# POLITECNICO DI TORINO

**Master's Degree in Engineering and Management**
**(Space Economy)**


**Master's Degree Thesis**

# A New Policy Framework for Resource Extraction and Property Rights in Outer Space


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**Abstract**

The rise of the new space economy represents a paradigm shift. In this context, the extraction of space resources represents a key opportunity to sustain space exploration and reduce the reliance on Earth resources. Lunar water could be converted into fuel, helium-3 might revolutionize clean energy production, and rare metals could enhance technological advancements. However, international agreements are outdated, general, and hardly enforceable. This created a legal void that has been filled by some national laws, contributing to the fragmentation of the regulatory landscape.

This thesis analyzes and examines the shortcomings of current international agreements and national laws in addressing equitability, environmental, and governance challenges. Furthermore, it proposes a new policy framework that hinges on these three dimensions. The new framework advocates for creating a new UN-backed organization regulating extraction, promoting sustainable practices, and ensuring benefit-sharing mechanisms. The framework lays its foundation on a credit-based system that drives innovation while fostering environmental stewardship and promoting global fairness. Space-faring nations would mainly benefit from the international legitimacy and innovation incentives embedded in the system, while non-space-faring ones would obtain actionable mechanisms to be part of the space race and benefit from it, in accordance with the Outer Space Treaty philosophy.

# Acknowledgements

A mamma, papà, Giulia e Noélie.

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# Acronyms

**OST**
Outer Space Treaty

**REE**
Rare Earth Element

**NEA**
Near-Earth Asteroids

**UN**
United Nations

**NASA**
National Aeronautics and Space Administration

**GNSS**
Global Navigation Satellite System

**ICMM**
International Council on Mining & Metals

**HDC**
Hydrocarbon-Dependent Countries

**MDC**
Minerals-Dependent Countries

**US**
United States

**UAE**

United Arab Emirates

**UNCLOS**

United Nations Convention on the Law of the Sea

**UNCED**

United Nations Conference on Environment and Development

**EIA**

Environmental Impact Assessment

**ICJ**

International Court of Justice

**CSCLA**

Commercial Space Launch Competitiveness Act

**EU**

European Union

**EC**

European Community

**DIFC**

Dubai International Financial Centre

**DFF**

Dubai Future Foundation

**SAA**

Space Activities Act

**ESPI**

European Space Policy Institute

**PNT**

Positioning, Navigation, and Timing

**EPI**

Environmental Performance Index

**ISA**

International Seabed Authority

**ISRA**

International Space Resources Authority

# Chapter 1

# Introduction

Mining resources in outer space represents a paradigm shift in humanity's approach to economic development, resource management, and the exploitation of outer space. Thanks to technological advancements and the growing investments of space agencies and private enterprises, space resource extraction is expected to become feasible in the coming decades [1]. For example, helium-3, a scarce isotope on Earth, which is more abundant on the moon, could become a key new energy source for nuclear fusion. This would increase humanity's capacity to produce clean energy on a large scale [2]. Similarly, water ice scattered across lunar poles could be used to support life in outer space and produce propellant, enabling deeper space exploration. However, the successful realization of these opportunities is inevitably intertwined with a clear, fair, and enforceable policy framework that currently does not exist.

Currently, the exploitation of outer space hinges on two important international agreements: the Outer Space Treaty of 1967 and the Moon Agreement of 1984. Both of them were signed during the Cold War era, meaning that they reflect the geopolitical tensions of the time. Preventing the militarization of space and avoiding that one superpower could crash the other were the main drivers of the signatory parties, as is clearly displayed in the Outer Space Treaty, where space is defined as "the province of all mankind" [3].

These treaties have done a great job in preventing potential conflicts and promoting peaceful operations in outer space. However, they are inexplicit and vague on the issues regarding property rights and the exploitation of space resources. For instance, the Outer Space Treaty explicitly prevents national entities from claiming property rights in space or celestial bodies but does not address at all whether private entities could extract resources from space [3]. The Moon Agreement attempts to address these issues by declaring the Moon's resources as the "common heritage of mankind" [4] to advocate for the equal redistribution of the benefits reaped by the extraction of space resources across all countries.

However, major spacefaring nations (e.g. United States, Russia, and China) refused to sign the Moon Agreement, meaning that its obligations do not bind the most influential space actors. Hence, it cannot be considered a serious foundation for a global policy framework.

Some countries, such as the United States and Luxembourg, as well as international consortia (the Artemis Accords), took advantage of this legal void by establishing domestic laws and multilateral agreements that allow private companies to own, extract, and commercialize space resources. For instance, in 2015, with a controversial, bold, and forward-thinking move, the United States established the U.S. Commercial Space Launch Competitiveness Act, which grants private players the right to own and sell resources from outer space. Following this initiative, Luxembourg promoted a legal framework that allows property rights over space resources, which made the country a hub for space mining companies [5]. These independent actions highlight on one hand the rising interest and tension that revolve around property rights in space and, on the other hand, the inadequacy of the actual legal regime that regulates the activities that exploit space resources. That is why a new policy framework is needed to ensure a fair, regulated, and sustainable development of space activities.

The creation of a fair and effective policy framework is a compelling issue. The interests of countries and private entities in space resources are increasing and, consequently, potential conflicts over resource claims and mining rights could arise if they are not properly regulated through a set of universally shared rules. Those potential conflicts would jeopardize international cooperation in space and heat up geopolitical tensions. Furthermore, an uncertain policy framework weakens the whole industry as investors are not keen to commit their resources to projects on which they might be unable to claim ownership or profit rights in the future.

Through a comprehensive analysis of existing international agreements, domestic laws, and analogous situations (e.g. Law of the Sea), this thesis proposes a new policy framework for property rights in outer space. The new framework will try to balance the interests of all different stakeholders in order to be equitable and actionable. At the same time, it will focus on the economic incentives it will generate to drive and sustain the development of human activities in space.

# Chapter 2

# Context

## 2.1 The Importance of Space Resources

The utilization of space resources offers tremendous potential to advance space exploration, support sustainable human presence beyond Earth, and provide economic and technological benefits. That is why understanding and developing legal and policy frameworks to govern the extraction and use of these resources is crucial for the future of space activities.

The most interesting resources that could be extracted in space include helium-3, lunar water, and metals.

Helium-3 is an isotope of helium abundant on the moon that can be used in many different fields, including energy, medicine, and space exploration. Helium-3 is mineable on Earth as well, but not in enough quantities to generate the amount of energy necessary to make its production and distribution commercially viable [6]. The impact of this new source of energy cannot be underestimated. Researchers estimate that fusion reaction through Helium-3 could provide ten times more energy compared to the energy that can be generated by Earth's recoverable coal, oil, and gas combined [7]. However, it must be noted that significant technological advancements have to be made in order to make Helium-3 fusion reactors feasible. Standard reactors cannot be used with Helium-3 and currently only one small-scale Helium-3 compatible fusion reactor has been built in the world. It was built at the Fusion Technology Institute at the University of Wisconsin and, as things stand today, its energy output is lower than its energy input [8]. Harrison Schmitt, an Apollo astronaut, estimates that it will take some decades before humanity will be able to develop technologies that could enable commercial fusion power plants [9]. In addition to that, France's eight billion dollar International Thermonuclear Experimental reactor is supposed to be a significant step toward

getting the necessary know-how to make Helium-3 commercially viable [10]. Helium-3 is receiving a lot of attention from private and public organizations because, if it is going to be used to lead the fusion reaction revolution, it will become the most valuable raw material of the solar system [11]. Helium-3 could provide humanity with a new clean source of energy. This will help to achieve the goals set by the UN agenda and reduce the stress on the Earth's reservoir of precious materials, which have various industrial applications [1].

As it has been proved by the analysis of lunar samples, the moon contains multiple water reservoirs that can be used to enhance space exploration, support human bases on the moon, and boost the new space economy [12]. Craters near the poles reach temperatures that are below 40 K. Here, water ice is formed due to the impact of comets or hydrated meteorites and by the migration of $H_2O$ and OH formed through the interaction between the solar wind and lunar regolith [13]. This lunar water can be used in the very near future to support human life on the moon (e.g. drinking, personal hygiene, agriculture). From water, humanity would be able to obtain oxygen and hydrogen, which would be used respectively for life support systems and to make fuel for rockets.

Large-scale space mining offers the possibility to extract critical metals (e.g. platinum, gold, and rare earth elements (REEs)) and minerals (e.g. nickel, copper, and cobalt). These materials are crucial for manufacturing technological components that are then used in different industries (e.g. electronics, renewable energy, and aerospace components) [14]. On Earth, these resources are quite concentrated in very geopolitically unstable regions and their extraction generates a lot of pollution [15]. Celestial bodies, in particular near-Earth asteroids (NEAs), might offer an alternative to on-Earth mining since they contain these minerals in higher concentration, and their extraction would be less polluting for planet Earth [16].

However, on an economic level, space mining faces critical challenges. As things stand today the costs associated with the transportation of heavy materials, the establishment of the necessary infrastructure and the management of mining missions in space remain prohibitively high, especially if compared with the cost of mining operations on Earth [17]. Anyhow, mining in space is still the wisest alternative for in-space operations if humanity starts expanding outside the Earth (e.g. colonization of Mars and the Moon). Moreover, the costs associated with the launch of rockets have dramatically decreased since the development of reusable rockets pioneered by SpaceX, meaning that it is not impossible to imagine a future where the utilization of space resources on Earth is economically sensible.

As space mining becomes a possibility thanks to technological advancements, the absence of an actionable international regulatory framework remains a significant barrier to its realization. Without a clear policy framework, investments will freeze and conflicts over ownership and control of these resources will arise.

## 2.2 Environmental and Socioeconomic Externalities

In the last decade, environmental externalities resulting from human activities have become a real concern and have led to a number of activities that monitor and try to reduce the negative effects of human activities on the planet. Among them, the production of energy through clean sources (e.g. solar energy, wind energy) has boomed, making some minerals such as nickel, copper, and cobalt essential for the transition to more sustainable sources of energy. However, this drastically increased mining activities, which have a negative effect on the planet [18]. In fact, due to population growth and higher living standards, mineral extractions have increased more than 60 times in the last 100 years [16]. Mining these minerals in space could decrease human pressure on the Earth's environment and, consequently, boost the sustainable development of human activities, which is a clear goal of the UN 2030 agenda [19].

The nations that participate in space activities reap the benefits in various economic sectors. As NASA states, in FY2021 NASA's efforts generated an economic output of more than 71.2 billion US dollars and supported more than 339,600 jobs [20]. In addition to economic benefits, space-faring nations reap the benefits of the technologies they develop, including GNSS systems, 3D printing in space, and Earth remote sensing activities. That's why the discussion around the new possibilities offered by mining activities in outer space must also consider the socioeconomic effects that this new business model will inevitably create. It is important to understand and govern these effects to guarantee a sustainable development of space activities and to avoid further expansion of the so-called "space gap" (i.e. the economic inequality between countries caused by the economic benefits reaped through space endeavors) [16]. Moreover, goal number 10 of the UN 2030 agenda states that countries should cooperate so that humanity is able to "Reduce inequality within and among countries" [19]. A policy framework and a regulatory model that does not consider the space gap will move the world further away from the UN goal number 10.

Resource extraction is the backbone of many economies around the world. According to the International Council on Mining & Metals (ICMM), 57 countries are resource-dependent. 23 of them are hydrocarbon-dependent countries (HDCs), meaning that they generate more than 75% of their resource export revenue with hydrocarbons, such as oil, gas, and coal. 18 of them are metals and minerals-dependent countries (MDCs), as they generate more than 75% of their resource export revenue with minerals and metals. 16 countries are dependent on both minerals and hydrocarbons, as their resource export revenue is a mix of minerals,

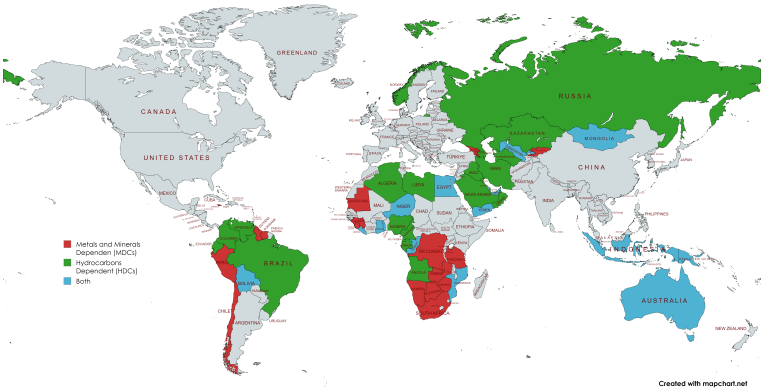


**Figure 2.1:** Distribution of resource-dependent countries around the world based on ICMM data

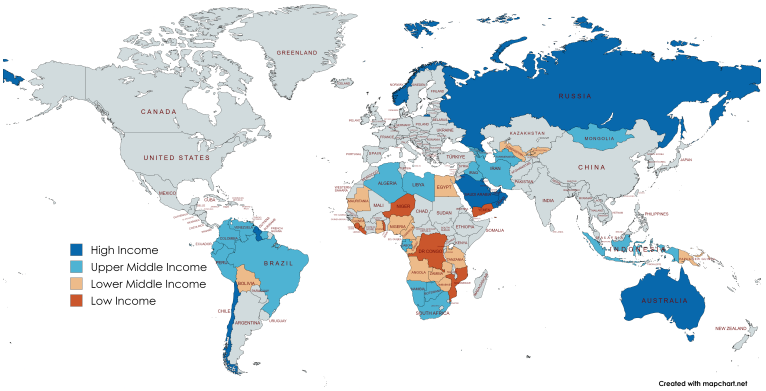


**Figure 2.2:** Resource-dependent countries categorized on income levels based on World Bank data

metals, and hydrocarbons [21]. Figure 2.1 shows the distribution of resource-dependent countries around the world.

As Figure 2.2 shows, many of these countries are not high-income ones [22], meaning that they will have a hard time competing in the space mining race. The vast majority of space-faring nations (almost 70%), in fact, are high-income countries [1], meaning that non-high-income countries will be impacted by the extraction of resources in outer space led by high-income spacefaring nations. Hence, if space mining is not regulated as it is today and space-faring nations reap all the benefits of space endeavors, inequality on Earth will dramatically increase.

## 2.3 The Current Policy Framework

The policy framework that currently regulates space activities and the ownership of space resources hinges on a combination of international treaties and national laws that try to fill the legal void left by those international agreements. The first international attempt to establish a space policy framework was the so-called Outer Space Treaty, which was signed in 1967. It is the most important space treaty since it has been ratified by 110 countries. Its first 2 articles ambiguously tackle the issue of the appropriation of space activities. The first article states as a general principle that outer space is the "province of all mankind" [3] and the second article prohibits national appropriation over space resources. These articles, however, remain too general and do not clearly address how property rights should be regulated. They aim to ensure that space endeavors benefit all countries and that nations cannot claim ownership of outer space, but they leave significant ambiguities related to the ownership and use of space resources by private entities.

In 1979 a more direct attempt to tackle the issue was made through the so-called Moon Agreement, which clearly states that the Moon and all other celestial bodies cannot be owned by any state or entity, proposing that all space resources must be equally shared by all humanity [4]. The Moon Agreement, however, failed to gain international recognition, as it has been ratified by only 18 countries, none of them being a space-faring nation. Moreover, categorically prohibiting the ownership of such resources and ideologically claiming that outer space must be shared by all humanity undermines all possible developments of human activities in space, preventing the advancement of humanity from a technological and economic perspective. That is also why major space-faring nations, which are at the forefront of such developments, refused to sign and ratify this treaty.

In 2020, The United States promoted a multilateral agreement to make sure that the interests of all nations participating in the Artemis Program are protected and that the mission lays on thorough legal foundations. Because of this, it has a very pragmatic attitude, clearly addressing operational aspects that will lead to the successful completion of the Artemis mission. It is a cornerstone of space law, but due to its limited scope, it fails to address more wide-ranging topics [23].

As a result of the legal void left by these international treaties, in 2015, The United States formalized the US Commercial Space Launch Competitiveness Act. This law explicitly grants US citizens and US-based companies the right to "transport, use, and sell" resources extracted from celestial bodies [24]. This smart phrasing kept the US committed to Article 2 of the Outer Space Treaty (prohibition of national sovereignty over space), while virtually enabling them to own space resources through their companies and citizens. This legislation paved the way to a new frontier of space law and to new legal frameworks, which have been adopted by other countries that recognize the commercial opportunities related

to space activities. For instance, Luxembourg passed a similar law in 2017 [25], followed by the United Arab Emirates and Japan.

These recent national laws aim at not violating the Outer Space Treaty while finding ways to legally own and exploit space resources contained in celestial bodies. However, this approach exposes space endeavors to the risk of a policy framework made of national, not universally shared laws that will generate conflicts and exacerbate inequalities. This led to several efforts to establish an international dialogue on the rising issue concerning property rights in space. In 2016, one year after the U.S. Commercial Space Launch Competitiveness Act, the Hague International Space Resources Governance Working Group was established to develop a new policy framework aiming to regulate space resource activities [26]. This body collects governments, space agencies, international organizations, and some private entities to build a thorough and robust framework. In 2019, the working group released some "building blocks" that, however, remain non-binding and didn't spur the creation of a new and comprehensive international agreement.

A thorough policy framework is needed to fuel the rising interest in space resources. Investments need certainty over ownership rights to thrive and a comprehensive policy framework will be useful to prevent potential conflicts and geopolitical tensions. To do that, the new policy framework must be equitable, sustainable, and formulated at an international level.

# Chapter 3

# Research Methodology

The research has been conducted to analyze the space law landscape related to space resource extraction from an international and national perspective. Particular attention has been given to three aspects that, as we have seen in the previous chapter, are of fundamental importance for the future of space exploration: equitability, sustainability, and governance. Furthermore, the context and objectives of each law have been analyzed to better understand the intents and goals behind all provisions. The research is based on a qualitative approach that hinges on both primary and secondary data.

## 3.1 Primary Data Analysis

International agreements and national laws form the primary data that has been considered in this thesis. Those are the laws that set the policy framework that regulates space mining activities. They are of fundamental importance. The international ones set the stage for all other unilateral or multilateral frameworks, while the national ones reflect the goals, needs, and specific interpretations of each country. Analyzing them is mandatory to develop a framework that builds upon international regulation while satisfying the needs expressed by important players.

- Outer Space Treaty (1967): The first international space law. Space is defined as the "province of all mankind" and national appropriation of celestial bodies is prohibited.

- Moon Agreement (1984): Builds upon the Outer Space Treaty and backs up non-space faring interests. It addresses modern topics, such as space resource extraction. Its tight provisions and reliance on future governance systems resulted in limited acceptance among space-faring nations.

- Artemis Accords (2020): Bilateral agreement promoted by the United States involving other nations participating in the Artemis programs. It highlights operative principles for cooperation in space exploration and resource extraction.

In addition to these international agreements, the research will analyze national laws issued to regulate space resource extraction under their respective jurisdictions. Those are the domestic laws promoted by the United States, Luxembourg, the United Arab Emirates (UAE), and Japan. All laws will be analyzed to dive deep into single-nation aspirations, needs, and implications in international activities. Furthermore, parallels will be made to understand the similarities and differences between national laws and international agreements (both vertically and horizontally).

## 3.2 Secondary Data Analysis

The analysis is also based on secondary data. In particular, existing literature on space law and analogous situations (e.g. Law of the Sea, climate regulations). This includes scholarly articles, policy papers, and technical reports issued by international organizations. The secondary data analysis serves several purposes:

- Literature Review on International Agreements and Domestic Laws:

  A comprehensive review of scholarly analyses of the Outer Space Treaty, Moon Agreement, and Artemis Accords will provide context for understanding the current legal regime's strengths and weaknesses. Similarly, the review of literature on national laws will offer insights into how different countries approach space resource utilization and what legal principles are emerging as norms in this domain.

- Analysis of Analogous Situations:

  To inform the development of a new legal framework, the research will examine analogous situations in international law where similar challenges have been addressed. Particular attention will be given to the regulation of deep-sea mining under the United Nations Convention on the Law of the Sea (UNCLOS). This case provides valuable lessons in managing common resources, preventing conflicts, and ensuring sustainable operations, which could be applied and adapted to create a new policy framework for space resource extraction.

- Scholarly Proposals for New Frameworks:

  The research will also review proposals from legal scholars and experts for new frameworks governing space property rights. These proposals range from

establishing an international regime for space resources to creating a credit-based system for resource utilization, as well as the application of soft law principles. Proposals will be considered to inspire the new policy framework. The analysis will focus on how these frameworks address key issues such as ownership rights, resource allocation, conflict prevention, and environmental protection.

## 3.3 Dimensions of the Analysis

The primary and secondary data analysis will be conducted taking into account the following 3 dimensions, which are not well framed in current frameworks, but require the foremost attention as discussed in the previous chapter. In particular:

1. Inclusivity and equitable access to space:

   - The utilization of space resources holds enormous promise for technological, economic, and societal advancement. However, the benefits of these activities risk being disproportionately concentrated among a small group of high-income space-faring nations, further widening the global "space gap." Many resource-dependent nations, particularly those classified as low- or middle-income, lack the technological capabilities to participate in space mining activities or access the benefits derived from them. This exacerbates existing inequalities and directly contradicts the goals of the UN 2030 Agenda, specifically Goal 10, which calls for reducing inequalities within and among countries.

     By focusing on inclusivity and equitable access to space, this thesis examines how current and proposed policy frameworks address the inclusion of non-spacefaring nations and proposes mechanisms for the equitable distribution of benefits. The goal is to explore whether current frameworks provide practical measures to ensure that space activities contribute to global welfare rather than deepen divisions. For instance, the redistribution of profits from space mining or collaborative ventures with non-spacefaring nations could be critical in achieving a fairer and more inclusive approach.

2. Environmental protection

   - Human activities, both on Earth and in outer space, have led to increasing environmental degradation. While space mining could provide critical resources to promote more sustainable operations, it also poses potential risks to the environment. Without adequate safeguards, space activities

could contribute to pollution in outer space, exacerbate the issue of orbital debris, or create unregulated exploitation of celestial bodies. This dimension evaluates how policy frameworks incorporate environmental sustainability into space resource activities. It emphasizes the necessity of preventing harmful environmental impacts, both in space and on Earth, while leveraging the potential of space mining to reduce the pressure on Earth's finite resources. For example, minerals such as nickel, cobalt, and rare earth elements, essential for renewable energy technologies, could be sourced from celestial bodies rather than being extracted through Earth's environmentally destructive mining practices. In doing so, humanity can meet its sustainability goals while preserving the planet's ecosystems. Furthermore, the focus on environmental protection also acknowledges the unique challenges of managing the pristine environments of celestial bodies. Protecting these extraterrestrial ecosystems aligns with the broader principles of sustainability and humanity's ethical responsibility to minimize its footprint as it expands into space.

3. Governance and international cooperation

- The absence of a comprehensive international policy framework to govern space resource utilization represents one of the greatest challenges to the realization of sustainable and equitable space exploration. Existing treaties, such as the Outer Space Treaty of 1967, establish general principles but fail to provide detailed guidance on the ownership, extraction, and distribution of space resources. More recent efforts, such as national legislation by the United States and Luxembourg, while innovative, risk creating a fragmented system of competing national interests rather than fostering international consensus. This dimension focuses on the need for robust governance structures and international cooperation to address these gaps. Without clear, binding agreements, the race for space resources could lead to geopolitical tensions, conflict, and legal disputes over ownership. Additionally, weak governance frameworks discourage investment, as uncertainty about ownership rights and regulatory requirements deters private sector involvement. Through this lens, the thesis explores whether proposed frameworks establish effective monitoring mechanisms, conflict resolution systems, and cooperative initiatives to regulate space activities. International cooperation is essential not only for ensuring fairness but also for pooling resources and expertise to address the technical and economic challenges of space exploration. For example, collaborative initiatives like the Artemis Accords show the potential for multinational partnerships in advancing shared goals in space exploration.

The following questions will guide the analysis of the different policy frameworks:

1. **Inclusivity and equitable access to space**
    - To what extent do proposed frameworks take into account non-space-faring nations?
    - Are there any mechanisms that ensure a redistribution of the benefits or resources on a global scale?
2. **Environmental protection**
    - Are environmental sustainability issues taken into account by regulators?
    - Are there systems to prevent space activities that are harmful to the environment?
3. **Governance and International Cooperation**
    - Do proposed frameworks put into place governance structures to monitor and regulate space activities?
    - Are there systems to ensure conflicts are prevented or managed fairly and non-violently?

Understanding these dimensions is key to assessing their incorporation into current policy frameworks and demonstrating the need for a new one.

## 3.4 Synthesis and Framework Development

The final stage of the research methodology involves synthesizing the findings from both primary and secondary data analysis to develop a new policy framework for property rights in outer space. This synthesis will be guided by several key principles:

- Inclusivity and Equity: The framework will aim to ensure that the benefits of space resources are shared globally rather than being monopolized by a few nations or corporations. This will involve proposing mechanisms for equitable access and distribution of resources, drawing on lessons from similar situations, such as deep-sea mining.
- Legal Clarity and Enforceability: The framework will seek to provide clear guidelines on ownership rights, resource extraction, and dispute resolution to reduce uncertainties and legal ambiguities that currently hinder investment and cooperation in space activities.

- Sustainability: The framework will incorporate principles of environmental sustainability, ensuring that space activities do not lead to the degradation of celestial bodies or the space environment. This may involve proposing regulations on space mining practices, debris management, and the preservation of key scientific sites.
- International Cooperation: The framework will emphasize the importance of international cooperation and collective governance in space, proposing structures that facilitate collaboration among nations while respecting their individual interests and contributions.

By integrating insights from international agreements, domestic laws, analogous legal frameworks, and scholarly proposals, this research aims to develop a comprehensive and forward-looking legal framework that can guide the future of space resource utilization in a manner that is fair, sustainable, and conducive to international peace and cooperation.

# Chapter 4

# International Agreements

## 4.1 Outer Space Treaty

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, commonly known as The Outer Space Treaty (OST), is widely regarded as the foundation document of space law. Signed in 1967, during the Cold War, the treaty reflects the political tensions and priorities of almost 60 years ago: preventing one superpower from claiming space as its own, fostering international cooperation, and avoiding the militarization of space. Article I, in fact, declares that space is "the province of all mankind" [3], meaning that access to space and the benefits humankind can reap from it should be shared by "all countries, irrespective of their degree of economic or scientific development" [3]. Following this principle, Article II prohibits any form of national appropriation, and Articles III and IV focus on preventing the militarization of space to ensure peaceful operations and to avoid the escalation of geopolitical conflicts outside the Earth.

### 4.1.1 The Principle of Common Benefit

Article I envisions outer space as a res communis omnium, meaning that it belongs to humanity as a whole, hence, it cannot be claimed, and the benefit associated with its use must be reaped by all humankind [27]. This approach, which hinges on the principle of collective benefit and non-appropriability, is leveraged by frameworks that address similar situations, such as the high seas and Antarctica [28]. Article I, however, does not frame an implementing mechanism, allowing States and scholars to speculate about its true meaning. Three main interpretations have emerged [29]:

1. Negative conception: The negative conception suggests that space-faring nations should not prevent other nations from exploring outer space and

should carry out their operations without harming other nations. States that do not monopolize space access or resources satisfy their obligation. Following this conception, States are not bound to share the benefits they have reaped through the exploitation of outer space.

2. Positive conception: States are allowed to carry out operations that benefit all countries simultaneously, without taking into consideration, however, the different benefit levels experienced by individual nations

3. Distributive conception: The distributive interpretation includes equitable sharing considerations. Space-faring countries must distribute tangible benefits to recipient states so that they effectively benefit from human space activities.

All those interpretations embody different definitions of fairness and equality, which have significantly different implications on the policies to adopt to regulate space commercialization.

Moreover, The Outer Space Treaty does not address private actors at all, which have been increasingly influential and increasingly driving space activities. To fill this legal void, nations such as the US and Luxembourg have granted private companies the possibility to own space resources [30]. Those provisions do not infringe the OST since only national appropriation is prohibited, but they create ethical and legal conflicts with the OST "common benefit principle". Those national legislations are also the result of the absence of a binding mechanism that allows all countries to interpret the benefit-sharing obligations to their advantage, minimizing the OST's effectiveness.

### 4.1.2 Environmental Protections Under the OST: Gaps and Challenges

Through Article IX, the OST addresses environmental issues by establishing 2 key obligations: to avoid "harmful contamination" of celestial bodies and to prevent "adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter" [3]. However, these terms remain undefined, creating significant interpretative challenges for modern space activities, such as space mining. Although some precautions can be taken, extracting resources always modifies the existing environment. Not knowing which degree and which kind of contamination is tolerated raises significant questions and, as Viikari theorizes, leaves the provisions open to subjective interpretation, forcing nations and private entities to operate without having clear environmental guidelines [31].

To apply those principles that aim at prohibiting outer space pollution, Article IX introduces the concept of "due regard", which requires states to carefully assess if their activities in space could impact the interests of other signatory parties. If they

do, they "shall undertake appropriate international consultations before proceeding with any such activity or experiment" (Duty of Consultation) [3]. Moreover, signatory parties can ask for international consultations if they reasonably believe that other states are planning activities that could impact the peaceful use of outer space (Right of Consultation). This formulation, however, does not take into account cumulative environmental impacts such as increasing the number of space debris. States might think they are respecting the treaty and doing no harm to other nations, overlooking the long-term impact of their actions [32]. Moreover, as Listner points out, states can ask for international consultation only if they have elements that led them to believe other parties are planning harmful activities, meaning they can't do it if such activities already materialized, as it happened, for instance, when Japan filed a claim against China's antisatellite tests on January 11, 2007 [33]. Chung interestingly compares Article IX with the Rio Declaration, a set of 27 principles adopted at the 1992 United Nations Conference on Environment and Development (UNCED) aiming at balancing economic growth, environmental protection, and social equality. In particular, principle 15 of the Rio Declaration frames the so-called "precautionary principle", which requires states to file a thorough Environmental Impact Assessment (EIA) to investigate and avoid potentially harmful activities. Adopting it would mean that the burden of proof would be reversed "when a prima facie evidence of risks is established" [34], which is particularly relevant for space activities since it's extremely difficult for states to monitor other states' space endeavors. EIAs would prevent the implementation of space projects that are detrimental to the environment while, at the same time, decreasing the costs associated with the pollution of outer space [34].

### 4.1.3 Governance Principles and Perspectives

The governance structure proposed by the Outer Space Treaty relies on broad self-regulated principles without providing a specific regulatory system to ensure its provisions are respected. This approach stems from the historical period in which it was formulated. In 1967, space was seen as a state-centric domain dominated by Cold War politics [35]. Private actors and space-faring nations were not in the picture, and therefore, the need for a heavier institutional governance structure was less impellent.

Article VI of the OST charges the responsibility of space activities to states [3]. They are the ones who need to authorize and supervise the activities of their citizens in outer space. While this approach allows to clearly identify who is accountable for space endeavors, it lacks cohesion and promotes fragmentation since it relies on state jurisdictions, which are different and inconsistent with each other [36]. This model was a good framework to fuel diplomacy and collaboration between a few space actors, but it is insufficient to manage the diversity of stakeholders that

are emerging and that are expected to increase thanks to the new space economy. On the contrary, it allows private actors to exploit inconsistencies in national regulations to their advantage, undermining the OST objectives. Moreover, the lack of an institutional mechanism makes it harder to enforce the provisions, since it requires states to rely on diplomacy or already existing institutional structures such as the International Court of Justice (ICJ), which only considers disputes between states [37]

Similarly, Article I, the cornerstone of the OST, is powerless without a structured governance framework. The important provisions related to the equitable use and access to space remain mere idealistic objectives and do not turn into applicable obligations in a space environment in which more than seventy nations have active space programs. This approach increases disparities without protecting smaller and less developed nations, which risks being left out of the outer space race. [38]

Governance limitations in the OST are particularly evident since the commercialization of space has become a reality. One of the current biggest challenges related to space activities is the management of space objects that orbit around the Earth. Private companies, such as Space X and Oneweb, are launching mega-constellations at an increasing scale in a deregulated environment. The OST's principle of equitable use and access to space are completely unaddressed, meaning that they currently are mere principles and not actual obligations [39]. The same shortcomings apply to resource exploitation. No specific guidance is provided on the matter, partially because when the OST was formulated, the topic seemed too far away in time to be addressed. Anyhow, this resulted in the creation of unilateral national legislations, such as the Space Resource Exploration and Utilization Act of 2015 and the Law of July 20th, 2017 on the exploration and use of space resources, promoted respectively by the U.S. and Luxembourg. These developments weaken the establishment of an internationally agreed policy framework, increase the likelihood of potential conflicts over resource rights, and undermine the OST principles, which have been the cornerstone of space law for more than half a century [37].

The rise of the new space economy reveals the limitations of the OST and increases the complexity of today's space environment. A new international enforceable legal regime that provides a consistent application and compliance to the OST principle, which has been signed by 115 states, is crucial. The absence of an international body and the vagueness of the OST provisions prevent its enforcement, the creation of a clear mechanism to resolve potential disputes, and the establishment of space as a true "province of all mankind", where all nations participate in its governance. Moreover, new principles have to be included to consider the involvement of the private sector, which is becoming more and more relevant.

## 4.2 Moon Agreement

The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, also known as the Moon Agreement, stands as one of the most significant yet controversial cornerstones of space law. By the end of the 70s, it became clear that the Outer Space Treaty had left significant gaps, especially regarding the exploitation of extraterrestrial resources and the governance of celestial bodies [40]. That is why, in 1979, 11 states including Australia, India, and France, signed the Moon Agreement (as today, the treaty counts a total of 17 parties) [41]. While the Agreement set ambitious principles to regulate outer space, it has not gained widespread acceptance. No major space-faring nations signed the Treaty, and France and India, which were two of the most prominent states that signed it, never ratified the Moon Agreement. The Treaty, with its very ideological and limiting provisions, sounded too stringent and impractical for space-faring nations and the development of space endeavors. The Moon Agreement, however, remains one of the most important documents about space law, and its provisions deserve to be analyzed and understood to develop a new policy framework.

### 4.2.1 Ideals of Equity and the Challenges of Implementation

The Moon Agreement stands as the most comprehensive international agreement on the exploitation of resources in outer space. Similarly to the OST, Article 11(1) of the Moon Agreement declares the Moon and its resources as the "common heritage of all mankind" [4] in an effort to include the whole world in space endeavors and the benefits they carry with themselves. However, as critics of the treaty notice, no practical mechanisms are put in place to ensure that ownership and access to space are shared between countries [42]. This general principle of equity between all men and countries is present also in Article 4, which states that "The exploration and use of the moon shall be the province of all mankind and shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development. Due regard shall be paid to the interests of present and future generations as well as to the need to promote higher standards of living and conditions of economic and social progress and development in accordance with the Charter of the United Nations." [4] This article expands the realm of influence of space activities since they have to be carried out to promote economic and social progress on Earth, and their benefit should be reaped by all countries, keeping in mind at the same time the interests of future generations. However, those provisions remain highly ideological, lacking real enforceable mechanisms to ensure such inclusions. Article 11(5) shyly mentions the institution of an international regime to govern the exploitation of lunar resources once it becomes feasible to

extract and exploit them. Nevertheless, it does not explain how it should be constituted and how states with limited or no space capabilities should be involved [43].

Marboe argues that relying on a future undefined international organism hinders the practical value of these provisions, especially for non-spacefaring nations [44]. This delayed implementation mechanism, combined with broad and ideological guidelines, leaves great uncertainty on how equitable principles should be operationalized. Moreover, the lack of major spacefaring nations as signatory parties expands the ineffectiveness of the treaty and the influence non-space-faring nations can have in the debate regarding the exploitation of space resources.

To show another example of the distance between the aspirational language and the operationalization of its provisions, we can consider article 11(7), which states that any international regime established under its regime shall envision "an equitable sharing by all States Parties in the benefits derived from those resources, whereby the interests and needs of the developing countries, as well as the efforts of those countries that have contributed either directly or indirectly to the exploration of the moon, shall be given special consideration." [4] Terms remain very vague and do not shape a path toward their application.

Delaying the implementation of an international regime when it becomes feasible to extract space resources carries another significant problem: States and private entities would not confidently invest large amounts of money to fuel space endeavors without a clear legal framework around their operations. Letting them know that nothing will be put into place until technologies are ready to exploit celestial bodies is a great setback to scientific and technological development. Such an institution would be crucial to ensuring the correct redistribution and equitable access to outer space, as the International Seabed Authority established under UNCLOS does by governing areas beyond national jurisdiction [45].

The Moon Agreement poorly addresses the needs of non-space-faring nations to build a just and inclusive policy framework that promotes the global transfer of benefits. In particular, it lacks binding mechanisms, experiences low ratification rates, and its ambiguous and ideological provisions weaken its aspirational principles. An operational and international regime is essential to enforce and promote its equitable vision of space.

### 4.2.2 Balancing Resource Use and Environmental Preservation

The Moon Agreement set various principles aimed at protecting the outer space environment. The cornerstone of those provisions is Article 7, which requires signatory parties to "avoid harmfully affecting the environment of the Earth or the Moon" and to "adopt measures to prevent the disruption of the existing balance

of the Moon's environment." [4] The central theme is the potential damage to both terrestrial and extraterrestrial environments due to space endeavors. The responsibility falls on States, which have to preemptively foresee those damages and act consciously.

Article 7(3) implements the designation of areas of the Moon as scientific preserves to protect areas of the Moon that are of particular interest from a scientific or environmental perspective. This provision would reduce the area of operations for resource extraction or general commercial use, effectively protecting parts of the Moon's environment. However, no criteria to identify those regions are provided, and there is no reference to processes or mechanisms that would designate which areas should be worthy of special protection. As a result, these environmental provisions remain more of an aspirational goal rather than real protection [46].

Article 11 tackles environmental considerations as well by stating that "the Moon and its natural resources are the common heritage of mankind" [4]. This implies that outer space resources must be exploited in the interest of all humanity, including future generations. Hence, the extraction of space resources must follow an environmentally sustainable and balanced approach.

Articles 7 and 11 indirectly address environmental protection, trying to promote a responsible exploitation of space resources. International cooperation is encouraged to preserve celestial bodies, but the lack of an implementation mechanism and the will to create an international overseeing regime only after the exploitation of resources becomes feasible make the Moon Agreement's environmental provisions a broad and general guideline instead of a real commitment. This approach is similar to Article IX of the Outer Space Treaty, which aims at avoiding "harmful contamination" of outer space without providing a clear definition of what can be considered as "harmful contamination", leaving room for different and contrasting interpretations. Ultimately, this leads to a fuzzy framework, difficult to enforce and ineffective at preventing the disruption of celestial bodies [46].

Environmental provisions are effective only if they are taken seriously by all the States and private entities operating in spaces. That is why another problem of the Moon Agreement is its limited adoption. Only 18 countries ratified it, and almost no space-faring nation was involved in the ideation of the treaty. Therefore, its ability to introduce environmental standards or to influence international policy frameworks is extremely limited [47]. Countries like the US, China, and Russia do not have to comply with the treaty, and, since they are the main players, even effective provisions would not be upheld.

Moreover, modern scenarios, such as space debris or the involvement of private companies in space activities, are not considered in the treaty, as you would expect from a framework developed more than 40 years ago. Since then, the spectrum of environmental risks has significantly widened, making the treaty ineffective in

protecting the extraterrestrial environment [43].

The Moon Agreement stands as an important document for its aspirational commitment to protecting the outer space environment. Nevertheless, its broad provisions, lack of enforcement mechanisms, and reliance on future international regimes weaken its aspiration to be an effective framework to drive a sustainable exploitation of space resources. Moreover, its limited adoption further undermines its influence, calling for a more shared and robust policy framework.

The Moon Agreement represents an important step toward integrating environmental considerations into the governance of outer space activities. However, its vague commitments, lack of enforcement mechanisms, and reliance on future actions undermine its capacity to address the environmental challenges of lunar resource exploitation effectively. The treaty's limited adoption and the absence of major space-faring nations as signatories further weaken its influence, highlighting the need for a more robust and universally accepted regulatory framework.

### 4.2.3 From Principle to Practice: The Governance Struggles of the Moon Agreement

The Moon Agreement does not develop a clear governance structure to enforce its provisions but relies on a future international regime. Article 11(5) advocates for creating a governance mechanism to control the extraction of space resources once this activity becomes feasible. In particular, based on the Moon Agreement regulatory perspective, the mechanism should ensure equitable sharing of the benefits derived from resource extraction and protect the interests of developing nations and future generations. However, the treaty does not mention the process for creating such an international regime, making its implementation challenging [48].

This vagueness and reliance on the future is one of the key reasons space-faring nations decided not to sign the Moon Agreement. From their perspective, the lack of clarity on how this governance structure would have protected their investments and technological advancements was unacceptable [49]. In fact, the ambiguity of the treaty has created dichotomic views on the results of the equitable sharing of benefits derived from outer space exploration. On one side, developing nations see that as a key component to maintaining space as the "common heritage of mankind" in a domain that is dominated by technologically advanced nations. On the other side, space-faring nations argue that redistributive provisions would be a deterrent to innovation and investments. Without copious and tangible returns, money would not flow to fuel progress in space exploration. Moreover, they extend the meaning of equitable sharing of benefits over monetary forms (e.g. technical assistance, international collaboration) [50].

Another key element is Article 11(3)'s prohibition of private ownership and

sovereignty of celestial bodies to both nations and private entities. Private entities' involvement is becoming more and more relevant in the space industry, and it is fueling innovation and progress. Private actors need to benefit from their groundbreaking discoveries or extraction of resources to operate and attract investments [51]. That is why more modern and balanced frameworks, such as the Artemis Accords, try to balance this tension by enabling commercial activities while prohibiting direct sovereignty claims [50].

Critics of the treaty argue that the aspirations of the Moon Agreement are completely aspirational and lack the pragmatism of frameworks tackling similar problems, such as the UNCLOS and the Antarctic Treaty System. The first one clearly established the International Seabed Authority to oversee resource extraction from the ocean, and the second one effectively postponed sovereignty claims while promoting collaborative provisions [48].

It's also important to notice that conflicts arising from resource claims or uncoordinated activities are not taken into account in the treaty. This is becoming more and more relevant with the recent interest in moon resources and its more valuable areas, such as the lunar poles. The absence of practical guidelines to avoid such conflicts reflects the inability of the Moon Agreement to effectively manage the realities of space governance [49].

To sum it up, the Moon Agreement falls short in addressing the divergent perspectives of developing and space-faring nations, where the firsts insist on prioritizing equity and inclusivity and the seconds claim that the focus should be on incentivizing space progress and investments without burdening driving actors with obligations towards developing nations. Moreover, its general and vague principle, combined with unclear guidelines for conflict prevention, make it an ill-equipped framework to govern space effectively and address the challenges of the 21st century.

## 4.3 Artemis Accords

The "Accords on the Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes", also known as the Artemis Accords, represent the most recent and significant attempt to develop an international policy framework to regulate space endeavors. Conceived by NASA and the US Department of State, the Accords emerged as a legal and diplomatic foundation for the Artemis Program, the mission which is supposed to land the first woman on the Moon and establish a sustainable human presence on the Moon by the end of the decade.

Inspired by the Outer Space Treaty, the Accords' foundational principles consist of strengthening international cooperation, seeking the peaceful use of space, and promoting transparency among countries. Moreover, it reflects current challenges,

directly addressing previously uncharted topics such as the use of space resources or the involvement of private actors. It is an effort to close the gap between old regulations, which don't tackle modern challenges, while trying to be more pragmatic, to drive the next space era.

Over 50 nations, including space-faring nations such as Canada, Japan, India, and several European countries have signed the Artemis Accords. However, major players (i.e. Russia and China) refused to participate in the formulation of the framework, which they perceived as being too aligned with the US strategic space agenda. This reflects the importance of geopolitics when drafting international policy frameworks and underlines today's political tensions and fragmentation, which ultimately undermines the long-term sustainability and effectiveness of the Artemis Accords.

The Accords stand as the modern cornerstone to drive the future of governance in outer space. Its principles and implications are key to understanding how space policies are evolving and what topics represent the core of today's regulatory challenges.

### 4.3.1 The Artemis Accords and Global Space Equity: A Critical Look

The Artemis Accords have a strong focus on space-faring nations despite being open to every country that is willing to embrace their principles. The main goal is to ensure that the interests of the nations participating in the Artemis Program are protected and that the legal ground on which they will all operate is set and shared. Their pragmatic focus is revealed by the fact that they mainly address operational aspects of space exploration and resource utilization. In particular, the Artemis Accords' provisions seek to guarantee safety, interoperability, and the prevention of harmful interference [52]. As an example, section 7 advocates for a commitment to determine which of the signatory parties "should register any relevant space object in accordance with the Registration Convention" [53]. While this provision is important to guarantee safety and accountability, it does not concern or include non-space-faring nations, which are unable to launch and operate space objects. Similarly, section 11 focuses on enhancing communication, collaboration, and coordination between nations to avoid harmful interference. This provision is again paramount to carrying on operations in outer space, but it only concerns space-faring nations.

The Artemis Accords do not explicitly theorize any mechanism to redistribute space benefits and resources. They simply reiterate the importance of existing international agreements, with a strong reliance on the Outer Space Treaty. However, as we have seen in the previous sections, the Outer Space Treaty's general principle that space endeavors should be carried out in the interest and benefit of

all countries does not translate into practical actions or redistribution mechanisms [23].

A form of benefit sharing is the Accord's principle to share scientific data. Section 8 binds signatory parties to openly share scientific data and advancements with the international community in order to contribute to a wider understanding of space and the benefits that nations can reap from it. Critics, however, argue that this provision is not enough to ensure fair and equitable access to scientific data [52]. As a matter of fact, no concrete framework is developed to facilitate technology transfers to developing nations. Moreover, the Accord's overall emphasis on bilateral agreements creates further concerns as space-faring nations could indulge in exclusive agreements that leave behind non-space-faring ones.

It is important to notice that the Artemis Accords also fall short because they are not meant to be a comprehensive policy framework for space governance. Their goal is to set a first step to develop shared and standard norms regarding space exploration and resource exploration in a domain that is rapidly evolving, especially from a technological and geopolitical perspective. That is why they are open to revision, and they could be complemented by further developments in international space law. As an example, the implementation mechanisms of the Moon Agreement, ideated by the Space Treaty Project, could broaden the provisions of the Artemis Accords. This proposed framework focuses on the "Grand Bargain", which states that private property rights can be granted in exchange for knowledge regarding technological advancements and the sharing of resources with developing nations [54].

To sum up, while the Artemis Accords propose some provisions related to the sharing of scientific data, they do a poor job of implementing them with a clear and equitable framework. The cornerstone of the accords is the operational and coordination aspect of space exploration between space-faring nations. This inherently ignores the integration of non-space-faring nations into the new space economy. Further developments of space governance could be integrated inside the Accord's provisions to create a more robust framework that not only eases the operational aspects of space exploration but ensures the equitable and profitable utilization of outer space.

### 4.3.2 Sustainable Lunar Exploration: The Artemis Accords' Approach

The Artemis Accords do not really address environmental considerations to foster sustainable operations in Outer Space. Section 10, which focuses on the benefits that humankind would reap from space activities, mainly supports "safe and sustainable operations" [53]. The Accords offer limited provisions explicitly addressing environmental sustainability in resource exploitation. While Section 10

acknowledges the potential benefits of space resource utilization for humankind, its emphasis lies predominantly on supporting "safe and sustainable operations". Scholars argue that the safety and sustainability of operations hinge on the feasibility and preservation of space endeavors rather than on the protection of the terrestrial and extraterrestrial environment [55]. Furthermore, the Accords heavily rely on The Outer Space Treaty, which, as seen in the previous sections, lacks a comprehensive framework to tackle environmental issues.

Similarly, Section 11 tackles environmental issues, but, again, without really focusing on developing a framework that ensures a more sustainable future for space endeavors. Section 11 provisions hinge on the concept of due regard for other states' interests and on how to avoid possible conflicts arising from environmentally harmful activities that could damage other parties' activities. That is the main reason behind the establishment of the so-called "safety zones". Moreover, scholars argue that safety zones are not sufficient to even prevent possible conflicts between signatory parties. The section, in fact, lacks a definition of such "harmful interferences" and does not set standards or frameworks to clearly enforce the regulation [52]. It is also important to notice that long-term effects of resource extraction, such as habitat damage or waste disposal, are never taken into account in the Artemis Accords, backing up critics' concerns [56].

Section 12 is also related to environmental considerations. It considers the impact of orbital debris. Tackling the issue is certainly valuable and modernizes the frameworks created by the Moon Agreement and the OST, but it is not enough to actually prevent the damages created by space debris. The provision, in fact, only commits signatory parties "to plan" for a policy framework without setting concrete requirements or enforcement mechanisms to actually reduce the impact of space debris. Some scholars also reflect on the fact that the Artemis Accords cannot be the instrument that regulates space debris management. They are not signed by all countries operating in space, meaning that the enforcement mechanism would not intervene in non-signatories' activities [23]. They argue that this is the reason why the Accords heavily rely on multilateral agreements to try to create a network of agreements that in the end would bind all countries to the same rules. This, however, is not a wise approach to create a sensible policy framework.

The Artemis Accords represent a modern and operational approach to step up international cooperation in space exploration. In this sense, environmental considerations are skewed towards safety and short-term conflict prevention activities without considering the bigger picture to ensure an overall sustainable future for extraterrestrial activities.

### 4.3.3 The Artemis Accords as a Governance Framework: Strengths and Weaknesses

The Artemis Accords, following the same logic as the other international treaties, do not create a formal international regime to regulate outer space activities but do theorize several provisions that contribute to a global policy framework. Elaborating on Article IX of the OST, transparency is a key principle of the Accords, embodied by several provisions that require signatory parties to disclose data and information related to their space policies, plans, and scientific advancements. It has to be noted that while this system enhances trust and accountability within nations, it does not implement a monitoring mechanism that could effectively account for every nation's space activities [52].

Section 5 of the Accords also includes governance provisions. There, the treaty advocates for the necessity of creating interoperability standards among space systems to make outer space exploration thrive. This provision aims at enhancing collaboration and efficiency among parties while also preventing possible conflicts that could arise due to technical incompatibilities [55]. Furthermore, to further increase transparency and to ease dispute regulation, section 7 upholds the registrations of space objects, in alignment with the Registration Convention.

However, the Accords do not advocate for an independent international body that could monitor and govern extraterrestrial activities, making it a weak instrument to actually resolve potential disputes and set a policy framework for the extraction of space resources in outer space. From a conflict prevention perspective, the treaty reaffirms the principle already stated in the OST. Section 11 of the Accords introduces "safety zones" to prevent space parties from harmfully interfering with each other in sensitive zones. The idea is to endorse peaceful operation in outer space, similar to what the OST does in Article IV.

Those steps are certainly positive, but they are certainly limited. First of all, the Accords are non-binding, meaning that they only rely on the goodwill of signatory parties [56]. This lack of enforceability poses serious concerns about the effectiveness of the Accord's provisions. Conflicts arising over the violation of safety zones or related to property rights over space resources are very likely, and they will not be solved through the Accords' provisions. Even innovative provisions, such as the safety zone one, rely on weak language and do not provide definitions or clear operational guidelines. For instance, the size, scope, and duration of such zones remain unclear [55]. Lastly, the absence of benefit-sharing provisions weakens the position of the Artemis Accords as a possible global framework to regulate space activities. This omission wears out international cooperation and leaves room for possible conflicts over the benefits reaped by space-faring nations [23].

The Artemis Accords represent a modern approach to the creation of space policies. The inclusion of more operational provisions and the concern over emerging

challenges, such as space resource utilization, make it a cornerstone for future space frameworks. However, their lack of enforceability, the ambiguity of some provisions, and the lack of benefit-sharing considerations underline the need to further refine and iterate the Accords to come up with a more comprehensive governance framework.

# Chapter 5

# National Laws

## 5.1 United States

The Commercial Space Launch Competitiveness Act of 2015 (CSLCA) lays the basis for the commercial expansion of the US. The act is instrumental in guiding the transition from a heavily publicly supported space sector towards a new private-driven one. To encourage private innovation and investments the act clarifies licensing procedures, and, most importantly, grants US citizens the right to own and use space resources. This is a groundbreaking change if we compare the act with the most prominent examples of international agreements that regulate space activities. Because of that, the treaty has faced several critics, especially from non-space-faring nations, but it certainly represents an epochal change in space law and clearly states the position of one of the most important space actors in a legal environment full of uncertain provisions and weak global policy frameworks.

### 5.1.1 Equity and Collaboration in Space: The US Legal Approach to Access and Benefit Sharing

The CSCLA's primary objective is to foster the US commercial capabilities in outer space to provide a clear legal framework for resource ownership. Section 51303 explicitly allows US citizens "to be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained" [24]. The section further elaborates that this right is given in accordance with applicable law on the matter, including internationally binding agreements that the US has undertaken. The Act does not specify which treaties constitute such applicable law but explicitly refers to "international obligations", meaning that it is reasonable to assume that all international agreements signed by the US fall inside this category. The goal, however, is clear: to create a stable and

predictable policy framework to allow private actors to invest more consistently and with more confidence to propel innovation and be the pioneers in space resource utilization [57].

The Act hinges on the promotion of US commercial interests, raising serious concerns about the creation of a fragmented space governance that would disadvantage non-space-faring nations. Critics also doubt the fact that the Act could really constitute a regulatory framework that respects the US international obligations. The OST, for instance, advocates for a use of outer space that could benefit all countries and establishes the principle of non-appropriation, while the act upholds resource ownership and ignores non-space-faring nations.

Contrary to other frameworks, the CSLCA provides definitions of what is considered a space resource. According to section 51301, an asteroid resource is "a space resource found on or within a single asteroid" [24], and a space resource is "an abiotic resource in situ in outer space" [24], including water and minerals. This is certainly helpful and a step forward to a more clear framework, but some scholars argue that it should be complemented to clarify whether claiming rights over a large portion of celestial bodies could constitute a form of appropriation and, therefore, constitute a possible violation of article 2 of the OST [58]. This is particularly important because a policy void in this sense could nourish a "land grab" scenario where technologically dominant nations would completely marginalize non-space-faring nations and reap all the benefits of space resource extraction [59].

Section 51302(b) mandates the president to submit "the authorities necessary to meet the international obligations of the United States, including authorization and continuing supervision by the Federal Government" [24]. This provision is seen as an attempt to make the US comply with the international agreements they have undertaken [60]. By stating the roles and responsibilities of federal agencies and by nominating the authorities needed to meet US international obligations, the US hopes to foster international dialogue and preempt criticism [57]. However, this openness towards international dialogue does not translate into benefit-sharing considerations. Supporters of the law argue that those considerations are voluntarily avoided because of the vastness of space resources. They say that compared to other situations, such as the high seas, the number of resources is so vast that monopolization concerns are unfounded. This statement, however, does not take into consideration the scenario in which a nation takes control over a large portion of the resources contained in a celestial body, as could be the case for Mars [60].

The CSLCA national focus is clearly visible, making it a weak framework to thoroughly regulate resource extraction in outer space. Mechanisms to include non-space-faring nations are not mentioned, but it has to be noted that the act is one of the first frameworks to clearly allow resource ownership, which is a critical step to fuel private and public investment in outer space.

### 5.1.2 Balancing Commercial Growth and Environmental Stewardship

The Act's environmental provisions are scarce, and they usually only indirectly refer to systems aimed at preventing harmful activities on the Earth or in space environments. Section 108 strives for the development of a framework to authorize and supervise space endeavors. In doing so, it envisions the inclusion of multiple agencies to address thoroughly commercial activities in outer space. In this context, even if environmental considerations are not explicitly stated, this section could lead to the inclusion of agencies that could provide their environmental expertise to further streamline and broaden the framework [59].

The act mainly focuses on safety and on the development of voluntary standards to foster innovation and include the private sector in space activities. Section 111 advocates for the creation of voluntary standards to foster innovation and improve the industry's efficiency and safety. Environmental issues are not explicitly stated, but they could be included in the development of safety standards, particularly when looking at risks associated with launch and re-entry. For instance, space debris reduction would clearly be a critical topic to ensure safety in space operations, and at the same time, it would reduce the harmful impact of space activities on the environment [58]. Another example could be the safety standards that handle hazardous substances during launch preparations. Minimizing the risks derived from their use would certainly increase the safety of space operators while avoiding solid and water contamination [61]. This approach ensures the space industry enough freedom to innovate through voluntary industry standards while starting to provide more stringent frameworks to address safety and environmental protection.

The focus on growing the US commercial activities makes the CSCLA inadequate from an environmental standpoint. Some provisions, especially safety-related ones, indirectly leverage environmental considerations. The Earth and the outer space environments, however, can't rely on this to ensure that space activities are carried out in order not only to expand the human reach in outer space but also to protect the environment in which we live and operate.

### 5.1.3 Shaping the Final Frontier: The US Space Governance Model and Its Implications for Global Policy

The CSLCA was born to promote US commercial space activities. Given this special focus, it does not directly set up governance structures. On top of that, it wouldn't really be enforceable worldwide since it's a national framework. It is still interesting to understand how the US intends to regulate domestic affairs and what interpretations they give to the international agreements they engaged with.

The most important and groundbreaking provision is contained in section 51303.

There, the CSCLA explicitly grants US citizens the right to "possess, own, transport, use, and sell the asteroid resource or space resource obtained" [24]. It is also stated that this provision is in accordance with the international obligations of the US, including the OST. This clarifies the US position on resource extraction but does not include any framework to oversee and regulate such extractions. Critics argue that this approach raises serious concerns around the sustainability and equitability of space resource activities [60]. The focus of this provision is directed at the possibility of US citizens to actively own space resources rather than on creating a comprehensive framework to effectively regulate the extraction of resources from outer space.

The CSCLA recognizes the need for the US to comply with international agreements. In this sense, section 108 calls for a series of assessments to upscale the US capabilities in overseeing their commercial activities. This includes the examination of all the relevant authorities inside the federal government, the update of safety procedures, and regulations to enhance competitiveness. By acknowledging the importance of committing to already signed international agreements, however, the Act relies heavily on unilateral interpretations and domestic implementation rather than pushing for a real international enforceable framework. Section 403, for instance, states that the CSCLA does not "assert sovereignty or sovereign or exclusive rights or jurisdiction over, or the ownership of, any celestial body" [24]. It is clear that it is an effort to comply with Article II of the OST while reinforcing that section 51303 is valid and aligned with previous agreements, including the OST [57].

From a conflict prevention and management perspective, the CSCLA does not come up with specific systems but counts on already established international frameworks. This approach raises significant questions since, at the same time, the CSCLA grants US citizens the right to own space resources. It is reasonable to expect, in fact, that different actors will have competing claims over space resources that will translate into conflicts due to section 51303 [60]. Furthermore, international agreements, such as the OST, prohibit national appropriation over space resources, meaning that those treaties are not equipped to sort out possible disputes hinging on resource ownership. This lack of clarity could potentially worsen existing tensions, leading to unilateral actions from states or private entities [62].

The CSCLA aims to create a framework that balances the promotion of commercial activities while respecting the provisions of the international agreement signed by the US. Its heavy reliance on previous agreements to manage potential conflict over space ownership weakens its strength and might be proven insufficient once the commercial space sector is populated by more actors and will inevitably become more complex.

## 5.2 Luxembourg

Luxembourg, through its forward-thinking space policy framework, aims to position itself as a space hub. Its 2017 law hinges on the exploration and use of space resources for commercial purposes, recognizing the right under its jurisdiction to claim property rights over them. Furthermore, in 2020, 2 years after the creation of the Luxembourg Space Agency (LSA), Luxembourg passed another law to complement the 2017 one with provisions regarding space activities in general. While those laws make Luxembourg a new important space law actor, its laws have faced international criticisms for multiple reasons, including its lack of transparency, limited international coordination efforts, and the absence of a clear framework for conflict prevention.

### 5.2.1 Equity and Benefits in Space: Evaluating Luxembourg's Space Legislation on Resource Utilization

The Law's main focus is to frame a legal environment in which private companies under Luxembourg's legislation can confidently operate. It prioritizes a favorable and certain environment for commercial actors, emphasizing authorization and licensing procedures, and ignoring non-space-faring nations' rights to space resources. This approach is similar to the US one, where nations started to autonomously lead the creation of space law, focusing on the enhancement of their domestic commercial industries.

Similarly to the CSCLA, the most important provision of the Law of 2017 is contained in Article 1: "Space resources are capable of being owned" [25]. Furthermore, it explicitly states that its provision must comply with Luxembourg's international obligations (Article 2(3)). This provision alone is not enough to ensure fairness and equity on the benefits reaped by nations thanks to space activities and raises concerns over a possible conflict with the OST, which Luxembourg signed. Proponents of the law argue that the promotion of commercial space activities already includes benefit-sharing ambitions since all technological advancements and the economic growth that will follow will ultimately benefit all nations. However, without a clear framework, this "cascade effect" still risks widening the space gap and benefiting disproportionately first movers in resource extraction activities [63].

Luxembourg affirms that the Law is in accordance with the OST because, according to them, the OST does not prohibit resource appropriation. To prove that, they argue that the OST specifically targets the celestial bodies themselves, not the resources they contain. Drafters of the treaty did not see that as an issue at the time and so did not explicitly mention it in the treaty [64]. To support their thesis, they refer to the UN Convention on the Law of the Sea (UNCLOS), where high seas cannot be appropriated, but the resources they contain, like fish,

can. Furthermore, they drive a parallel with the Moon Agreement, which explicitly prohibits the appropriation of space resources. The argument here is that if the OST wanted to ban resource ownership, they would have stated it, as drafters of the Moon Agreement did [65]. Finally, they point their attention to Article I of the OST which advocates for freedom of exploration and "use" of outer space. Luxembourg argues that extracting and using space resources ultimately aligns with the overall OST objective to sustain peaceful operations in space [64].

Critics of the Law raise another important point: Luxembourg does not have launching capabilities, making the whole picture more complex since companies operating under Luxembourg's jurisdiction will have to interact with other countries to extract space resources [65]. The launching state legal framework will likely influence the recognition and rights under Luxembourg law and could possibly lead to jurisdictional uncertainties where companies might argue about what law should be applicable for their specific case [63]. This reflects the complexity and intersection of different parties inherently included in space law, which cannot be regulated by independent national frameworks but must fall under a shared international enforceable regulation.

In summary, Luxembourg's space resources law is an important development in space law. Following the US move, it raises significant questions about the future of commercial space exploration and the role of international space treaties. Its focus on commercial purposes and its status of national law, however, does not make it suitable to effectively manage space resource extraction, especially considering the fact that provisions hinging around benefit-sharing and equitable access to space are not considered.

### 5.2.2 Luxembourg's Space Law and Environmental Safeguards for Sustainable Space Resource Utilization

Luxembourg's law of 2017 is recognized for its lack of regulation on the preservation of both the Earth and Outer Space environments. It does not provide mechanisms for the sustainable extraction of resources from celestial bodies and does not address the issue of space debris.

Article 10(1) states that, in order to obtain authorization to operate, applicants need to provide a "risk assessment" of the corresponding mission. This, as Hofmann recognizes, might include environmental considerations, but it certainly does not make them mandatory [66]. Article 16 advocates for full responsibility on the operators in case of damages derived from their activities. It is, however, unclear if they also consider environmental ones.

More interestingly, the 2020 general Space Law contained some environmental provisions in the 2018 draft, which have been deleted in the final regulation. The draft, in fact, obliged operators to protect the environment by setting up effective

measures to prevent negative effects. However, the provision was perceived as vague and, since the 2017 one did not include that, it was decided to remove such obligation in the final draft. The 2020 Law retrieves environmental considerations by applying the 2017 rule related to the damage created by operators. Article 2 of the 2020 Law includes the formulation "environmental damage", but only if it is directly caused by the space objects of the operator. While this is certainly an advancement compared to the 2017 law, it is definitely not enough, in particular considering the fact that environmental measures have been voluntarily deleted from previous drafts [66].

Luxembourg's policy framework focus, similar to what the US did, is clearly focused on guaranteeing a more reliable and commercially-driven legal environment to foster innovation and resource extraction activities. In doing so, it fails at delivering a comprehensive environmental policy framework, which was vaguely discussed during draft creation but was never implemented.

### 5.2.3 Luxembourg's Contributions to Space Governance and Conflict Resolution Mechanisms

The 2017 Space Resources Law of Luxembourg aims to achieve its goal of boosting commercial activities in space by creating a licensing regime overseen by the Luxembourg government. Article 2 states that every entity under Luxembourg's jurisdiction must obtain written authorization from the designated ministers before "using or exploring space resources" [25]. The law, however, does not come up with specific provisions to ensure that such use and exploration are carried in a responsible manner.

Licenses are granted for commercial purposes only and only to companies incorporated under Luxembourg Law. In order to apply for them, companies must include all relevant information [25]. This includes a comprehensive mission program, a clear administrative and accounting structure, and the existence of a central administration and a statutory office in Luxembourg. Furthermore, applicants must demonstrate the financial and technical feasibility of their mission. For transparency purposes, they also have to disclose their governance structure and the identities of shareholders holding at least 10% of the capital or voting rights. Lastly, they must submit a risk assessment of the mission which includes all the procedures that will be put into place to mitigate those risks [67].

The law further reinforces the concept that such authorization is not enough to guarantee the implementation of the mission. Applicants, in fact, must still make sure that their space endeavors comply with international law. This, however, as De Man notices, is problematic. The OST provisions about space resources ownership are not clear and the activities of companies incorporated under Luxembourg's law will also operate outside Luxembourg's jurisdiction since the country has no

launching capabilities [65]. There might be a case where another country might perceive the company's activity as a violation of the non-appropriation principle of the OST, making the mission authorized by Luxembourg not enough to actually claim property rights on what has been extracted.

From a conflict prevention perspective, the law falls short in addressing the topic. First, no provision regarding the sharing of information or consultation between potentially affected states is put into place [63]. This lack of transparency could potentially lead to possible conflicts over property rights that could be avoided with proper consultation mechanisms. This unilateral approach is reinforced by the fact that Luxembourg asserts jurisdiction over companies that will inevitably operate outside its territory, as explained before. Lastly, as this is a national framework, it lacks the international consensus to effectively manage space resource extraction and the conflicts associated with such activity [63].

The Luxembourg space policy framework, similarly to the CSCLA, while being a pioneer in granting property rights over space resources, lays its foundation on a non-shared interpretation of the OST and couples this uncertainty with unclear conflict prevention mechanisms, making it unsuitable to effectively manage space resources extraction on an international level.

### 5.2.4 Interconnected Frameworks: Exploring the Dependencies Between Luxembourg's Space Law and EU Regulations on Space Resources

Luxembourg is part of the European Union (EU), hence, it is interesting to explore whether Luxembourg's space law provisions might apply to other European countries or if some European laws might be enforceable in Luxembourg's legal framework.

Luxembourg space law maintains a very pronounced national character. All the obligations derived from Luxembourg's space law are enforced only to entities under its jurisdiction and are not expanded to EU countries. These laws, in fact, were designed to position Luxembourg as a leader in the space sector and did not aim to align with broader EU policies [67].

Unlike product standards or trade regulations, where the EU takes a harmonizing role, space law is still independent, and every country can develop its national laws and frameworks as long as it complies with international obligations [64]. However, EU regulations intersect with Luxembourg's space law activities. This is the case with the export of dual-use goods or technologies, which refers to objects that can have both civilian and military use. Based on the Export Control Law and Council Regulation (EC) No. 428/2009, dual-use objects are subject to controls to avoid the proliferation of weapons. In case some space resources are considered dual-use, then Luxembourg would need to comply with EU regulations and obtain proper

authorization to export them [67]. Regarding the recognition of property rights, the whole concept is not recognized at the EU level, meaning that entities that want to operate in other jurisdictions outside Luxembourg in the EU will need to obtain further recognition of such rights.

Proof of the fact that the UE did not take a harmonization role can be found in the multilateral agreements and partnerships Luxembourg is actively seeking. For instance, Luxembourg has published with the Netherlands a working paper called "Building Blocks for the Development of an International Framework on Space Resource Activities", meaning that Luxembourg is actively trying to align with EU countries to build a shared international framework on space resources [63]. Other examples can be seen in cooperative agreements Luxembourg has signed with Portugal and Belgium, which are a sign that they are trying to gather like-minded European countries on the topic [68].

While some applications of EU law in the space sector might be uncertain, the EU has not taken a harmonizing role yet, and Luxembourg space provisions remain excluded from the broader European legislation. Luxembourg, however, is actively participating in international debates to gather like-minded states to promote space resource ownership.

## 5.3 United Arab Emirates

The UAE has demonstrated a strong commitment to shaping space law by proclaiming 2 federal laws. The first one, federal law No. (46) of 2019 is the first Arab space law and focuses on promoting peaceful and sustainable use of outer space, while framing licensing and authorization procedures for entities operating in space, including the ones that engage in space resource extraction activities. The goal was to make the UAE's space sector thrive while respecting the international agreements undertaken by the country. To complement the 2019 law, the UAE issued a new one in 2023 to further attract private investment and to encourage private companies to pursue space activities. The UAE's policy framework hinges on three main axes: the effort to align with international treaties, the attraction of private investments, and the development of sustainable practices, in particular regarding space debris mitigation.

### 5.3.1 Outer Space and Global Fairness: The UAE's Framework for Equitable Resource Use and International Cooperation

Similarly to the US and Luxembourg laws, the UAE policy framework was born to enhance the country's position in the space sector by providing a clear legal

framework and allowing space resource ownership and utilization. The UAE, however, does not reserve a specific article to state that space resources can be owned, as the US and Luxembourg do. Based on the 2019 law, it is possible to notice that Article 4, when listing what activities will be regulated under the law, refers to the exploration and use of space resources [69]. Furthermore, Article 18 empowers the Council of Ministers to come up with procedures to ensure the acquisition, purchase, sale, trade, transportation, and storage of space resources [69]. In 2023 Cabinet decision No. 19, finally explicitly clarified the UAE position on space resources ownership by stating that authorized operators can exercise ownership rights under UAE laws [70].

The law grants property rights over space resources, but the focus is all on national interests and equitable access to space, and benefit-sharing considerations are not included in the UAE's framework. UAE's law manifests the intention to respect international treaties such as the OST, which include high-level equitable provisions that, however, are vague and ideal as we have seen in previous chapters. However, the UAE includes interesting provisions related to space debris mitigation, which could in fact be interpreted as considerations promoting a more equitable access to space. Article 23 of the 2019 law, in fact, is entirely dedicated to space debris mitigation and obliges operators to mitigate space debris impact and actively file reports to the authorities to minimize their impact [69]. Some scholars suggest that those provisions could effectively reduce space debris pollution and leave more room for newcomer space nations to develop their programs and reap the benefits of space exploration [71]. To reiterate the importance space debris has for the UAE, such provisions are repeated in the 2023 law and in the cabinet's decisions.

Creating an equitable space environment is not the focus of UAE's space law, even if some considerations can be seen in space debris-related provisions. Further advancements must be made in this sense, in accordance with other nations, to develop a truly effective and equitable policy framework.

### 5.3.2 UAE's Role in Promoting Environmental Sustainability in Space Resource Exploitation

As we have quickly seen in the previous section, similarly to other national legislations, while the UAE laws focus on enhancing commercial space activities, it is interesting to notice that specific provisions regarding space debris mitigation are included. Article 1 defines space debris as "a space Object that has no role or purpose, or the remains thereof, and the materials, waste, or fragments resulting therefrom, whether in Outer Space, including the Earth's orbit or inside the Earth's atmosphere." [69]. The law of 2019 highlights obligations for operators who have been authorized to pursue space activities. In particular, they have to take measures and plans to minimize the risks associated with space debris by notifying the UAE

Space Agency if their objects are generating space debris, if potential collision risks are arising, or if mitigation plans are changing [69]. Furthermore, as Cabinet Decision No. 19/2023 confirms, operators need to submit the measures they intend to undertake in order to minimize space debris generation throughout the whole mission, from launch to disposal [70].

Critics raise some concerns. First of all, Article 43-45 of the Law of 2019 specifically set up fines and penalties in case operators file false information or interfere with the Agency's inspection activities. However, no provision aiming to punish non-compliance with space debris mitigation is put into place, weakening the framework [72]. On top of that, the framework suffers from the fact that it takes into account only entities that operate inside the UAE jurisdiction, making it more difficult to actually enforce such provisions in an environment that is filled with objects launched by many different countries.

UAE space laws also mention the environment in their provision. In order to obtain the authorization to operate, in fact, entities must demonstrate they are taking measures to prevent or mitigate risks related to harmful pollution in space, production of space debris, and harmful interference with other space debris [70]. This suggests a certain degree of commitment of the UAE towards environmental protection, even if those provisions are vague and not easily enforceable. There are similarities with the environmental provisions contained in the OST, which the UAE signed and reiterated in its own national law.

The UAE space law demonstrates some consideration of environmental aspects, especially the ones related to space debris mitigation. However, while it provides some general provisions on the harmful effects of space debris and pollution, it lacks clear and enforceable legal mechanisms. This ambiguity, paired with the national character of the law, raises questions on the effectiveness of the UAE space law to actively mitigate environmental risks.

### 5.3.3 The UAE's Role in Space Governance: Building a Framework for Responsible Resource Management and Cooperation

Similarly to the US and Luxembourg laws, the UAE establishes an authorization system to validate space missions under its jurisdiction. Such authorizations can take different forms [70]:

- Licence: granted for commercial space activities, allowing companies to engage in profit-making ventures
- Consent: specifically for non-commercial space activities conducted by government bodies, academic institutions, or research entities

- Permit: facilitates the implementation of other already authorized activities, focusing on specific actions or operations necessary for the primary activity to proceed
- Trial Licence: reserved for experimental or testing phases of new technology or space systems, allowing for innovation and development without immediate financial returns

The UAE Space Agency grants the authorizations necessary to operate in order to promote responsible and sustainable space activities. In particular, it assesses the effect of space missions on public health and safety, national interests and security, and the environment. Furthermore, operators must comply with the UAE's space-related laws and international obligations and also need to demonstrate the financial feasibility of their endeavors [70].

From a conflict prevention perspective, it is interesting to notice that the Dubai International Financial Centre (DIFC) and the Dubai Future Foundation (DFF) launched in 2021 the Courts of Space Initiative, a specialized court that has been created to develop expertise in space law and provide guidelines for dispute resolution [73]. The court is tasked to promote several initiatives. First of all, it mandates an international working group, which includes actors from both the public and the private sector, to monitor and anticipate future challenges, so that specific training programs and guidelines can be put into place to face future disputes. The Court also frames the so-called Space Dispute Guide, a set of guidelines to ease conflict resolutions and the applications of the same standards across different cases. Furthermore, recognizing the complexity and the speed at which the sector changes, judges are constantly trained to ensure they are equipped with the necessary knowledge to handle specific space cases [73].

The goal is to provide certainty and foster private investments by ensuring that companies can operate in a predictable legal environment. It is also important to note that the UAE recognizes the importance of building an international consensus on space issues. The international working group, in fact, can be interpreted as an effort to harmonize interpretations of international law [74].

While those initiatives are certainly interesting and beneficial, there is still a gap in the UAE space law. Enforcement mechanisms remain weak, especially on environmental issues. However, the creation of a specific space court is an interesting innovation that could bring some clarity to an internationally blurry legal system.

## 5.4 Japan

Japan's space law is based on the Basic Space Law of 2008. This law frames the fundamental principles that must guide Japan's space endeavors, which include

international peace, improving citizens' lives, and economic growth. Then, in 2016, Japan promulgated the Space Activities Act (SAA), which articulates the discipline around space objects, satellites, and launch site management. Finally, in 2021, Japan became the fourth country to allow under its jurisdiction to own and extract resources from celestial bodies.

Such a legal framework emphasizes Japan's engagement in outer space activities and legislation. While the first legislations were more tailored towards promoting space technologies for public needs, recent developments suggest Japan's intention to further strengthen Japan's private sector competitiveness.

### 5.4.1 Promoting Equitability in Outer Space: A Critical Review of Japan's National Space Laws

Japan's attention to the international consequences its activities might trigger can be found repetitively in Japan's policy framework. Both the 2008 Basic Space Act and the 2021 Space Resources Act emphasize the importance of complying with Japan's international agreements and other nations' interests [75]. In particular, Article 6 of the Space Resources Act states that space activities must not interfere with Japan's international obligations and must not harm other nations' interests [76].

The law frames what is intended as space resources. The definition is the following: "water, minerals, and other natural resources that exist in outer space including the moon and other celestial bodies" [76]. Japanese law also clarifies that only the resource can be owned and not the celestial bodies the resources come from to comply with international agreements. Furthermore, the Prime Minister can approve licenses to operate only if requestors' activities do not potentially harm international cooperation [77].

As the ESPI (European Space Policy Institute) recognizes, Japan promotes the free sharing of data collected through satellites such as remote sensing or PNT (Positioning, Navigation, and Timing) data. This can be seen as an effort to share the benefits reaped by space activities with non-space-faring nations [78].

From a space resources perspective, however, Japan leverages international agreements, which are ineffective. Hence, space resources extraction under Japanese legislation will still indirectly advocate for a first come, first served framework, since no enforceable provisions go into the direction of regulating space resources extraction [79].

Japan seems to promote multilateralism and international discussions to regulate space endeavors, but its provision lacks enforceability to actually regulate space resource extraction internationally. In particular, relying on actual international agreements is insufficient. It has to be recognized, however, that promoting the free sharing of space data can be incredibly beneficial to boost many different sectors'

efficiency and effectiveness.

### 5.4.2 From Earth to Orbit: Japan's Approach to Space Sustainability Challenges

Japan's space laws and policies reflect the intent to address environmental issues, however, most provisions handle the topic only indirectly and with less clarity than in other areas of the law. For instance, the Basic Space Law of 2008 requires that Japanese space endeavors must be carried out with careful consideration for the effect of such activities on the environment. The law intends to pursue environmentally sustainable policies but does not provide environmental standards or a specific framework to enforce such provisions and protect the environment [78].

Some provisions that indirectly address environmental issues can also be found in the Space Activities Act of 2016. The goal of this law is mainly to manage satellite and launching operations. Uchino notices that Article 4(1) of the SAA requires operators to obtain a license from the prime minister to approve their space activities [75]. One of the requirements is to comply with international agreements, including the OST, which mentions environmental safety in its provisions. However, as we have seen, the OST environmental framework is weak and ineffective, so even compliance from Japanese operators would not automatically translate into environmental stewardship.

Similarly, Article 6 of the Space Resources Act of 2021 advocates that the actions taken under the Act must not hinder Japan's international commitment and must not cause damage to other countries' space activities [80]. Furthermore, Article 7 requires Japan to collaborate with the international community to frame a shared and consistent framework to structure the exploration and extraction of resources from outer space [80]. This could potentially include the definition of environmental standards, but it only relies on future hypothetical actions.

Despite these efforts, Japan's environmental commitment in its space law framework is not enough to effectively protect the Earth and outer space environments. It's particularly interesting to notice that safety and security measures are more clearly stated and framed, proving that environmental considerations were not carefully discussed when drafting the different laws [75]. The issue gets bigger if we consider that the SAA's goal to boost commercial ad launching activities incentivizes foreign actors to use Japan's launching sites, meaning that the creation of new space debris and environmental pollution will inevitably fall under Japanese jurisdiction [81].

To conclude, even if Japan's policy framework addresses environmental considerations, they usually are only embedded indirectly within safety, security, and international obligations. This is an issue especially because Japan's thriving space industry is expanding towards commercial activities, meaning that environmental

considerations will be even more important once launches, emissions, and space debris will inevitably increase.

### 5.4.3 Orchestrating Space Activities: Japan's Policies and Regulatory Mechanisms

One of the key elements of Japan's space governance is the licensing mechanism established in the SAA. According to it, every entity willing to launch a satellite from Japan's territories must obtain a license from the Prime Minister [77]. In particular, the idea is to supervise all non-governmental activities to ensure that Japanese space endeavors are undertaken safely and in accordance with Article VI of the OST [75], which states that "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty" [3].

Additionally, the 2021 Space Resources Act creates a new layer of licensing procedures for space resources extraction activities. The requirements in this case are more stringent, requiring the submission of a business activity plan. This plan must detail the purpose, term, location, methods, and financial aspects of the space activities that the requester wants to carry out [79]. Furthermore, licenses are granted only if the extraction of resources is intended for peaceful purposes and if the activities do not interfere with other nations' interests [79].

From a conflict prevention perspective, Japanese space laws repetitively insist on complying with international agreements and respecting other nations' interests in space. This could, in theory, be considered as some sort of conflict prevention mechanism, even if more enforceable and punctual provisions would be beneficial. Furthermore, Japan advocates for transparency to avoid disputes by publishing all submitted business activity plans. Scholars, however, note that it is still allowed to withhold sensitive information, which may weaken transparency objectives and lead to conflicts due to information misalignment [79].

Regarding conflict management, Japanese law does not provide specific provisions, relying heavily on international frameworks and discussions.

Japanese licensing system, similar to other countries' frameworks, can certainly help to monitor local space activities in order to make them responsible and sustainable. Furthermore, Japan's willingness to collaborate internationally can be interpreted as a good sign for future developments, even if the reliance on current international agreements weakens Japan's space governance system. The conflict prevention and management systems are fragile and need further refinement to be more effective and enforceable.

# Chapter 6

# Comparative Analysis

Outer space regulations and frameworks involve an intricate relationship within international treaties and national legislations. The following section will highlight key differences and analogies between the national laws and international agreements that have been analyzed in the previous chapters. The analysis of the different approaches adopted by countries and international drafters and the interplay with them will be key to developing a new thorough policy framework.

## 6.1 Horizontal Comparison

### 6.1.1 International Agreements

The Outer Space Treaty (1967), the Moon Agreement (1979), and the Artemis Accords (2020) are the three key international agreements that frame outer space law.

The Outer Space Treaty, which is the most internationally adopted space treaty with 115 [82] parties is the foundation of space law and establishes key principles that shape all space law, such as the prohibition of national appropriation over celestial bodies and the principle that outer space endeavors must benefit humanity as a whole. With only 17 parties [41], the Moon Agreement set the stage for non-space-faring nations' interests by promoting equitable resource-sharing principles but has experienced low influence due to its low adoption. Finally, the Artemis Accords are the most modern multilateral agreement on space activities, aiming to boost commercial space endeavors.

The OST derives most of its principles from the idea that space is the "province of all mankind", which advocates for equality between countries when addressing topics such as equitable access to space and how benefits derived from space exploration should be handled. It prohibits national appropriation over space

or celestial bodies, without explicitly addressing privates' rights to extract space resources. The treaty relies on vague language, which ultimately leads to different interpretations, making it weaker from an enforceability perspective. Furthermore, it does not take into account modern challenges since it was drafted almost 60 years ago.

Article IX frames the environmental policy of the OST by requiring parties to avoid harmful contamination of both the Earth and outer space environments. The treaties hinge on the "due regard principle", which mandates international consultations in case space activities might impact other nations. This approach, however, falls short in addressing environmental problems that do not directly harm another country and struggles to face cumulative impacts such as the one related to space debris management. Furthermore, consultations can only start after the harmful activities as taken place, making it useless from a prevention perspective. Some scholars advocate for the introduction of Environmental Impact Analysis instruments, such as the ones used in the Rio Declaration.

From a governance perspective, the OST relies on a self-regulated governance structure based on general principles rather than specific regulations. Article VI assigns to states, which are meant to authorize and monitor their space activities, leading to fragmentation, inconsistent national regulations, and a weak international enforcement mechanism. The OST provisions and governance structure are vague and idealistic and fall short when trying to address modern challenges such as the emergence of private space actors and the creation of unilateral national space policy frameworks.

The Moon Agreement declares the Moon and its resources as the "common heritage of mankind", but, similarly to the OST, relies on weak language and does not actually ensure equitable access among nations and ownership rights. The long-term view of the agreement can be recognized by the fact that it supports economic and social progress on Earth while considering future generations' interests. This, however, is considered more as an ideological purpose than a reality. The Moon Agreement also advocates for the creation of an international regime to govern the equitable distribution of space resources and the benefits associated with them, but only once resource extraction becomes feasible. The delay creates uncertainty and does not help to encourage innovation and sustainability.

The Moon Agreement tackles environmental challenges primarily through Article 7, which requires states to avoid harming terrestrial and extraterrestrial environments while advocating for the protection of scientifically significant lunar areas. Article 11 and its consideration for future generations can also be interpreted as a way to ensure environmental sustainability. Nevertheless, such provisions lack implementation mechanisms and are weakened by the low adoption rate of the agreement.

The Moon Agreement's governance structure relies on a future international

regime to govern space resource extraction, but its vagueness related to the protection of investments to get there contributed significantly to its low adoption, particularly among space-faring nations. This has created tensions between developing countries' interests and more advanced ones. Furthermore, the insufficient conflict mechanisms proposed by the agreement affected its popularity and made it unsuitable to tackle modern space governance challenges and close the gap between space-faring and non-space-faring nations.

The Artemis Accords propose a more pragmatic and operational approach to organize and coordinate space-faring nations' activities. It builds upon past international agreements, the OST in particular, and does not come up with benefit-sharing provisions. It advocates, however, for the sharing of scientific data, which critics argue lacks a real framework to make relevant data accessible to everyone. The Accords heavily count on bilateral agreements, raising questions on the fact that they could potentially leave behind some countries. Policy reviews and the adoption of new concepts such as the "Grand Bargain" could frame the creation of a more equitable framework.

The Artemis Accords focus more on operational safety rather than environmental protection. Sections 10 and 11 promote the prevention of harmful interference with the outer space environment, but they do not provide any concrete mechanism. Section 12 assigns to signatories the responsibility to plan policies to tackle the issue of orbital debris but does not come up with enforceable requirements.

The Artemis Accords set a framework to boost operational activities in space by regulating aspects such as the interoperability and registration of space objects, but they do not envision an international regime for outer space activities. From a conflict prevention perspective, safety zones are created even if their definition remains unclear. Furthermore, the Accords are non-binding, meaning that they rely on the good faith of its signatories, making it a weak instrument. Another problem is the lack of consideration for non-space-faring nations, which could lead to tensions and undermine international cooperation.

The OST, the Moon Agreement, and the Artemis Accords are the three more influential instruments of international law regarding outer space activities. The OST establishes foundational principles like the idea that outer space is "the province of all mankind" and that national appropriation is prohibited. The Moon Agreement shares those ideals and moves a step forward focusing on the Moon and its resources, taking a pro-non-space-faring nations approach. The Artemis Accords are the most recent piece of international law and focus on more practical operational aspects. All three regulations consider, directly or indirectly environmental challenges. They all generally focus on the prevention of harmful interference with terrestrial and extraterrestrial environments with the OST introducing the "due regard principle". It has to be said that none of them provides clear, enforceable measures. The key difference lies in their governance structures. None of them establishes a clear

international regime, but the OST advocates for a self-regulating framework, the Moon Agreement envisions future international bodies, and the Artemis Accords are in favor of a more bilateral approach to solve regulatory problems in space.

### 6.1.2 National Laws

The US Commercial Space Launch Competitiveness Act (2015), Luxembourg's Space Resources Law (2017), Japan's Space Resources Act (2021), and the UAE's Space Laws (2019, 2023) are the four key national space policy frameworks that regulate property rights in outer space. They all acknowledge the possibility for their citizens to extract and own space resources, leveraging a certain interpretation of current international agreements, particularly the OST.

The CSCLA creates a policy framework that, for the first time in history, allows citizens to legally own space resources. The Act clearly defines what is intended with space resources and mandates the President to oversight space endeavors in order to comply with international obligations. Some critics have argued that the CSCLA is in contrast with the Outer Space Treaty principles and could lead to a fragmented space governance. While its national characters and shortcomings make it a weak instrument to address space resource legislation challenges globally, it is certainly a first step in establishing clearer provisions related to space resource extraction in outer space.

The Act overlooks environmental challenges. Section 108 advocates for a multi-agency approach that could potentially address environmental issues, and section 111 indirectly refers to environmental measures when discussing safety norms to ensure the smooth deployment of space endeavors. The approach is more focused on innovation and safety, falling short on environmental-related topics.

Section 108 also mandates an assessment of US federal capabilities to effectively monitor space activities. Instead of creating a new framework, it mainly relies on justifying its provisions by deriving them from interpretations of the OST. A similar approach is taken to address conflict prevention and management issues, even if international agreements were not designed to grant and manage conflicts over the ownership of space resources. The CSCLA focuses on promoting US commercial efforts rather than creating a balanced space policy framework, which will be critical when space commercialization inevitably becomes more complex because of the emergence of new actors and innovations.

Luxembourg's Law of 2017 shares the same intents of the CSCLA. It creates a legal environment that promotes space resource extraction by granting ownership rights over them. The respect of international obligation is again paramount. Benefit-sharing and equitable access to space provisions are overlooked.

Environmental challenges are indirectly tackled through Article 10(1), which asks operators to provide risk assessment analyses of their missions, and Article

16, which assigns operators the responsibility for eventual damages. The 2020 general space law refers to environmental damage in Article 2, but it only seems to apply to damages directly caused by space objects, reiterating the commercial focus of the law. Furthermore, the 2018 draft of the 2020 law included more robust environmental standards, which were eliminated in the final legislation.

From a governance perspective, the Law comes up with a licensing regime that grants authorization from Luxembourg's government to operate. Some scholars pointed out that this approach raises questions since Luxembourg does not have launching capabilities, meaning that such authorization will inevitably interact with other jurisdictions, which might be in conflict. This problem, combined with the fact that it heavily relies on a unilateral interpretation of international agreements (similar to the US), makes it a weak instrument to effectively manage space resource extraction.

The UAE framework prioritizes space national commercialization interests as well, overlooking equitability challenges. Some scholars argue that the focus of UAE's space law on space debris management could contribute to the preservation of the space environment. Therefore, it could be considered a provision in favor of opening access to all countries since it would allow for more room for emerging space countries to deploy some of their programs.

The UAE's environmental policy is particularly focused on space debris management. Operators are required to implement space debris mitigation processes throughout the whole lifecycle of the mission. While the intent is praiseworthy, scholars noticed two main limitations: non-compliance with the actual implementation of such mitigations does not translate into penalties, and the impossibility of applying such regulation outside the UAE jurisdiction (for a topic that is inherently international).

The UAE's also set up a license system to oversee the space activities under its jurisdiction, dividing the authorizations into 4 categories (commercial licenses, non-commercial consents for government and academic entities, permits for implementing authorized activities, and trial licenses for experimental technologies). An interesting innovation is included in the 2021 Law, which creates the Courts of Space Initiative, a body engaged in international discussions trained and specialized to solve space disputes and set important precedents in the field.

Japan's space policy set its foundation on the respect of international law. This approach is repeated several times in the laws' provisions. It allows space resource ownership but clearly states that celestial bodies can't be owned. Japan promotes some benefit-sharing initiatives, such as the free distribution of satellite data, but critics argue that the strong emphasis on respecting current international agreements supports a "first come, first serves" approach since they are vague and weakly enforceable.

Japan's environmental provisions are generic and heavily rely on international

agreements, the OST in particular. The Law of 2008 vaguely mentions environmental considerations, the Law of 2016 calls for the respect of the OST, and the 2021 one contains aspirational goals regarding international cooperation and damage prevention. Such vagueness is particularly concerning since Japan's commercial space sector is growing and trying to attract foreign launches to its facilities, increasing environmental impacts

Japan's governance system relies on a licensing system to regulate satellite launching activities and mandates operators for details plans to assess space resource extraction activities before authorizing them. To prevent conflicts, Japan publishes the operators' business plan. This could be useful, but scholars argue that operators can ask to hide some information on sensitive topics, undermining transparency. Japan promotes the deployment of responsible space activities but its heavy reliance on international agreements and poor conflict management provisions show the need to refine its space policy framework further.

The four space national laws all share the same approach of prioritizing local commercial interests, overlooking global equitability issues. In particular, the US and Luxembourg demonstrate low interest in creating a framework that promotes equitable access to space and its resources. Japan supports some benefit-sharing ideas, such as the free sharing of satellite data, but ultimately supports a first come, first served due to the heavy reliance on current international agreements, which have low enforceability on the topic. Similarly, the UAE only indirectly addresses the topic by promoting space debris management regulations, which some scholars argue might be interpreted as an equitability provision.

From an environmental perspective, the US indirectly addresses environmental challenges through safety and innovation measures, without direct mechanisms to support environmental stewardship. Luxembourg provides a stronger framework mandating operators to file risk assessment reports and assigning them the responsibility for environmental damages, even if the law's environmental provisions are weakened compared to its previous drafts. The UAE provides the most thorough environmental framework, especially when addressing space debris management, however, due to jurisdictional constraints, it might be highly ineffective. Japan's approach relies heavily on international regulations, which do not address modern challenges and are too vague.

Each nation has created a national governance framework to administrate and monitor space activities and resource extraction. The US leverages its own interpretation of international agreements, and it is based on a monitoring system controlled by federal agencies. Luxembourg has implemented a licensing system and created dedicated courts to solve space-related cases. Japan also created a licensing system, which requires the filing of detailed business planning. Those business plans are published to prevent conflicts, but transparency can be a concern since sensitive information can be withheld.

## 6.2 Vertical Comparison

The interaction between international agreements and national regulations shapes the current policy framework in which agencies and private companies operate. Understanding the tensions, shared provisions, and ultimate objectives it's critical to understand the current framework and develop a more equitable, sustainable, and regulated one.

### 6.2.1 National vs International Law

International agreements were specifically designed to promote an inclusive and equitable approach. In fact, they all insist on the fact that outer space belongs to humanity as a whole, independently from geographical, economic, or social differences. However, this philosophical foundation remains theoretical due to vague language and weak enforcement mechanisms. National Space laws focus on domestic commercial interests. They rely on interpretations of international agreements that align with national strategic interests, indirectly promoting a "first come, first served approach". Furthermore, they contribute to the creation of a fragmented legal regime rather than a globally shared one.

From an environmental perspective, international agreements adopt a similar approach. They create a framework to protect the Earth and outer space environments, but they rely on weak language and do not create practical mechanisms to ensure environmental stewardship. National laws demonstrate different degrees of engagement regarding environmental issues. The US and Luxembourg minimally address the topic and only do so indirectly, mainly through safety provisions. Japan heavily relies on international agreements, and the UAE has developed a more thorough framework, especially on space debris management. However, due to its domestic nature, it can't effectively protect the environment since it is a global problem that needs the commitment of every country that launches objects into space.

International agreements fall short of establishing an international governance regime. The Outer Space Treaty advocates a self-regulating approach, the Moon Agreement relies on future international bodies, and the Artemis Accords promote bilateral agreements. National laws create more thorough frameworks, relying on licensing and oversight mechanisms. The UAE also creates special space courts, which are an interesting innovation in space conflict management. However, they remain unilateral, meaning that they can't be the foundation for the international coordination that is needed to ensure equitable, sustainable, and successful space exploration.

| Feature | Outer Space Treaty (1967) | Moon Agreement (1979) | Artemis Accords (2020) |
|---|---|---|---|
| **Core Principles** | | | |
| Legal Standing | Most widely adopted space treaty (115 parties); foundation of space law | Low adoption (17 parties); primarily supported by non-space-faring nations | Modern framework designed to promote commercial space activities |
| Ownership | Declares space as "province of all mankind"; prohibits national appropriation | Declares the Moon and its resources as "common heritage of mankind" | Builds on OST and allows space resource extraction |
| Key Limitations | Vague language leads to different interpretations and weak enforcement | Relies on a future international regime, delaying clear governance | Bilateral nature could exclude non-space-faring nations, risking fragmentation |
| **Environmental Protection** | | | |
| Core Principle | Avoid harmful contamination of Earth and outer space (Article IX) | Avoid harm to terrestrial and extraterrestrial environments (Article 7) | Focus on operational safety; lacks concrete environmental enforcement |
| Key Provisions | Relies on "due regard principle"; international consultations only after harm occurs | Advocates protection of scientifically significant lunar sites; considers future generations | Sections 10-12 promote safety and debris management but lack enforcement |
| Key Limitations | Does not address cumulative environmental impacts (e.g., space debris) | Lacks implementation mechanisms; weakened by low adoption rate | No clear environmental enforcement; relies on voluntary commitments |
| **Governance Structure** | | | |
| Regulatory Approach | Self-regulated framework; assigns oversight to national governments (Article VI) | Envisions future international regime for space resources | Relies on bilateral agreements rather than multilateral governance |
| Conflict Prevention | Vague enforcement; fragmented national regulations | Lacks clear mechanisms, leading to low adoption | Introduces safety zones, but definitions remain unclear |
| Key Limitations | Does not address modern challenges (e.g., private actors, unilateral policies) | Unclear protection for investments; fails to balance interests of space-faring vs. non-space-faring nations | Non-binding, making compliance dependent on signatories' good faith |

**Table 6.1:** Comparison of the Outer Space Treaty, Moon Agreement, and Artemis Accords

| **Country** | **Equitability Issues** | **Environmental Issues** | **Governance Issues** |
|---|---|---|---|
| **United States (CSCLA, 2015)** | | | |
| Core Approach | Allows U.S. citizens to extract and own space resources, leveraging an interpretation of the OST | Does not explicitly address environmental concerns; focuses on safety and innovation | Relies on federal agencies to monitor compliance with international obligations |
| Key Limitations | No provisions for benefit-sharing or global equitability | Section 108 suggests a multi-agency approach but lacks direct environmental protections | Prioritizes commercial growth over creating a structured international legal framework |
| **Luxembourg (Space Resources Law, 2017)** | | | |
| Core Approach | Promotes private ownership of extracted space resources with minimal focus on equitable access | Requires risk assessment reports (Art. 10) and assigns operators liability for damages (Art. 16) | Implements a licensing system for companies to extract resources |
| Key Limitations | No strong benefit-sharing or provisions for equitable resource access | 2020 Space Law references environmental damages, but its impact is limited | Jurisdictional conflicts may arise as operations span multiple countries, given Luxembourg lacks launching capabilities. |
| **United Arab Emirates (UAE Space Laws, 2019, 2023)** | | | |
| Core Approach | Prioritizes national commercial interests with no explicit provisions for equitable access | Strong emphasis on space debris management | Introduces a four-category licensing system and the Courts of Space Initiative for dispute resolution |
| Key Limitations/Innovations | Some scholars argue that space debris policies indirectly contribute to equitability by preserving space access | Lack of penalties for non-compliance with mitigation efforts; jurisdictional constraints limit enforcement | The Courts of Space Initiative could set international legal precedents for space disputes |
| **Japan (Space Resources Act, 2021)** | | | |
| Core Approach | Supports international law but allows ownership of extracted space resources while prohibiting ownership of celestial bodies | Environmental provisions are vague and rely on international agreements | Implements a licensing system requiring operators to submit business plans before extraction activities |
| Key Limitations | Supports a "first come, first served" model due to weak enforcement of global agreements | Mentions environmental concerns but does not contain specific regulatory measures | Operators may withhold sensitive business information, limiting transparency and governance effectiveness |

**Table 6.2:** Comparison of National Space Laws on Space Resources

| **Legal Framework** | **Equitability Issues** | **Environmental Issues** | **Governance Issues** |
|---|---|---|---|
| **International Agreements (OST, Moon Agreement, Artemis Accords)** | | | |
| Core Approach | Emphasize outer space as the "province of all mankind," promoting inclusive access | Establish principles for environmental protection but lack enforcement mechanisms | Advocate different governance models: self-regulation (OST), future international bodies (Moon Agreement), and bilateral cooperation (Artemis Accords) |
| Key Limitations | Vague language and weak enforcement mechanisms prevent equitable distribution of resources | No binding mechanisms to ensure compliance with environmental standards | No unified global governance framework; reliance on national implementations creates fragmentation |
| **National Space Laws (U.S., Luxembourg, UAE, Japan)** | | | |
| Core Approach | Prioritize domestic commercial interests, promoting a de facto "first come, first served" approach | Address environmental concerns to varying degrees, with UAE leading in space debris management | Establish licensing and oversight mechanisms to regulate space activities |
| Key Limitations | Contribute to a fragmented legal regime rather than a globally shared framework | U.S. and Luxembourg address environmental issues only indirectly; Japan relies on weak international agreements; UAE's laws are limited by jurisdiction | Unilateral governance frameworks cannot serve as the foundation for international coordination in space activities |

**Table 6.3:** Comparison of International Agreements and National Space Laws

# Chapter 7

# A New Policy Framework

Has seen in previous chapters, technological advancements and increasing investments have made space resource extraction a feasible reality. However, the current regulatory framework remains inadequate and fragmented both from an international and national perspective.

In this chapter, a new policy framework will be developed to guarantee a more thorough policy to regulate space resource extraction. The framework hinges on three aspects: equitability, sustainability, and governance. Those elements are the ones that have been analyzed throughout all the chapters and represent some of the most important topics that are lacking in current frameworks.

## 7.1 Establishing Equitable Distribution Mechanisms: A Credit-Based Framework for Extraterrestrial Resource Rights

As table 6.1 and table 6.3 show, international treaties pave the way for a more equitable policy framework but rely on weak language and do not come up with a defined plan to make resource extraction more equitable. Furthermore, space national laws focus on domestic commercial initiatives, leaving almost no room for benefit-sharing provisions.

The new policy framework must take into account the interest, made explicit by various nations, in pursuing space resource extraction. This could have enormous benefits to innovate and create a more sustainable future for humanity, as we have seen in chapter 2. On the other hand, this approach must be balanced by benefit-sharing and equitability provisions that ensure that outer space does not become a "first come, first served" market to protect non-space-faring interests and to comply with already existing international agreements, which highlights the

need to include all countries in the new space economy.

As Byrd states, it is important to make a clear distinction between the possibility to own land in outer space and the possibility to claim the resources extracted from celestial bodies [83]. By aligning with Japan's policy framework and Article 2 of the OST, the appropriation of land over celestial bodies should be prohibited, while property rights over the extracted resources should be considered legal and regulated accordingly. For instance, in the new international agreement that will regulate resource extraction in outer space, we could envision an article similar to article 1 of Luxembourg Law of 2017, which states that "Space resources are capable of being owned" [25]. In this sense, both private companies and public organizations could conduct missions aimed at collecting and claiming property rights on space resources.

To ensure that space resources are mined equitably and that the benefits are shared among nations, two solutions are possible. One option is to follow the Law of the Sea approach, where applicants have to pay fees and share revenues in order to operate. On the other hand, a system of tradable credits could be envisioned, where all countries have some sort of predetermined credit allocation [83]. The first option could be less efficient because the US is historically against this system adopted by the Law of the Sea, and the new framework necessitates the buy-in of space-faring nations in order to be effective and enforceable [83].

The credit system could be framed in the following way. An international body that will be discussed in section 7.3 allocates credits to member countries. Credit allocation for each country (i) is calculated thanks to the following formula:

$$\text{Total Credits}_i = \underbrace{\text{Base}_i}_{\text{Inclusivity}} + \underbrace{\text{Performance}_i}_{\text{Rewards}} + \underbrace{\text{Redistribution}_i}_{\text{Solidarity}}$$

The base allocation ensures that all nations are considered in the framework, irrespective of every other metric that will be considered to allocate credits. 30% of all credits are allocated to countries on a per capita basis:

$$\text{Base}_i = 0.3 \times \text{Global Credits} \times \left( \frac{\text{Population}_i}{\text{Global Population}} \right)$$

To incentivize space-faring nations to keep innovating and fueling technological progress, while considering environmental stewardship, the following formula will regulate 40% of credit allocation based on contributions to space exploration and environmental stewardship:

$$\text{Performance}_i = 0.4 \times \text{Global Credits} \times (\alpha \cdot \text{Tech}_i + \beta \cdot \text{Env}_i)$$

where:

- $\text{Tech}_i$: % of global R&D spending on space endeavors

- $\text{Env}_i$: % calculated by normalizing an environmental score that will be calculated by the governing body based on sustainable initiatives of each country considering:
  - Sustainable extraction practices (e.g., water recycling on the Moon).
  - Terrestrial environmental policies (e.g., carbon neutrality).

  The environmental score of each country can be summarized by this formula:

$$\text{Env}_i = \frac{\gamma \cdot \text{SpaceScore}_i + (1-\gamma) \cdot \text{EarthScore}_i}{\sum_{j=1}^{n} \left(\gamma \cdot \text{SpaceScore}_j + (1-\gamma) \cdot \text{EarthScore}_j\right)}$$

  where $\gamma$ and 1-$\gamma$ are weights that can be used to give more or less importance to Earth or space sustainability initiatives.

- Weights: $\alpha = 0.5$, $\beta = 0.5$ (adjustable during the draft of the international agreement to prioritize innovation or sustainability).

Finally, to make sure that the framework is equitable, countries with high GDP will receive fewer credits, so that poorer nations, which risk being excluded from the new space economy and participating less in space activities, can still reap its benefits by selling the credits.

$$\text{Redistribution}_i = 0.3 \times \text{Global Credits} \times \left( \frac{\frac{1}{\text{GDP}_i}}{\sum_{j=1}^{n} \frac{1}{\text{GDP}_j}} \right)$$

It has to be noted that the weights (30% on base, 40% on performance, and 30% on redistribution) are arbitrary. They should be further discussed and refined to meet an international consensus so that the vast majority of countries are aligned and the framework can be truly effective. These weights have been chosen to reward space-faring nations, which make space endeavors possible and sustain most of their costs while ensuring enough redistribution is granted to avoid the widening of the space gap.

Credits are tradable, so that even poorer nations, which do not have the capabilities to carry out their own space missions, can sell them to other countries, cashing in some of the benefits of outer space exploration. Private companies will buy them or receive them from the country that mandates the space mission.

Recurring estimations of credit value will be undertaken by the governing body. As an example, mining 1 ton of platinum-group asteroids might cost 100 credits, while extracting 1 ton of lunar regolith (lower value, lower impact) might cost 10 credits.

To avoid the creation of monopolies, credit ownership should also be capped to avoid its concentration in a small set of countries or companies.

## 7.2 Environmental Performance Metrics in Space Resource Extraction: Extending EPI Beyond Earth

As shown in table 6.2, international agreements broadly tackle environmental challenges, but they do not come up with enforceable mechanisms and ignore modern challenges (e.g. space debris management). Some national laws, especially the UAE one, address environmental challenges, but due to their domestic nature, they fail to produce effective environmental frameworks.

The first instrument that the international body can use to enforce environmental policies is the environmental score discussed in the previous section. A similar approach to the Environmental Performance Index (EPI) could be envisioned to effectively measure each country's environmental performance [84]. Furthermore, it could be used to incentivize companies and agencies to respect environmental policies. Developed by Yale and Columbia University, the 2024 EPI's framework organizes 58 environmental indicators, that are gathered into 11 categories and 3 policy objectives [85]. Each indicator contains a weight that represents the impact of the metric on the total score. Figure 7.1 displays the 2024 EPI framework.

Similarly, the environmental score could be calculated through the quantification of environmental policy objectives set by the international body that will be discussed in the next section. The international regime could set some environmental policies that will actively impact the number of credits assigned to countries, giving them incentive to comply with environmental criteria. The criteria should be flexible for two main reasons. First of all, it is important to meet an international consensus so that most countries adhere to the framework, meaning that rules cannot be too strict and require some flexibility to meet conflicting requirements from member nations. Secondly, the flexibility gives the possibility to change environmental policies dynamically, which is critical to navigating the challenges of such a fast-paced environment.

The international body could develop different strategies that better address the current environmental challenges. Different weights could be given to Earth and Outer Space environment-related activities proposed by each country (and the relative companies that operate under their jurisdiction). Countries and companies will be incentivized to support sustainable practices to receive more credits, which means extracting more resources and increasing revenues. A possible breakdown structure can be seen in figure 7.2. Based on those metrics, the international body could calculate the environmental scores of each country (high score, good environmental practices), which will then be used to directly calculate credit allocations. The real breakdown structure should be reached through an international consensus to ensure the participation of all countries, similar to what

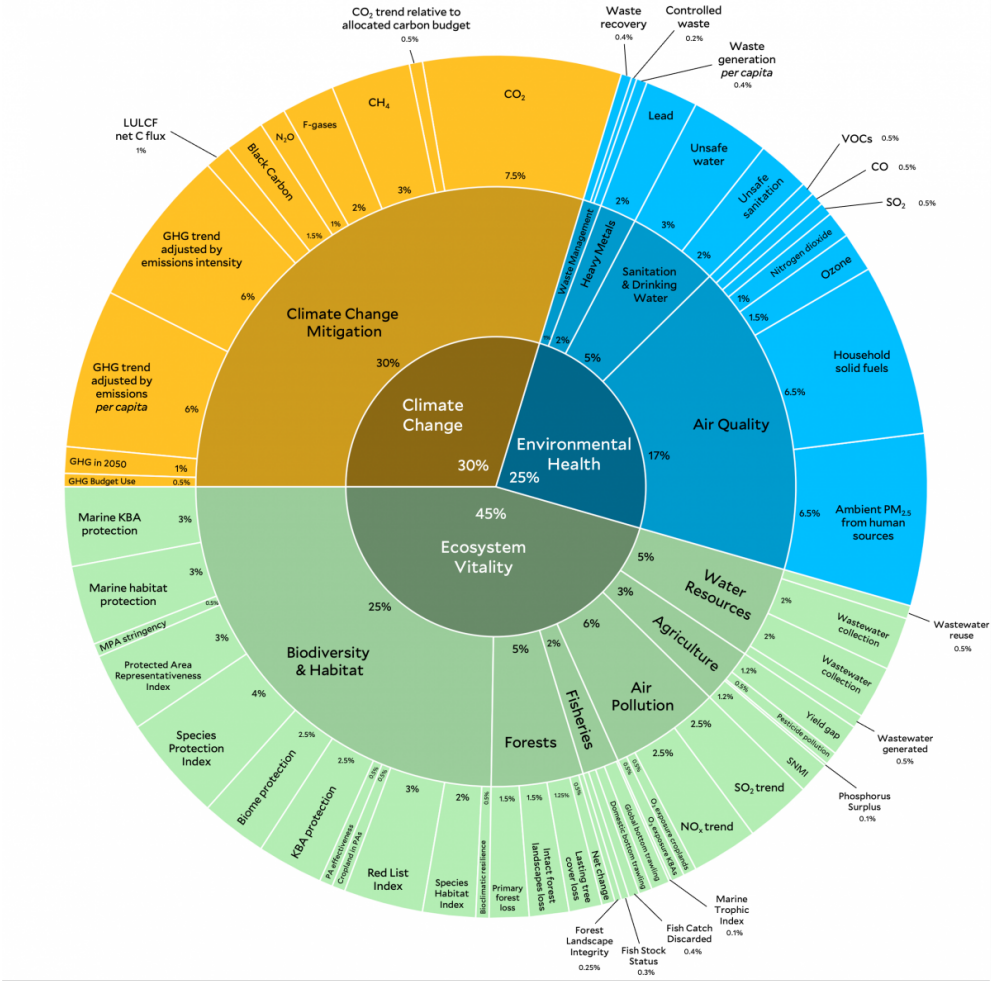


**Figure 7.1:** 2024 EPI Framework

was already said in section 7.1. It is important to notice that in figure 7.2, the percentages related to the Earth and Outer Space represent $\gamma$ and 1-$\gamma$ in the environmental formula presented in the previous section. Furthermore, following the example of the Artemis Accords, specific "safety zones" should be created to preserve scientific sites and avoid unintentional interference between different actors' operations on celestial bodies.

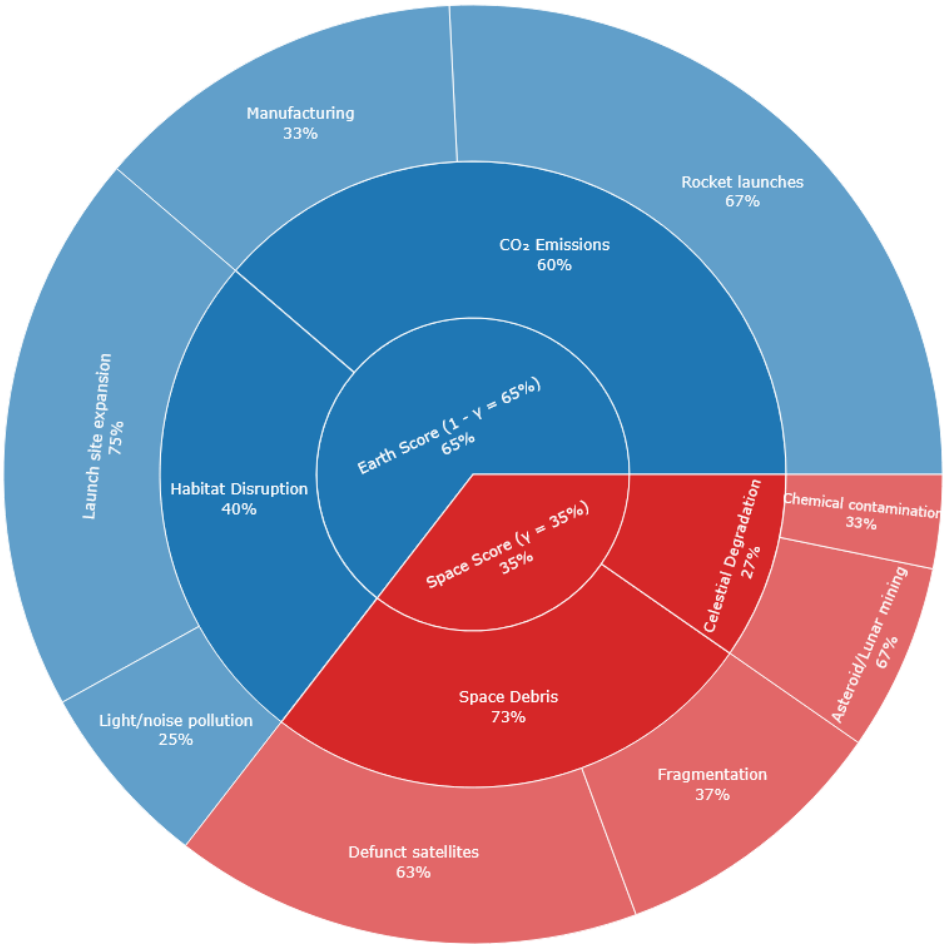


**Figure 7.2:** Breakdown example of criteria that the international body could frame to calculate the environmental score of each country

## 7.3 Establishing the International Space Resource Activities Organization: A New Model for Global Commons Governance

The governance of the new policy framework should stem from an international agreement (similar to the OST). It is in fact important that the new framework is shared between as many nations as possible since equitability and environmental policies require a global effort to be effective. Furthermore, even licensing and regulations must have a global character since space activities inherently affect a large number of countries. The treaty must include the credit system discussed in section 7.1, should be in accordance with the OST, and should develop licensing provisions to ensure that space resource extraction is well regulated. Under the treaty, a new international body of the UN should be created, following the example of the International Seabed Authority (ISA) [86]. The newly formed International Space Resources Authority (ISRA) will be in charge of granting credits, licensing space missions, and monitoring the environmental impact of each country, including the companies that operate under each country's jurisdiction. When drafting the treaty, a time frame will be established for the periodic review of the weights associated with the credit systems and for the periodic distribution of credits to every nation. For instance, the agreement could mandate that environmental criteria can be reviewed every 10 years, so that the plans are actually actionable. At the same time, credits could be distributed every 3 years and have an expiry date of 15 years, so that incentives (the weights in the credits allocation formula that promote innovation and sustainability) kick in regularly and, at the same time, countries have enough time to plan wisely the usage of their credits. The possibility of issuing emergency credits should also be considered to avoid a deadlock in resource extraction operations (e.g. if 85% of available credits have been used and the new credit distribution event is too far away in time, the ISRA can issue emergency credits following the same criteria for normal credit distribution). Similarly, if the utilization of credits falls under a certain threshold (e.g. 30% of total credits), the ISRA should be able to freeze the issuance of new credits to avoid market flooding. By following the example of the UAE space policy framework, an international space court should be created [73]. Its duties will be to regulate space disputes based on international agreements, set legal precedents for space activities, enforce anti-monopoly measures (e.g. a country buys too many credits and obtains too many licenses to extract a particular resource), and has the ability to revoke credits in case of misconduct.

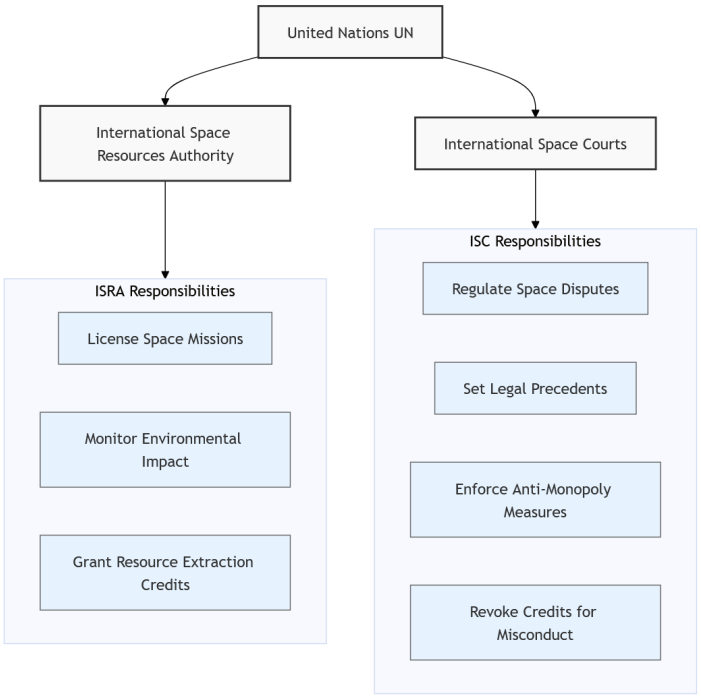


**Figure 7.3:** Governance structure of the new policy framework

## 7.4 Feasibility & Implementation Challenges

It has to be noted that a policy framework based on mining credits through a UN-backed organization might face some political and practical challenges. While such a system would increase equitability, foster environmental sustainability, and provide more legal certainty, it must also align with the strategic interests of space-faring nations. They could argue that, thanks to their position of power, they would prefer to support a "first-come, first-served" model, betting on their technological and economic advantage. This is also the policy framework that has been regulating space until now, backed up by the national legislations that have been analyzed in chapter 5.

However, the key incentive that could lead space-faring nations to agree with the new policy framework is the uncertain and quickly evolving status of the space industry. More than ever, emerging space countries are achieving remarkable breakthroughs, and private companies are flourishing all over the world to compete in the new space economy [87]. In this environment, pushing for a unilateral approach might get risky, especially in the long run, where geopolitical, technological, and economic positions of power might change. Switching to an internationally

recognized approach, where space resource extraction activities are recognized by all countries, will give to space operations more legitimacy and will ultimately be beneficial in times of geopolitical turmoils or technological and economic pushback. Furthermore, such legitimacy will also protect space-faring nations' investments, ensuring that they would not be undermined by shifts in global power dynamics.

Hence, while space-faring nations do not have many incentives to participate in this new space organization in the short term, due to their position of power, they might be convinced by the opportunity to bring more legal security, legitimacy, and long-term stability to a rapidly evolving and legally uncertain industry.

# Chapter 8

# Conclusion

Thanks to technological advancements and increased investments, space resource extraction is becoming a reality. Mining resources in space is not just an economic opportunity, but is a critical step to sustain the future of space exploration and back up human colonization of outer space. As launching costs decrease and resource extraction technologies improve, critical resources, such as lunar water for fuel production, rare metals for manufacturing, and helium-3 for potential clean energy, will fuel the new space economy. Moreover, utilizing space resources would decrease the dependency on Earth-based supply chains and reduce the need for activities that pollute the Earth's environment. However, the absence of a clear and enforceable international policy framework for space resource extraction has contributed to the creation of a regulatory void. Hence, it is critical to address such issues to guarantee equitability, environmental stewardship, and governance structures to effectively regulate space mining activities.

Due to this legal void, national laws have emerged, contributing to the fragmentation and unilateral approach to space endeavors. Those laws groundbreakingly set the precedent for private ownership over space resources. However, since their main provisions hinge on boosting commercial exploration, they lack sufficient structure on important themes, such as equitability, environmental sustainability, and governance. This risks creating an unbalanced "first-come, first-served" model, which is in contrast with international agreements, such as the Outer Space Treaty.

This thesis proposes a new policy framework grounded on three key principles: equitability, environmental sustainability, and international governance. By creating a UN-backed governance organization that regulates space activities and a credit system that promotes equitability and fosters environmental stewardship, the frameworks try to balance the interests of both space-fairing and non-space-fairing nations, while respecting the spirit of previous international agreements. The framework, in fact, rewards and incentivizes innovation, which is primarily led by space-faring nations, while ensuring that the benefits reaped by space resource

extraction are shared with non-space-faring nations as well, in accordance with international agreements' provisions.

Although space-faring nations might initially resist this change due to power dynamics that might make them prefer a more "first-come, first-served" approach, the emergence of new space powers and private companies could shift current power dynamics, meaning that even space-faring nations could be interested in operating in an internationally legitimated environment.

As humanity's colonization of space becomes a reality, space resource extraction will become a key activity. It is imperative to fill the current legal void with an international policy framework that promotes fairness, sustainability, and long-term stability.

# Bibliography


[1] J.A. Dallas, S. Raval, J.P. Alvarez Gaitan, S. Saydam, and A.G. Dempster. «Mining beyond earth for sustainable development: Will humanity benefit from resource extraction in outer space?» In: *Acta Astronautica* (2020) (cit. on pp. 1, 4, 6).

[2] Thomas Simko and Matthew Gray. «Lunar Helium-3 Fuel for Nuclear Fusion: Technology, Economics, and Resources». In: *World Futures Review* (2014) (cit. on p. 1).

[3] UNOOSA. *The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*. 1967 (cit. on pp. 1, 7, 15–17, 43).

[4] United Nations General Assembly. *The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*. 1979 (cit. on pp. 1, 7, 19–21).

[5] Marc Serres. «How Luxembourg becomes Europe's commercial space exploration hub». In: *Annales des Mines-Reálités Industrielles* (2019) (cit. on p. 2).

[6] Harrison Schmitt. *Return to the Moon: Exploration, Enterprise, and Energy in the Human Settlement of Space*. Copernicus, 2006 (cit. on p. 3).

[7] Ezra J. Reinstein. «Owning Outer Space». In: *Northwestern Journal of international Law & Business* (1999) (cit. on p. 3).

[8] John Lasker. «Race to the Moon for Nuclear Fuel». In: *WIRED* (2006) (cit. on p. 3).

[9] David Brown. «Lunar Land Rights». In: *AAPG EXPLORER* (2023) (cit. on p. 3).

[10] Sarah Coffey. «Establishing a Legal Framework for Property Rights to Natural Resources in Outer Space». In: *Case Western Reserve Journal of International Law* (2009) (cit. on p. 4).

[11] John S. Lewis. *Mining The Sky: Untold Riches From The Asteroids, Comets, And Planets*. Basic Books, 1997 (cit. on p. 4).

[12] Kang Shuai Hejiu Hui Ziyan Han. «Origin of water in the Moon». In: *National Science Review* (2024) (cit. on p. 4).

[13] Ian A. Crawford. «Lunar Resources: A Review». In: *Physical Geography* (2015) (cit. on p. 4).

[14] Volker Zepf. «Rare Earths Industry Technological, Economic, and Environmental Implications». In: *Elsevier* (2016) (cit. on p. 4).

[15] Guillaume Pitron. «The Geopolitics of the Rare-Metals Race». In: *The Washington Quarterly* (2022) (cit. on p. 4).

[16] Maxwell Fleming, Ian Langea, Sayeh Shojaeinia, and Martin Stuermer. «Mining in space could spur sustainable growth». In: *PNAS* (2023) (cit. on pp. 4, 5).

[17] Chris Welch Pablo Calla Dan Fries. «Asteroid mining with small spacecraft and its economic feasibility». In: *Cornell University* (2019) (cit. on p. 4).

[18] Mehdi Azadi, Stephen A. Northey, Saleem H. Ali, and Mansour Edraki. «Transparency on greenhouse gas emissions from mining to enable climate change mitigation». In: *Nature Geoscience* (2020) (cit. on p. 5).

[19] United Nations. *Transforming Our World: the 2030 Agenda for Sustainable Development*. Tech. rep. United Nations, 2015 (cit. on p. 5).

[20] Jackie McGuinness and Gerelle Dodson. *NASA Economic Impact Report October 2022*. Tech. rep. NASA, 2022 (cit. on p. 5).

[21] ICMM. *Social Progress in Mining-Dependent Countries*. Tech. rep. International Council on Mining & Minerals, 2021 (cit. on p. 6).

[22] The World Bank. *The World by Income and Region*. 2023 (cit. on p. 6).

[23] Jack Wright Nelson. «The Artemis Accords and the future of international space law». In: *American Society of International Law*. Vol. 24. 31. 2020 (cit. on pp. 7, 25–27).

[24] United States of America Government. *U.S. Commercial Space Launch Competitiveness Act*. 2015 (cit. on pp. 7, 29, 30, 32).

[25] Luxembourg. *Law of 2017 on the Exploration and Use of Space Resources*. 2017 (cit. on pp. 8, 33, 35, 55).

[26] University of Leiden. *The Hague International Space Resources Governance Working Group*. 2020 (cit. on p. 8).

[27] Martin Svec. «Outer Space, an Area Recognised as Res Communis Omnium: Limits of National Space Mining Law». In: *Space Policy* (2022). ISSN: 0265-9646 (cit. on p. 15).

[28] Erik J. Molenaar, Alex G. Oude Elferink, and Donald R. Rothwell. *The Law of the Sea and the Polar Regions: Interactions between Global and Regional Regimes*. Brill/Nijhoff, 2013 (cit. on p. 15).

[29] Rossana Deplano. «INCLUSIVE SPACE LAW: THE CONCEPT OF BENEFIT SHARING IN THE OUTER SPACE TREATY». In: *International and Comparative Law Quarterly* (2023) (cit. on p. 15).

[30] Gil Denis, Didier Alary, Xavier Pasco, Nathalie Pisot, Delphine Texier, and Sandrine Toulza. «From new space to big space: How commercial space dream is becoming a reality». In: *Acta Astronautica* (2020) (cit. on p. 16).

[31] Viikari and Lotta. *The Environmental Element in Space Law: Assessing the Present and Charting the Future: Assessing the Present and Charting the Future*. Brill/Nijhoff, 2008 (cit. on p. 16).

[32] Dr Mineiro. «FY-1C and USA-193 ASAT Intercepts: An Assessment of Legal Obligations under Article 9 of the Outer Space Treaty». In: *Journal of Space Law* (2008) (cit. on p. 17).

[33] Michael J. Listner. «THE PARADOX OF ARTICLE IX AND NATIONAL SECURITY SPACE ACTIVITIES». In: *Æther: A Journal of Strategic Airpower & Spacepower* (2022) (cit. on p. 17).

[34] Gordon Chung. «Emergence of Environmental Protection Clauses in Outer Space Treaty: A Lesson from the Rio Principles». In: *A Fresh View on the Outer Space Treaty*. Ed. by Annette Froehlich. Springer International Publishing, 2018, pp. 1–13 (cit. on p. 17).

[35] Stephen Buono. «Merely a 'Scrap of Paper'? The Outer Space Treaty in Historical Perspective». In: *Diplomacy & Statecraft* (2020) (cit. on p. 17).

[36] Henry R Hertzfeld. «Developments that Could Create a Fragmented Space Law Regime». In: *PROCEEDINGS OF THE INTERNATIONAL INSTITUTE OF SPACE LAW* (2018) (cit. on p. 17).

[37] Timiebi Aganaba. «Deriving Meaning Through Treaty Interpretation or Is It Time for New Innovative Space Governance Instruments for Space Resources?» In: *Alb. L. Rev.* (2021) (cit. on p. 18).

[38] Cassandra Steer. «Who has the power? A critical perspective on space governance and new entrants to the space sector». In: *Ga. J. Int'l & Comp. L.* (2019) (cit. on p. 18).

[39] Henry R Hertzfeld, Brian Weeden, and Christopher D Johnson. «Outer space: Ungoverned or lacking effective governance?: New approaches to managing human activities in space». In: *SAIS Review of International Affairs* (2016) (cit. on p. 18).

[40] Sylvia Maureen Williams. «International law before and after the Moon Agreement». In: *International Relations* (1981) (cit. on p. 19).

[41] United Nations. *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*. Accessed: 2025-02-17. 2025. URL: https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXIV-2&chapter=24&clang=_en (cit. on pp. 19, 44).

[42] João Marques de Azevedo. «Regulating Space Resource Activities in a Fair and Equitable Manner: Understanding the Principle of Common Heritage of Humankind in Space Law». In: *European Review of International Studies* (2024) (cit. on p. 19).

[43] Antonella Bini. «The Moon Agreement in the 21st century». In: *Acta Astronautica* (2010) (cit. on pp. 20, 22).

[44] Irmgard Marboe. «Reviewing the Moon Agreement or Amending the Outer Space Treaty?-Views of UNCOPUOS Member States». In: *Journal of the Grand Duchy of Luxemburg of* 28 (2017), p. 8 (cit. on p. 20).

[45] Ingo Heidbrink. «From the oceans, via Antarctica and the Moon, to deep space: Maritime history and its relevance for outer space exploration». In: *International Journal of Maritime History* (2024), p. 08438714241305600 (cit. on p. 20).

[46] Vinicius Aloia. «Regulation of commercial mining of space resources at national and international level: An analysis of the 1979 Moon agreement and the national law approach». In: *International Astronautical Congress*. 2019 (cit. on p. 21).

[47] Fabio Tronchetti. «The commercial exploitation of natural resources of the Moon and other celestial bodies: what role for the Moon Agreement?» In: *Proceedings of the International Institute of Space Law* 53 (2010), pp. 614–624 (cit. on p. 21).

[48] Maria Manoli. «The Architecture of Authority in Global Space Governance: The Moon Agreement as a Deconflicting Mechanism of Space Activities.» In: *Utrecht Law Review* 20.1 (2024) (cit. on pp. 22, 23).

[49] James Clay Moltz. «Toward cooperation or conflict on the moon? Considering lunar governance in historical perspective». In: *Strategic Studies Quarterly* 3.3 (2009), pp. 82–103 (cit. on pp. 22, 23).

[50] Ricky J Lee. «Creating an international regime for property rights under the moon agreement». In: *Proceedings of the Forty Second-Colloquium on the Law of Outer Space*. 1999 (cit. on pp. 22, 23).

[51] Oleksandr Svetlichnyj and Diana Levchenko. «Commercialization of space activities: Correlation of private and public interest in the pursuit of outer space exploration». In: *Advanced Space Law* 4.1 (2019), pp. 21–29 (cit. on p. 23).

[52] Rossana Deplano. «The Artemis Accords: Evolution or revolution in international space law?» In: *International & Comparative Law Quarterly* 70.3 (2021), pp. 799–819 (cit. on pp. 24–27).

[53] NASA and the U.S. Department of State. *Artemis Accords*. 2020 (cit. on pp. 24, 25).

[54] Dennis O'Brien. «The Artemis Accords: repeating the mistakes of the Age of Exploration». In: *The Space Review (online)* (2020) (cit. on p. 25).

[55] Nancy Riordan, Miloslav Machoň, and Lucia Csajková. «Space Diplomacy and the Artemis Accords». In: *The Hague Journal of Diplomacy* 18.2-3 (2023), pp. 380–408 (cit. on pp. 26, 27).

[56] Inesa Kostenko. «Artemis Accords and the Future of Space Governance: Intentions and Reality». In: *Advanced Space Law* 8 (2021), pp. 40–50 (cit. on pp. 26, 27).

[57] Michael Dodge. «The US commercial space launch competitiveness act of 2015: Moving US space activities forward». In: *Air & Space Law.* 29 (2016), p. 4 (cit. on pp. 30, 32).

[58] Scott Atkins. «The commercialization of outer space: How an international securities framework can be the launching pad for a global space economy». In: *Int Corporate Rescue* 19.3 (2022) (cit. on pp. 30, 31).

[59] Tyler Conte. «Property rules for Martian resources: how the space act of 2015 increases the likelihood of a single entity controlling access to mars». In: *J. Air L. & Com.* 84 (2019), p. 187 (cit. on pp. 30, 31).

[60] Sagi Kfir and Ian Perry. «Title IV of the US commercial space launch competitiveness act of 2015: A critical step forward in facilitating the development of a viable space infrastructure». In: *New Space* 5.3 (2017), pp. 163–169 (cit. on pp. 30, 32).

[61] Paul Stephen Dempsey. «National laws governing commercial space activities: Legislation, regulation, & enforcement». In: *Nw. J. Int'l L. & Bus.* 36 (2016), p. 1 (cit. on p. 31).

[62] PJ Blount and Christian J Robison. «One small step: The impact of the US Commercial Space Launch Competitiveness Act of 2015 on the exploitation of resources in outer space». In: *NCJL & Tech.* 18 (2016), p. 160 (cit. on p. 32).

[63] Antonino Salmeri. «The Multi-Level System of Space Mining: Regulatory Aspects and Enforcement Options». In: *Unilu-University of Luxembourg, Luxembourg* (2022) (cit. on pp. 33, 34, 36, 37).

[64] Isabel Feichtner. «Mining for humanity in the deep sea and outer space: The role of small states and international law in the extraterritorial expansion of extraction». In: *Leiden Journal of International Law* 32.2 (2019), pp. 255–274 (cit. on pp. 33, 34, 36).

[65] Philip De Man. *Luxembourg law on space resources rests on contentious relationship with international framework*. Leuven Centre for Global Governance Studies Leuven, 2017 (cit. on pp. 34, 36).

[66] Mahulena Hofmann. «Luxembourg Completing its Space Legislation». In: *65th Colloquium on the Law of Outer Space*. Elsevier, Den Haag, Netherlands. 2022 (cit. on pp. 34, 35).

[67] Bob Calmes, Laurent Schummer, and Blazej Gladysz-Lehmann. «The Space Law Review: Luxembourg». In: *The Law Reviews* (2021) (cit. on pp. 35–37).

[68] Marc Serres. «How Luxembourg becomes Europe's commercial space exploration hub». In: *Annales des Mines-Reálités Industrielles* 2 (2019), pp. 69–72 (cit. on p. 37).

[69] UAE. *Federal Law No. (12) of 2019 on the Regulation of the Space Sector*. 2019 (cit. on pp. 38, 39).

[70] Whittle Eastwood Main Garcia. *Key features of the new United Arab Emirates regulations on space activities*. Tech. rep. Watson Farley & Williams, 2023 (cit. on pp. 38–40).

[71] Alyssa Goessler. «Waste studies' insight into orbital debris: a United Arab Emirates case study». PhD thesis. Faculty of the Graduate School of The University of Texas at Austin, 2022 (cit. on p. 38).

[72] Rafael Popper et al. «Towards a Roadmap for Future UAE Deep Space Missions and the Sustainable Settlement of Humans on Mars: White Paper». In: *VTT Technical Research Centre of Finland* (2020) (cit. on p. 39).

[73] Hamda Al Hosani, Naser Al Rashedi, and Fatheya Al Sharji. «Empowering the UAE Space Sector Through an Attractive Regulatory Framework». In: *Air and Space Law* 46.3 (2021) (cit. on pp. 40, 60).

[74] Darcy Beamer-Downie. *Space Law and Arbitration: An Introduction to Space Law in the UAE*. Tech. rep. Clyde & Co, 2024 (cit. on p. 40).

[75] Masaya Uchino. «Can Japan Launch Itself into Becoming a Leader in Global Space Business with Its New Space Legislation?» In: *PROCEEDINGS OF THE INTERNATIONAL INSTITUTE OF SPACE LAW* (2018), p. 31 (cit. on pp. 41–43).

[76] Japan. *Space Resources Act*. 2021 (cit. on p. 41).

[77] Matsumoto Hamada. *A general introduction to Space Law in Japan*. 2024 (cit. on pp. 41, 43).

[78] European Space Policy Institute (ESPI). *ESPI Report 74 - Securing Japan - Full Report*. Tech. rep. European Space Policy Institute (ESPI), 2020 (cit. on pp. 41, 42).

[79] Ishido Sato. *Current Status of Japan's Active Development of Space Laws and Systems for Legal Compliance in the Age of Celestial Exploration* (cit. on pp. 41, 43).

[80] Morgan M DePagter. «Who Dares, Wins:" How Property Rights in Space Could be Dictated by the Countries Willing to Make the First Move». In: *CHI. J. INT'L L.* 1 (2023), pp. 116–133 (cit. on p. 42).

[81] Yuichiro Nagai, Mukund Rao, Hideaki Shiroyama, KR Murthi, Motoko Uchitomi, and Baldev Raj. «Policy Analysis: Space Programmes of Japan And India». In: *Eleven International* (2015) (cit. on p. 42).

[82] United Nations Office for Disarmament Affairs. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*. Accessed: 2025-02-17. 2025. URL: `https://treaties.unoda.org/t/outer_space` (cit. on p. 44).

[83] Laura C Byrd. «Soft Law in Space: A Legal Framework for Extraterrestrial Mining». In: *Emory LJ* 71 (2021), p. 801 (cit. on p. 55).

[84] Yale Center for Environmental Law & Policy. *Environmental Performance Index (EPI) - Yale University*. Tech. rep. Yale University, 2024 (cit. on p. 57).

[85] S. Block, J. W. Emerson, D. C. Esty, A. de Sherbinin, Z. A. Wendling, et al. *2024 Environmental Performance Index*. Yale Center for Environmental Law & Policy, 2024 (cit. on p. 57).

[86] J. S. Koch. «Institutional Framework for the Province of all Mankind: Lessons from the International Seabed Authority for the Governance of Commercial Space Mining». In: *Astropolitics* 16.1 (2018), pp. 1–27 (cit. on p. 60).

[87] Santiago Rementeria. «Power dynamics in the age of space commercialisation». In: *Space Policy* 60 (2022), p. 101472 (cit. on p. 61).