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Environmental law principles as guidelines for protecting the outer space

Abstract

Sustainable development practices in the terrestrial environment have been implemented for a long time and, despite their lack of uniformity, have so far proven to be successful. Sustainability in the space environment is a concept that has been under development for over a decade and its implementation is much more difficult, given how challenging, from various perspectives, space domain is. Hence, sustainability in outer space depends on many factors, not only technological development, responsible approaches, and measures taken by all space stakeholders, but also on properly constructed legal foundations. The peculiarities of the space sector, especially from a legal perspective, are characterized by limited experience in regulating such a challenging area. There are a number of normalization activities in addition to Corpus Iuris Spatialis that contribute to a process of unification of space activities (at least at the technical level), even though they remain outside the strictly regulatory aspect. Therefore, lawyers dealing with the space domain frequently use analogies from various legal branches. In the study of space law, particular attention has been paid to aspects of the law of the sea (regulations of high seas) or mining law in the context of space resources. Nevertheless, owing to the increasing problem of the condition of the outer space environment (mainly due to the dangerous amount of space debris in orbit) references to environmental law are increasingly visible in legal research aimed at ensuring sustainable development in outer space. National Space Legislations (NSL) often refer to 'soft law' instruments in the form of internationally recognized and recommended guidelines and standards[1]. Nevertheless, the question arises regarding the extent to which such recommendations will be implemented and enforced, particularly given their diversity. To propose a potential solution, it is important to refer to the principles based on environmental protection law, which, according to the authors, could be analogously applied in the formulation of regulations protecting the outer space environment or at least act as an inspiration for searching for the best solution in the area of space law. Starting from the foundations of the concept of sustainability, in the following study, the authors focus on the Precautionary Principle as well as the Polluter Pays Principle through appropriate risk allocation between the state and non-governmental entities. Regulations at the global, European and national level are reviewed in order to introduce the evolution of the concept of sustainable development and its potential impact on the shaping of space law. This analysis aims to examine the functioning of environmental regulation at national,

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[1] The various standards and guidelines commonly used or recommended, includes in particular: Space Debris Mitigation Guidelines (COPUOS, 2010); The Long-Term Sustainability Guidelines (LTS Guidelines, 2019); European Code of Conduct for Space Debris Mitigation; Recommendation of International Telecommunication Union, Inter-Agency Space Debris Coordination Committee Space Debris Mitigation Guidelines (IADC); International Organization for Standardization Standards and Technical Reports (ISO).

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supranational and international level, thereby creating potential guidance for the regulation of the protection of space environment.
Keywords: sustainable development, space law, environmental law, precautionary principle, polluters pay principle, space debris

1. The Current State of Affairs

Minimum binding regulations and, in certain aspects, the total absence of rules imply an increasing number of doubts and difficulties in determining the appropriate direction for the sustainable development of space activities. The consequence of this state of affairs is a high risk and legal uncertainty for both states and private entities, which must comply with the requirements imposed by legislators to properly conduct space activities. In 2022, the space industry recorded 161 launches, once again setting a record number.[2] This trend will be increasing in the following years. Therefore, permanent access to space is threatened by the frequent launches of space objects into outer space. This consequently leads to an increased risk of collisions, explosions, or break-ups of space objects in the Earth's orbit. According to NASA's latest estimates, the current state of affairs is critical in terms of the mass of space debris (10,800 tonnes). The latest data related to space debris, provided by the ESA Space Debris Office at the European Space Operations Centre (ESOC), show the following figures (based on statistical models) regarding the estimated number of debris objects in orbit: more than 36,000 space debris objects greater than 10 cm, 1 million space debris objects greater than 1 cm to 10 cm, and 130 million space debris objects greater than 1 mm to 1 cm.[3] Even millimeter-sized fragments can pose a huge threat because space debris travels at speeds of up to 29 000 km/h. Since 1999, the International Space Station (ISS) has conducted approximately 30 debris-avoidance maneuvers to avoid potential collisions with pieces of debris.[4] Recent international activities have focused on the use of anti-satellite weapons, which have become a visible threat to the future of space activities and the entire space environment. Because of the importance of certain satellites, various countries have developed anti-satellite (ASAT) weapons, especially those connected to national security. This tool is used to destroy or incapacitate satellites in orbit. Consequently, fragments from destroyed satellites are added to the large existing mass of space debris.[5] In response to the ASAT test conducted by Russia in 2021 (which aimed at destroying the non-functioning satellite Kosmos 1408),[6] United Nations General Assembly introduced a draft Resolution calling on member states *"to not conduct destructive direct-ascent anti-satellite missile tests"* thereby stating that *"such a commitment to be a urgent, initial*

[2] SIA, Record Setting Growth Highlights Commercial Satellite Industry as it Continues to Dominate Expanding Global Space Business – SIA Releases 26th Annual State of the Satellite Industry Report.
[3] ESA 2023.
[4] Bhutada 2022.
[5] Ibid.
[6] As a result of this test, additional precautionary measures were taken against the crew on the International Space Station.

measure aimed at preventing damage to the outer space environment, while also contributing to the development of further measures for the prevention of an arms race in outer space."[7]

The above facts explicitly show that the problem is important and should be addressed by lawmakers or at least by legal doctrine. Thus, the goal of this study is to assess the current state of law and propose adequate solutions de lege ferenda. The research methods proposed by the authors include the dogmatic method, by analysis of legislation and legal texts, as well as comparative methods, both at the level of NSL of various countries and between various branches of law, such as environmental law and mining law.

2. 'Permeation' of Sustainable Development Into Space Law

Sustainable development was enshrined as one of the fundamental objectives of European integration, based on Article 2 of the Treaty Establishing the European Community in 1957 as modified by Maastricht Treaty in 1992. [8] Since then, the concept of sustainability has evolved gradually.[9] The 1972 United Nations Conference on the Human Environment (Stockholm Conference) outlined the beginning of sustainable development principles in the Stockholm Declaration and Action Plan for the Human Environment by prioritizing environmental issues in an international forum.[10] The clear concept has emerged in the 1980s when the United Nations Brundtland Commission[11] in 1987 released the 'Our Common Future' Report (so-called Brundtland Report) in which the definition of sustainable development appeared. The term was explained as the *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* This was a significant milestone in directing subsequent efforts toward achieving environmental sustainability. The Rio Declaration on Environment and Development of 1992, (which reaffirmed the Stockholm Conference Declaration) included many provisions related to sustainability.[12] In accordance with Principle 4 *"in order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it."* The important milestones in the development of sustainable development law were constituted in the Agenda 21

[7] The new draft resolution, entitled Destructive direct-ascent anti-satellite missile testing approved by The Committee on the Peaceful Uses of Outer Space (Document A/C.1/77/L.62).

[8] *"The Community shall have as its task, by establishing a common market and an economic and monetary union and by implementing common policies or activities referred to in Articles 3 and 4, to promote throughout the Community a harmonious, balanced and sustainable development of economic activities, a high level of employment and of social protection, equality between men and women, sustainable and non-inflationary growth, a high degree of competitiveness and convergence of economic performance, a high level of protection and improvement of the quality of the environment, the raising of the standard of living and quality of life, and economic and social cohesion and solidarity among Member States."*

[9] Pallemaers & Azmanova 2006.

[10] Bándi 2022, 17–73.

[11] Formerly the World Commission on Environment and Development. Sub-organization of the United Nations, whose goal was to unite countries in terms of sustainable development. Founded in 1983 when Gro Harlem Brundtland, former Prime Minister of Norway was appointed by the Secretary-General of the United Nations as chairperson of the commission, hence its name.

[12] Bándi 2022, 18–19.

implemented by the United Nations during the Conference on Environment & Development in Rio de Janerio (June 1992) as well as in Report of the World Summit on Sustainable Development (Johannesburg, South Africa, 2002) in which the collective responsibility to strengthen the *"pillars of sustainable development – economic development, social development and environmental protection – at the local, national, regional and global levels"* were expressed.[13]

Confirmation of the significance of the concept of sustainable development can be found in the unratified Treaty establishing a Constitution for Europe,[14] which indicated that *"in its relations with the wider world, the Union shall uphold and promote its values and interests. It shall contribute to peace, security, and the sustainable development of the Earth (…)."*[15] In its resolution adopted on 16 September 2005, the United Nations General Assembly distinguished three components of sustainable development, which are based on social development, economic development and environmental protection.[16] Among the many milestones towards sustainable development[17], it is important to point out the most current aspects concerning the document entitled 'Transforming our world: the 2030 Agenda for Sustainable Development' which finally concluded 17 Sustainable Development Goals (SDGs) and related 169 actions.[18] One of the objectives of the SDGs is to present an appropriate approach that demonstrates how environmental improvements will bring both economic and social benefits by seeking to reduce environmental risks and increase the resilience of societies and the environment as a whole.[19] In general, for the purposes of this article, environmental sustainability can be understood as preserving the integrity of the environment, keeping all the Earth's environmental systems in balance, while maintaining the rate at which humans consume the natural resources so that they are able to replenish themselves.[20] This raises the question of whether this understanding can also be applied to the outer space environment, particularly considering its complexity.

The various steps taken internationally in the field of sustainable terrestrial development have laid the foundation for space stakeholders to follow similar paths. The Working Group on Long-Term Sustainability in Outer Space Activities was established in 2010 by the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS). Since then, the committee has developed a set of measures and internationally recognized standards relating to the safety of space activities. Nine years later, in 2019, the Committee on the Peaceful Uses of Outer Space adopted the Guidelines for Long-Term Sustainability of Outer Space Activities (LTS Guidelines),

[13] Annex of Johannesburg Declaration on Sustainable Development.
[14] Draft Treaty Establishing A Constitution For Europe Adopted by consensus by the European Convention on 13 June and 10 July 2003.
[15] Pallemaerts & Azmanova 2006.
[16] Resolution adopted by the United Nations General Assembly on 16 September 2005. A/RES/60/1. 2005.
[17] Such as the establishment of the expert group by UN General Assembly in 1992: the Commission on Sustainable Development.
[18] The leaders of UN member states signed the document at the summit in New York between 25 and 27 September 2015.
[19] UN Environment Programme 2023.
[20] McGill University 2023.

thereby presenting a definition of long-term sustainability in outer space. In the UN guidelines the term is determined as *"the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations."*

As previously mentioned, at the time of the creation of international space treaties, the concept of sustainability did not have much relevance as the number of players in this sector was limited to the two major powers. However, it should be noticed that the subject of sustainability appears, in a fragmented manner, in the already existing Space Treaties. Provisions regarding sustainable development can be found in most international space law treaties. Outer Space Treaty in Article IX provides that *"[…] States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose […]."* Directly included protection of the environment and celestial bodies can only be found in the Moon Agreement in which, in accordance with Article 7 *"In exploring and using the Moon, States Parties shall take measures to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise. State Parties shall also take measures to avoid harmfully affecting the environment of the Earth through the introduction of extraterrestrial matter or otherwise."* The concept of sustainability also emerged in the Registration Convention through the Registration of Space Objects as well as in the Liability Convention. Because environmental protection appears only in the Moon Agreement, these regulations at the international level are negligible (through the number of parties), particularly because of the limited relevance of this treaty to the international space ecosystem. Therefore, the current New Space era, which consists of various non-governmental entities, inevitably requires proper activities, especially more decisive legal actions, to reduce risks to the outer space environment.

3. Environment – Dual Perspective

In this section, the authors draw attention to legislative gaps in the context of the definition of the environment, from both a space and terrestrial perspective. The purpose of this chapter is to describe national legislation that attempts to partially define this matter.

3.1. Outer Space Environment

The term 'outer space', which is frequently used in documents and treaties concerning space activities, has never been defined.[21] There is no legal definition of the outer space environment in international law. Consequently, the approaches to their protection vary in many respects, leading to a lack of universal standards governing environmental issues. This matter is unresolved at the international level, but some states

[21] Max Plan Encyclopedia of International Law 2006.

have attempted to regulate at least the delimitation of outer space in their national space legislation, which may facilitate legal interpretation and simplify possible disputes on this matter. The relevance of such a demarcation is questioned because of the nuisance of certain activities, for example, in the airspace. Nevertheless, although consensus has not yet been reached at the international level to avoid legal ambiguity, some opinions favor designating a precise line.[22] A commonly accepted measure of space 'demarcation' is the so-called Kármán Line which lies at an altitude of 100 km above sea level. An example of a country that has introduced clear space delimitation line is Denmark on the basis of the Danish Outer Space Act from 2016 in which Outer Space is defined as *"Space above the altitude of 100 km above sea level."*[23] Indonesia has adopted a definition of space outside the Air Space and surrounding it, along with what is in it.[24] Likewise, Kazakhstan defined outer space as a space extending beyond airspace at an altitude of more than one hundred kilometers above the sea level .[25] In South Africa's Space Affairs Act,[26] 'outer space' refers to space above the Earth's surface from the height at which it is possible to operate an object in an orbit around the Earth.[27] From the above examples, it can be seen that many countries decided to draw a precise demarcation line based on the Kármán Line, and the vast majority tended towards a broad and rather general definition that provided a wide scope for interpretation. Therefore, space demarcation becomes problematic in the context of being subject to the relevant legal regime, which may lead to concerns about the interpretation and qualifications of space-related activities in the future.[28]

In addition to the line of demarcation, the question arises as to what exactly is the space environment and what can we include in it? As mentioned before, despite the commonly accepted 'border' of 100 km, a clear distinction between airspace and outer space can cause different problems as the development of space technology grows rapidly. However, from a legal perspective, this is particularly relevant because of international treaties as there is a fundamental difference between their content concerning airspace and outer space. According to Article I of the Convention Relating to the Regulation of Aerial Navigation from 1919, *"The High Contracting Parties recognise that every Power has complete and exclusive sovereignty over the air space above its territory"*[29] whereas in the Article II of the Outer Space Treaty *"Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."*[30] In this case, the demarcation of space and airspace seems necessary from a legal perspective. However, it has not yielded satisfactory results with respect to outlining the elements of the outer space environment, which is the starting point for the introduction of legal protection instruments.

[22] European Space Policy Institute 2017.
[23] The Danish Outer Space Act (act no.409 of 11 May 2016).
[24] Law No. 21 of 2013 on Space Activities (Undang-undang tentang keantariksaan).
[25] Law of the Republic of Kazakhstan on Space Activities No.528-IV of 6 January 2012 (О космической деятельности).
[26] Space Affairs Act 1993.
[27] Malinowska et al. 2022.
[28] For example sub-orbital flights.
[29] This principle was confirmed in Article I of the Convention on International Civil Aviation.
[30] Harris & Harris 2006.

3.2. Terrestrial Environment

Although, looking from an 'Earth perspective' there also seems to be no universal definition of the environment itself. International law does not explicitly define the environment itself. Nevertheless, from the perspective of non-binding international instruments, an important starting point is the identification of documents such as previous mentioned Stockholm Declaration or the World Charter for Nature[31] which proclaims five general principles *"of conservation by which all human conduct affecting nature is to be guided and judged."*[32,33] For the purposes of this article, the authors refer to the definition of natural resources as well as environmental damage contained in the EU Environmental Liability Directive (ELD),[34] as well as to the selected legislation of CEE countries.[35] The Directive indicates 'natural resource' as protected species and natural habitats, water and land. Furthermore, the Directive also defines environmental damage, which refers to damage to protected species and natural habitats (any damage that has significant adverse effects on reaching or maintaining the favorable conservation status of such habitats or species), and includes water damage[36] as well as land damage.[37] As in the case of 'outer space', detailed definitions can also be observed in some national legislation, more often than at the international level. For example, in the Polish Environmental Protection Act of 2008 the environment is understood as *"the totality of natural elements, including those transformed by human activity, and in particular the surface of the earth, minerals, water, air, landscape, climate and other elements of biodiversity, as well as the interaction between these elements."*

[31] Adopted on October 28, 1982 by United Nations member nation-states.

[32] Preamble of the World Charter for Nature

[33] Resulting from the World Charter of Nature, these general provisions are as follows: (1) Nature shall be respected and its essential processes shall not be impaired. (2) The genetic viability on the earth shall not be compromised. The population levels of all life forms, wild and domesticated, must be at least sufficient for their survival, and to this end necessary habitats shall be safeguarded. (3) All areas of the earth, both land and sea, shall be subject to these principles of conservation. Special protection shall be given to unique areas, to representative samples of all the different types of ecosystems, and to the habitats of rare or endangered species. (4) Ecosystems and organisms, as well as the land, marine and atmospheric resources that are utilized by man, shall be managed to achieve and maintain optimum sustainable productivity, but in a way that does not endanger the integrity of those other ecosystems or species with which they coexist. (5) Nature shall be secured against degradation caused by warfare or other hostile activities.

[34] On the 21st April 2004 the European Parliament and the Council adopted Directive 2004/35/CEi on environmental liability with regard to the prevention and remedying of environmental damage.

[35] Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage (ELD, 2004/35/WE).

[36] *"water damage, which is any damage that significantly adversely affects the ecological, chemical and/or quantitative status and/or ecological potential, as defined in Directive 2000/60/EC, of the waters concerned, with the exception of adverse effects where Article 4(7) of that Directive applies;"*

[37] *"land damage, which is any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms;"*

In the Hungarian Act LIII of 1995 on the General Rules of Environmental Protection environment is defined as *"the environmental components and the systems, processes and structure thereof."* Environmental components, according to the Act means *"land, air, water, the biosphere as well as the built (artificial) environment created by humans as well as the constituents."* Hungarian law, also defines natural resources as *"environmental components or certain constituents thereof (with the exception of the artificial environment) that may be used for satisfying the needs of society."* In the Czech Environmental Liability Act[38], natural resources are defined as *"land and rocks, including peloid natural medicinal sources, protected species of wild fauna and flora, and natural habitats, surface waters, and groundwater, including natural medicinal sources and sources of natural mineral waters."*

From this perspective the legal situation of the 'terrestrial' environment is far clearer than that of outer space, due to the possibility to predict the types and effects of damage that may occur on Earth. When it comes to outer space, most of the technology involved, for example, in the extraction of space resources, is still under development. Therefore, so in terms of regulating future activities that have not yet been tested in practice poses some difficulties regarding the identification of damages in the outer space environment.

4. Legal Mechanisms ensuring Sustainable Development

Current legal instruments ensuring the implementation of the concept of sustainable development mainly take the form of guidelines and standards in the shape of the so-called 'soft law'. In the context of environmental protection, this is particularly relevant because of the emphasis on a broad spectrum of legal and sociological concepts that are compatible with the idea of soft law.[39] These are often resolutions and recommendations of international organizations, conclusions drawn by expert groups, declarations, and summaries edited at the end of international projects and conferences.[40] For example, in the context of environmental protection, an organization dealing with environmental issues that formulates soft law instruments in the form of various recommendations is the Commission on Transnational Corporations (ECOSOC), operating under the UN. The situation is similar to the recommended international standards for activities in outer spaces. Over the years, common and recommended guidelines have been developed to prevent the formation of space debris. This catalog includes the Committee on the Peaceful Uses of Outer Space (UN COPUOS) Space Debris Mitigation Guidelines, the Inter-Agency Space Debris Coordination Committee (IADAC) Space Debris Mitigation Guidelines, and the International Organization for Standardization (ISO Standards).

[38] Act No. 167/2008 Coll., on prevention and remedying environmental damage and amendment on some laws.
[39] Peterson 2012.
[40] Dupuy 1990.

5. Environmental Law Principles

Most environmental and pollution control legislations were formulated in the early 1970s to protect public welfare and health.[41] International environmental law is fragmented and consists of many global, regional and sub-regional as well as unilateral and multilateral treaties. Examples of such treaties includes the previously mentioned United Nations Framework Convention on Climate Change (UNFCCC),[42] the Vienna Convention,[43] and the Basel Convention.[44] The Union's environmental policy, developed over the years, is based on the main pillars related to the principles of prevention and removal of pollution at the source, the precautionary principle, and the so-called polluters pay principle.[45] For the purposes of this article, the authors developed the concepts of the precautionary principle and polluters pay principle to analyze them in terms of space law.

5.1. Precautionary Principle

One of the most influential declarations concerning the precautionary approach is Principle 15 of the Rio Declaration, which states that "*In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, a lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation."*[46] The precautionary principle was similarly replicated in the preamble of the Convention on Biological Diversity (CBD)[47] and Article 3 of the UN Framework Convention on Climate Change[48] from 1992. At the European Union level, this principle was endorsed in the Maastricht Treaty and is enshrined in Article 191 of the Treaty on the Functioning of the European Union: *"Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should be rectified at source as a priority, and that the polluter should pay."* The precautionary principle, which is widely implemented internationally and at the national level, has extended from the

[41] Peirce et al. 1998, 15–30.
[42] Ginzky H Soil governance at the international, regional and national level 2022.
[43] Vienna Convention for the Protection of the Ozone Layer from 1985.
[44] Basel Convention on the Control of Transboundary Movements of Hazardous Wastes from 1989.
[45] European Parliament 2023.
[46] Gollier & Treich 2013, 332–338.
[47] *"Where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat."*
[48] *"The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors. Efforts to address climate change may be carried out cooperatively by interested Parties."*

regulation of industry or health risks to the broader management of science, trade, and innovation.[49] Because of the frequency with which this approach is invoked in both international environmental law and internal national regulations, the precautionary rule has reached the level of a customary rule of international law.[50] However, again, there is no universal definition of precautionary principle and its scope (as European Commission indicates) *"depends on trends in the case law, which to some degree are influenced by prevailing social and political values."*[51] According to the European Court of Justice (ECJ) judgment in the case of Artegodan v. Commission[52] *"the precautionary principle can be defined as a general principle of Community law requiring the competent authorities to take appropriate measures to prevent specific potential risks to public health, safety and the environment, by giving precedence to the requirements related to the protection of those interests over economic interests […]."* The precautionary principle also appeared in the case concerning Gabcikovo- Nagymaros Dispute, where owing to the extreme importance of natural resources, the precautionary principle is justified in environmental law, even if danger is not fully realized.[53] Owing to the accepted uncertainty in scientific evidence[54], the reference of the precautionary principle to the outer space environment seems to be justified. The Outer Space Environment and space activities are often at a developmental stage; therefore, predicting the effects of human activity in outer space seems difficult at this stage. Nevertheless, current estimates indicate, for example, the possibility of the so-called Kessler Syndrome, that is, a situation in which, despite no further objects being launched into outer space, the amount of debris in orbit may increase owing to collisions between them. Another argument in favor of this analogy is the notion of outer space as a fragile environment.[55] This rationale is also relevant to Article IX of the Outer Space Treaty in the context of avoiding harmful contamination of outer space, including the Moon and other celestial bodies.

Thus, the precautionary principle prevailed. Its application to the space environment and its resources, which are extremely fragile, has its justification, especially based on a lack of full knowledge of the hazards and, thus, the enormous consequences as a result of possible damage. According to the latest executive summary published by the Organization for Economic Cooperation and Development (OECD), an experimental model was developed to assess the economic effects of a collision event through value chains. It estimates worldwide monetary losses in the case of Kessler Syndrome to USD 191.3 billion. This is a large sum of the resources currently committed to global debris mitigation and remediation.[56]

[49] Renn 2015.
[50] Bittencourt Neto 2013.
[51] European Parliament 2023.
[52] Judgment of the Court of First Instance (Second Chamber, extended composition) of 26 November 2002. Artegodan GmbH and Others v Commission of the European Communities.
[53] Bittencourt Neto 2013.
[54] European Parliament 2023.
[55] Larsen 2006.
[56] OECD Library 2023.

5.2. Polluters Pay Principle

In 1972 for the first time OECD introduced the so-called 'polluter pays principle' for allocating the costs of pollution control in the form of economic principle.[57] This principle means that the polluter should bear the expenses of the pollution prevention and control measures *"decided upon by the public authorities in order to ensure that the environment is in an acceptable condition."*[58] Initially, the focus was on the cost of pollution control and prevention. Later, it included the costs of the anti-pollution measures taken by the authorities. Environmental responsibility is an extension of this principle.[59] Environmental Liability Directive indicates that *"the prevention and remedying of environmental damage should be implemented through the furtherance of the 'polluter pays' principle, as indicated in the Treaty and in line with the principle of sustainable development."*[60] Based on this principle the ELD indicates the responsibility of the operator to take all necessary remediation measures at his own expense.[61] Besides the OECD document, this principle is expressed in the Rio Declaration. According to Principle 16 *"National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investments."*

Applying the polluters pay principle to legal instruments dedicated to the space sector, the launching state would have to guarantee a certain amount of debris generation during a space mission. One reason for this is that, at the current stage of technological development, it is practically impossible to avoid creating debris during these activities.[62]

Among the many principles of international environmental law (such as principle of prevention, prohibition of discrimination, principle of intergenerational justice and equity, etc.) the authors have chosen the principles described above due to their potential applicability to space law as well as the rare reference in space-related legal research to the principles mentioned. The principle of prevention is the principle that should be applied first in the context of the formation legal instruments concerning space activities, no less, its complexity as well as the way of implementation require extensive research, which is why the authors have chosen not to expand on this principle in this article. Nevertheless, what such a proposed application of the precautionary and polluter pays principle would look like if there is no unified system for protecting the space environment as there is absence of homogeneous regulations for protecting the terrestrial environment. As mentioned earlier the precautionary principle is justified in an extremely risky and unexplored environment such as the space environment, and the polluter pays principle forces the authorities to introduce specific economic rules in the form of pollution prevention measures. Space activities often involve a number of international actors, and this rule could contribute to economic efficiency in *"the event of an incident*

[57] OECD 2023a.
[58] OECD 2023b.
[59] European Court of Auditors 223.
[60] Directive 2004/35/CE.
[61] Ibid.
[62] Chowdhury 2023.

causing transboundary harm, assessing the actions of polluters according to a strict liability standard."[63] The concept of both prevention and polluter pays does not have the status of a principle of general international law and currently only operates as a general guideline of public international law.[64] Is it then possible to develop such an international principle for the space environment. In the context of harmonizing regulations protecting the space environment, achieving consensus in the form of an international treaty seems difficult, and soft law mechanisms are not sufficiently effective in the event of a potential dispute. However, to avoid fault-based liability as much as possible and to minimize the risk of collisions, which lead to a deterioration of the space environment, the interest of all space stakeholders should be the adoption of coherent measures. Prevention and remediation of environmental damage should be in the so-called 'good practices' of each stakeholder involved in space activities. Such instruments should be introduced most effectively by means of soft law mechanisms that can be easily adapted and to such a dynamic environment as outer space and rapidly evolving space technology. The dynamic nature of the space industry is a key indicator that international rules may appear too time-consuming to develop and, consequently, may not be very effective.

6. Conclusion

The principles of environmental law can be determinants and guidelines for the development of future widely used and internationally established principles for protecting the space environment. The widespread use of environmental principles, that is, the precautionary or pollution pay principle, proves their effectiveness and general acceptance by society. Nevertheless, with the possible implementation of these principles in the space law regime, attention should be paid to the nature of the space sector, which is undoubtedly a more complicated area requiring an interdisciplinary approach. It is an emerging domain that is very costly and carries a high risk; therefore, the responsible actions of both state and private entities should contribute to sustainable development. Therefore, the appropriate regulation of aspects related to the protection of the space environment is necessary to guarantee equal access to outer space for future generations.

[63] Separate opinion of udge Bhandari (regarding two separate but related disputes that have arisen between Costa Rica and Nicaragua pertaining to the San Juan River, which serves as the international boundary between these two nation-States).
[64] Ibid.

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