues were not given much attention to humans, before the launch of Sputnik I by the Soviet Union. There is no human activity in space awareness of the impact on the welfare and survival of humans on this earth. So, since the launch of Sputnik I by the Soviet Union, namely on October 4, 1957, only then have the countries in the world questioned it, both from the ideological, political, economic, cultural, and legal implications. Based on the agreement of the United Nations General Assembly, the application and application of International Law and the United Nations Charter to outer space, the moon and other celestial bodies and that all things are freely explored and used by all countries in accordance with applicable international law and that outer space, the moon and other celestial bodies are not allowed to be objects of ownership of any country. The launch of celestial bodies has a positive impact on human life on this earth where the launch of these celestial bodies is a form of technological progress in utilizing space (Gupta & Rathore, 2019).

This progress can be seen from the improvement of the quality and standard of human life, the existence of various researches in various fields of science, and the search for new natural resources using various types of celestial bodies. cause various losses both on land, air space, and in space itself. Loss is a

negative impact that can be felt by mankind due to competition to manage space. Some satellites are created using radioactive materials and the use of nuclear weapons for activities in space. If the launch of the satellite fails and falls in the territory of another country, it can automatically cause losses for countries that fall on a celestial object (Popova & Schaus, 2018).

Not a few celestial bodies launched by countries in the world have failed or malfunctioned. This happens when the launch of a nuclear-powered satellite, which is generally a low-orbit satellite, because it is very easy to malfunction. The satellite itself has a life time, where when the time has ended it will endanger the celestial bodies that are still functioning, even the satellite can fall to the earth's surface. Both launching countries and countries associated with the launch or even countries not participating in the launch can also feel the negative impact. A country can be held responsible for the launch of its celestial body, if the celestial body has become space waste and falls into another country and causes losses to that country. This has been mentioned in international law, especially in the 1972 Convention on International Liability for Damage Caused by Space Objects.

The issue of space debris was included in the agenda of the 31st Session of the Scientific and Technical Subcommittee of the United Nations Committee on the Use of Space for Peaceful Purposes (The United Nations Committee on the Peaceful Uses of Outer Space). -UNCOPUOS) in February 1994, based on General Assembly Resolution 48/39 of 10 December 1993 (United Nations, 1999). Previously, the discussion on the issue of space debris was carried out separately in various international fora. At the session, the Sub-committee agreed that the discussion of space debris is important and that international cooperation is needed to minimize the potential impact of space debris on future space missions (Mardianis, 2012).
There are three ways to handle space debris from a technical point of view, including:

a. Prevention: guidelines for limiting operational debris space: e.g., bolt reduction, cover caps, ropes, pyrotechnic devices and residue.
b. Protection of satellites to limit debris impact effects and aging process. This includes specific shields and other remedies including self-healing ingredients.
c. Disposal at the end of life (EOL) is by retrieval, descent technology from orbit while it is still active, such as tether assisted, intentional detonation of parts of a spacecraft through demise technologies or disposal into graveyard orbit.

Meanwhile, in terms of regulation, there are also three reasons why space debris needs to be regulated, namely:

a. The current space debris environment poses a risk to spacecraft in earth orbit and the risk of damage to the earth if the space debris falls to earth
b. the potential for space debris to damage the spacecraft causing loss of mission or loss of life in the case of manned spacecraft
c. the need for measures to preserve the space environment for future generations

The supremacy of international space law tends to disappear gradually due to the stages of the trend towards the formation of space law which until now has been grouped into 4 stages, namely (i) First Stage (1950-1979): Binding international agreements (ii) Second stage (1980-1995): United Nations General Assembly Resolutions on Special Space Activities (iii) Third Phase (since 1995): United Nations General Assembly Resolutions that tend to interpret international treaties on outer space, (iv) Fourth Phase; Non-binding and technical provisions based on common understanding (still a question?) (Hobe & Mey, 2009).

There are several arrangements regarding space debris in the international, regional and in their respective countries. Some of these settings include

a. UN COPUOS Space Debris Mitigation Guidelines (A/62/20);
b. IADC Space Debris Mitigation Guidelines (Revision 1);
c. NASA Procedural Requirements for Limiting Orbital Debris (NPR8715.6);

d. Process for Limiting Orbital Debris (NASA-STD-8719.14);
e. European Space Debris Safety and Mitigation Standard;
f. ESA Space Debris Mitigation for Agency Projects (ESA/ADMIN/IPOL); and
g. Russian Aviation & Space Agency Standard: General Requirements, Mitigation of Space Debris Population.

The development of space activities in outer space causes various problems in parts of the world, but all existing arrangements are preventive measures for other serious problems to occur. In the discussion in recent years, the view has emerged that the Scientific and Technical Sub-committee expresses its appreciation for several countries that have implemented space debris mitigation measures that are consistent with the Space Debris Mitigation Guidelines at the United Nations Committee on the Use of Space for Peaceful Purposes (The Space Debris Mitigation Guidelines of the Committee on The Peaceful Uses of Outer Space) and/or IADC Space Debris Mitigation Guidelines (The Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines) or countries that have developed their own space debris mitigation standards based on these guidelines. Besides that, against other countries that use the IADC Guidelines and the European Code of Conduct for Space Debris Mitigation as a reference in the regulatory framework established for national space activities (Report of the Scientific and Technical Subcommittee on its forty -Fifth Session, 2008). In addition, countries are of the view that each of these guidelines can be complementary.

Methods

In preparing this paper, we conducted an initial research by collecting data first. We used descriptive-qualitative method in describing the research problem which refers to the delivery of facts related to the focus of the research. As for the data collection technique, the researcher conducted a documentation study (library research). Where the data is obtained from various written sources such as books, magazines, journals, papers, articles, newspapers and internet sites that have a correlation with the object of research. All data collected were then examined qualitatively, namely by describing the existing data based on quality. Existing data is presented with descriptive analysis, namely reviewing and describing in detail the core of the existing problems. After doing the analysis, it will produce discussion results which can then be concluded which is the solution to the problems of this research.

Results and Discussion

Definition of Debris

In the IADC guidelines, the definition of space debris is all man-made objects including parts and elements inherent in them that are in Earth's orbit or enter the atmosphere, which are no longer functioning (IADC 2002). The definition of the IADC version is also a reference in discussing the issue of space debris at the UNCOPUOS scientific and technical sub-committee session. In the United Nations space debris mitigation guidelines, it is stated that the main sources of space debris in earth orbit include:

a. The release of fragments into Earth's orbit, both intentional and unintentional, resulting in the formation of long-term space debris.
b. Space debris released intentionally during the operation of spacecraft and launch vehicles enters orbit.

The existence of space debris began with the launch of the Sputnik satellite by Russia in 1957. Since then countries have competed to master space technology and launch satellites into space. The existence of space objects can be grouped into types of orbits, namely:

a. Low Earth Orbit (LEO) is an orbit with an altitude of less than 5500 km and an orbital period of less than 225 minutes
b. Medium Earth Orbit (MEO) is an orbit with an altitude of 5,500-36,000 km, generally navigation satellites occupy this orbit, such as GLONASS (Global Navigation Satellite System) and GPS (Global Positioning System).
c. Geosynchronous Earth Orbit (GEO) at an altitude of 36,000 km, generally communication satellites and weather observers occupy this orbit.

In general, the causes of the presence of space debris are grouped into 3 causes, namely; (a) Space mission, (b) Accident, and (c) Intentional. As is well known that every space mission such as launching a satellite into orbit passes through the release stage. In the process of placing a space object/satellite there are several parts/components that accompany and detach at the time of launch, such as former tanks, rocket fuel, rocket shells and so on. The detached parts/components become space debris.

In addition to space debris caused by space missions, accidents are also one of the causes of space debris, collisions between space objects with one another as well as collisions between debris that are already in space cause new debris fragments. Collisions between space objects with one another have occurred on the Russian Cosmos satellite which crashed into the United States' Iridium satellite in 2009, based on data obtained from NASA, this collision between satellites caused at least 1000 debris measuring 10 cm. The last cause of the existence of space debris is intentional, one concrete example is the anti-satellite weapon test (ASAT) conducted by China which destroyed its own satellite. According to the results of tracking conducted by the United States, the impact of the ASAT test resulted in at least 2,087 debris fragments which were large in size and constituted the worst amount of debris.

The Impact of Space Debris

Space Security. The increasing amount of space debris in outer space certainly has an impact and threat, especially for space security. The existence of space debris threatens the security of outer space in terms of the space environment and also the sustainability of the use of outer space in the future. If the amount of space debris increases and is not handled immediately, saturation will occur and allow the space environment to no longer be used in the future. In addition, space debris also threatens the safety of astronauts in space. For example, in 2009, the International Space Station (ISS) was almost hit by fragments of space debris which, although only 0.8 cm in diameter, had a speed of 30,000 km per hour. This certainly threatens the lives of the astronauts who are in the space station.

The danger of space debris also threatens the safety and security of other space objects such as satellites that are still functioning. The risk of collision is a threat to the safety of other space objects in orbit. The large and high-speed fragments of space debris certainly have the potential to hit other space objects, this will certainly be very detrimental to parties or countries whose satellites are threatened with colliding with space debris. The losses incurred are not only in terms of the function of technology but also in terms of economy.

The ASAT test event by China is one concrete example that fragments of space debris threaten other space objects that are still functioning. The debris caused by the ASAT test threatens at least 16 satellites of other countries that are still functioning.

Earth Safety. Space debris not only impacts and threatens security in space, but also security and safety on earth. Uncontrolled re-entry of space objects is one of the factors that can threaten and endanger human life and the earth's environment. The lower the position of space debris, the faster it will fall to the earth's surface. The large trash includes satellites that are no longer functioning, such as NASA's UARS satellite, Russia's Phobos-Grunt, and parts of the satellite launch vehicle. Reentry is the recommended end-of-mission option for objects located in LEO. This reentry is directed to a safe area, so as to minimize casualties. (Weaver & Ailor, 2012). Space debris also has an impact on ozone depletion, this is caused by the payload

of space objects. Research on the re-entry of space objects to earth has been carried out and research has shown that the material and chemical charge of space objects can cause ozone depletion.

Political Impact. In addition to having an impact on the security and safety of the earth and space. Space debris either directly or indirectly has an impact on the political situation. An example of this can be seen from the test firing of an anti-satellite weapon (ASAT) by China which destroyed its own satellite and caused an increase in the amount of space debris in space. This incident not only affected the space environment but also became a polemic for countries, especially the United States. This weapons test is believed to trigger an arms race in space. It also drew strong protests from countries that have satellite programs and were affected by the shooting. Several countries, such as Japan, Russia, the United States and the United Kingdom, gave official responses to China's actions related to this satellite shooting test.

Space Debris Governance

Since the emergence of space debris as a space problem, countries have made various efforts together in dealing with this issue. Discussion of Space debris as an issue that needs to be addressed by countries, international organizations and related stakeholders. Through the UN forum (UNCOPUOS) member countries propose that the problem of space debris get attention. In 1993, through Resolution No.48/39, the United Nations set the issue of space debris to be discussed on the agenda of the Scientific and Technical Subcommittee session in 1994. At the Scientific and Technical Subcommittee session in 1995, a work plan was agreed upon for 1996-1998 (Balogh & Hedman, 2009), that is: 1996: Measurements of space debris, understanding of data and effects of this environment on space systems. 1997: Modeling of space debris environment and risk assessment.

From this discussion, a Technical Report on Space debris was produced which was later ratified in 1999. This report outlines the measurements of space debris and a common understanding of the term space debris. A further effort to handle space debris at UNCOPUOS is the formation of a working group that discusses space debris mitigation guidelines in 2004 to 2006 (Permatasari, 2019). In 2007, the Committee adopted the Space debris Mitigation Guidelines of COPUOS. These guidelines contain procedures that are deemed to be able to reduce the amount of space debris.

Besides being discussed in UNCOPUOS, efforts to handle space debris are also realized in the IADC (Inter-Agency Space Debris Coordination Committee), an international forum whose members are the space agencies of countries to coordinate activities related to debris in outer space. IADC was formed with the aim of sharing information on space debris research activities and facilitating collaboration opportunities in space debris research as well as reviewing the development of collaborative activities and identifying ways to mitigate space debris.

In IADC members share a number of common interests related to space debris research that can be developed into various collaborative research activities. The IADC is intended to identify, plan and assist in the implementation of mutually beneficial cooperative activities. In its development, efforts to handle space debris are not only carried out through UNCOPUOS and IADC but also by other international forums. UNOOSA (United Nations Office for Outer Space Affairs) through UNCOPUOS based on the contribution of Canada, the Czech Republic and Germany provides an appeal to member countries and international organizations to report summaries containing information on arrangements and standards for mitigating space debris to UNOOSA which are collected in a overview/compendium.

The purpose of this compendium is to inform countries about the instruments and measures for mitigating space debris that have been implemented by countries and international organizations (Yudiatmaja et al., 2020). In addition, this Compendium is expected to be able to assist those who wish to enforce or develop similar standards in relation to the topic of this space debris. This compendium contains reports from countries regarding the mechanisms or standards that have been applied in dealing with space debris in their countries and how they are applied. This compendium also informs whether the applied national mechanism refers to existing international mechanisms. So far, 24 countries have submitted reports on their national mechanisms for mitigating space debris. These countries include Algeria,

Argentina, Australia, Austria, Belgium, Canada, Chile, Czech Republic, France, Germany, Indonesia, Italy, Japan, Mexico, Netherlands, Nigeria, Poland, Slovakia, Spain, Switzerland, Thailand, Ukraine, England, and the United States.

The territory of the state's sovereignty includes the air space above its territory. This area has been discussed for a long time, especially as seen in a theorem of Roman Law which reads "cujus est solum, ejus est usque ad coelum." This proposition means "whoever owns a piece of land thus also owns everything that is above the surface of the land up to the sky and everything that is in the ground (Salter, 2016). According to international law, the territory of a state consists of three dimensions, namely land, sea and air. The sea area is an extension of the land area, and the airspace of a country follows the boundaries of the country's territory on land and at sea. This is reflected in Article I of the Paris Convention for the Regulation of Aerial Navigation in 1919 which recognizes full state sovereignty in the air space above its land and territorial sea. In the beginning, state sovereignty was not set vertically (*usque ad coelum*) which was then limited by the regulation of space (Kusmaatmadja & Agoes, 2019).

Nowadays the frequency of satellite launches is increasing where countries are competing fiercely to launch satellites into space. The United States with NASA has created a space shuttle that can take several satellites into space at once, place them in orbit, and return to earth. The shuttle can be reused for the next satellite launch program. The Soviets were no less active in their space projects. His Soyuz, Sputnik and Cosmos projects are not new. Indonesia, with the help of the United States, launched its first communications satellite, PALAPA A-1, in the 1970s. This also indicates that since that year Indonesia has participated in the era of space utilization.

Humans make large amounts of waste not only on the earth where we live, but also humans make waste in outer space, also seen from the high human space activity today. Many objects launched in space have become useless trash. Space debris is an artificial object that orbits the earth other than a functioning satellite. It is estimated that space debris has fallen every day since the launch of the satellite in 1957. This waste is in the form of rocket and satellite waste that has burned up in the atmosphere. These objects generally fall in unpopulated areas so they are not dangerous.

The case of collisions between satellites in space or even satellites that are no longer functioning and become space junk has a very bad impact on the earth that must be the attention of international governments. as an anticipation mechanism for resolving international environmental disputes because these activities contain high risks for the environment and humans on earth. Regarding space debris, this is very worrying because this problem threatens the safety of outer space as well as the possibility of falling to the earth's surface. The lower the position of the satellite orbit or space debris, the faster it will fall to the earth's surface. For example, the fall of the space junk cosmos 954 owned by the Soviet Union in 1979 which made the international community aware to regulate further in international law because it is very dangerous to anyone in the world and harms other countries which can be in the form of environmental damage and human casualties.

The crash of the Soviet Union's Cosmos 954 satellite in the Northwest Territories Provinces of Alberta and Saskatchewan Canada caused losses because radioactive waste was very dangerous for the environment and property of the people in the area (Power & Keeling, 2018). The cosmos 954 waste weighs about 65 kg and contains about 3,500 radioactive particles. The radiation levels of these particles vary widely from thousands to millions of one x-ray/hour. Some of them have very lethal properties. One small shard, 25 mm x 15 mm x 10 mm, radiates up to 500 x-rays/hour which is enough to kill a human within hours of first contact.

The data above is only data that mentions the direct impacts (acut impacts) of the fall of Cosmos 954, and Canada has not taken into account the indirect impacts (cronic impacts) (Putra, 2003). For these problems, it is necessary to have a real implementation of the principle of preventing pollution and contamination from outer space, including by space objects so that environmental sustainability is maintained (as regulated in Article IX of the Space Treaty). In contrast to the earth, which has cleaners and waste recycling departments, unfortunately in outer space there is no cleaning team, garbage is allowed to

orbit continuously in outer space. Even though there is international law that regulates liability for damage caused by space objects, namely the Convention on International Liability for Damage Caused by Space Objects 1972, but it is still necessary to prevent the damage that may be caused by space objects or spacecraft. As a result of the increasing population of space debris, it is difficult to find the location of the fall of the garbage so that prevention efforts are needed with a mechanism carried out by humans to clean up the space debris The launching state of the spacecraft must monitor the spacecraft, because only the launching state knows the orbital period of each space object it launches.

Launching nations must constantly monitor the presence of space junk and map it out. This effort can then be carried out by sending a mission, namely by forming a Space Waste Cleaning Agency to collect space debris and destroy it into small pieces so as to reduce the danger. What is more important is the cooperation between countries in reducing the environmental impact due to the fall of space debris, namely by transferring technology and contributing costs from developed countries to developing countries in order to maintain environmental sustainability on this Earth.

Discussion

Along with the development of space technology and the increasing number of space objects in orbit, the space environment is currently experiencing saturation and this is directly proportional to the increasing amount of space debris in orbit. Space debris is not only a threat to the safety and security of the space environment, but also safety and security on earth and has an impact on various aspects of life. Considering the increasingly widespread impact of space debris, until now the issue of space debris has become a developing issue that is still being discussed in various international space forums. In overcoming the issue of space debris, the international community in this case countries and international organizations feel the need to make joint efforts by conducting discussions in overcoming the issue.

Space debris is essentially the impact of technological developments which eventually becomes a common problem. Countries realize that the problem of space debris is not a problem that can be solved individually. Cooperation and disclosure of information between countries and stakeholders is indispensable in dealing with the growing problem of space debris, this causes interdependence between countries and international organizations because this issue must be addressed and maintained together. International institutions such as UNCOPUOS or IADC become a forum for countries and space agencies in solving this space debris problem. This was later realized by the establishment of an international mechanism that contained a set of regulations regarding the mitigation of space debris.

Several international mechanisms in handling space debris are realized in the form of guidelines. In a liberal perspective, rationality is a firm universal characteristic of the individual. Countries and international organizations that are part of the international community realize that space debris is a common problem and the international community essentially has a mindset to act according to reason in overcoming and resolving this space debris problem.

Individuals rationally pursue their own interests, however, there is a potential alignment of interests among each individual. The rationality possessed by the international community is basically driven by the interests of countries in the use of technology and the space environment to support their national interests. And referring to this, space debris becomes a threat to the sustainability of the use of outer space that can interfere with the national interests of a country (Akbar et al., 2020). So, the resolution of the problem of space debris is in the common interest of the international community in supporting their respective interests.

Based on this, countries and international organizations carry out a series of collaborations, this is realized by continuous discussions on space debris in international forums and the establishment of a series of international mechanisms, which are embodied in the form of Guidelines, namely a set of arrangements that contain guidelines for dealing with space debris that can be used as a reference or basis for countries to be applied in their national mechanisms in efforts to mitigate space debris.

The space debris mitigation guidelines are the result of an agreement with countries in handling space debris. An international mechanism formed based on mutual needs and interests (Akbar et al., 2021). The form of cooperation in the settlement of space debris reflects that liberalism opposes the division between domestic and international areas, this can be seen in the existing guidelines that the problem of space debris and its solution is no longer a problem faced by only a few countries, but all space actors.

The set of arrangements contained in the guidelines recommended by international institutions such as COPUOS, IADC and the EU, are universal arrangements that can be applied by all countries and therefore the guidelines are seen as regulations that penetrate state boundaries and countries and actors. Other space probes have lost some of their independence in handling space debris. And in this case, indirectly, countries are forced to participate in a more intensive form of cooperation. This is illustrated by the call for countries to report their national mechanisms to UNCOUPUOS.

The existing guidelines are a big step for countries and space actors in working together to mitigate space debris. Measures such as preventing and limiting the formation of more space debris through spacecraft design and operation International institutions have been successful in calling on countries to play a role in handling space debris. Several reports on national mechanisms were compiled in the UNCOUPUOS compendium, countries have participated in reporting on their national mechanisms and most countries have made these guidelines as guidelines in their national mechanisms, both in the form of regulations and operational standards.

Conclusion

Humans make large amounts of trash, not only on the earth where we live, but also humans making waste in outer space, also seen from the high human space activity today. Many objects launched in space have become useless trash. Space debris is an artificial object that orbits the earth other than a functioning satellite. It is estimated that space debris has fallen every day since the launch of the satellite in 1957. This waste is in the form of rocket and satellite waste that has burned up in the atmosphere. These objects generally fall in uninhabited areas so that they are not dangerous. The case of collisions between satellites in space or even satellites that are no longer functioning and become space debris has a very bad impact on the earth which must be the attention of international governments. as an anticipation mechanism for resolving international environmental disputes because these activities contain high risks for the environment and humans on earth.

In the perspective of international relations, the international mechanism for handling space debris which is manifested in the form of guidelines is a reflection of liberalism where the rationality of the international community realizes that the handling of space debris is a common interest and cooperation in handling an issue no longer looks at state boundaries and international institutions more closely. role than countries. Therefore, countries feel the need to discuss and find a common way out in overcoming the issue of space debris and this is realized by discussing the issue of space debris in international forums and the establishment of a set of guidelines that are agreed upon by all countries and space agencies. so that the existing arrangements are more universal and more applicable to countries and other space actors. Of the five international mechanisms above, the Space debris Mitigation Guidelines of UNCOPUOS and the IADC Space debris Mitigation Guidelines are the dominant guidelines because they are agreed upon by countries and serve as references for both international and national mechanisms for handling space debris.

How to cite:

Permata, C. Q. N. & Khasanah, N. B. U. (2021). Space debris governance: A perspective of international law. *Public and Social Review, 1*(2), pp. 81-89.

References

Akbar, D., Setiawan, A., Mariani, M., Adhayanto, O., Okparizan, O., & Yudiatmaja, W. E. (2021). Environmental awareness and concern over transboundary oil spill in Bintan Island: A preliminary analysis results. *E3S Web of Conferences*, *324*, 06003.

Akbar, D., Setiawan, A., Prayuda, R., Putra, A., Aznor, A., & Yudiatmaja, W. E. (2020). Community preparedness on transboundary oil spill governance in Bintan Island. *Journal of Physics: Conference Series*, *1655*(1), 012144.

Balogh, W., & Hedman, N. (2009). Review of the work of COPUOS in 2009. *Space Policy*, *25*(2), 128–132.

Gupta, B., & Rathore, E. (2019). United Nations General Assembly resolutions in the formation of the outer space treaty of 1967. *Astropolitics*, *17*(2), 77–88.

Hobe, S., & Mey, J. H. (2009). UN space debris mitigation guidelines. *Zeitschrift Für Luft-Und Weltraumrecht*, *58*, 388.

Kusmaatmadja, M., & Agoes, E. R. (2019). *Pengantar hukum internasional*. Alumni.

Mardianis, M. (2012). *Analisis kompatibilitas pedoman mitigasi sampah antariksa (space debris) antara IADC dan UNCOPUOS*. LAPAN.

Permatasari, Y. (2019). The urgency of guidelines for the long-term sustainability of outer space activities for Indonesia. *Global Strategis, 13*(2), 63–74.

Popova, R., & Schaus, V. (2018). The legal framework for space debris remediation as a tool for sustainability in outer space. *Aerospace*, *5*(2), 55.

Power, E., & Keeling, A. (2018). Cleaning up cosmos: Satellite debris, radioactive risk, and the politics of knowledge in operation morning light. *Northern Review*, *48*, 81–109.

Putra, I. B. W. (2003). *Hukum lingkungan internasional: Perspektif bisnis internasional*. Refika Aditama.

Salter, A. W. (2016). Space debris: A law and economics analaysis of the orbital commons. *Stanford Technology Law Review*, *19*(2), 221–238.

Weaver, M. A., & Ailor, W. H. (2012). Reentry breakup recorder: Concept, testing, moving forward. *AIAA SPACE 2012 Conference & Exposition*.

Yudiatmaja, W. E., Samnuzulsari, T., Suyito, S., & Yudithia, Y. (2020). Transforming institutional design in addressing sludge oil in Bintan seawater, Kepulauan Riau, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *423*(1), 012059.