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Space Technology and Environmental Harm: The Role of Astro-Green Criminology

INTRODUCTION

It has become clear that alongside new opportunities, New Space has brought numerous new challenges, opening up a wide discussion regarding the long-term sustainability of the use and exploration of outer space. In the early phase of space law developments, which included the drafting of the main space treaties, sustainability and preservation of outer space environment were not seen as a priority.[1] It is therefore not surprising that they made little progress towards achieving sustainability. Not only did many of these provisions lack effective enforcement, but their broadness and lack of concretisation allowed for several (sometimes even contradictory) interpretations, posing difficulties in defining which activities are compliant with the legal framework, and which, on the other hand, are unlawful. Researchers have long recognised the danger of these legal shortcomings, and have called for the creation of a new discipline – Astro-Green Criminology, that would expand the lenses through which most of the legal research in this area is currently carried out, by including consideration of the question of the *harmfulness* of certain space activities, and not just their *unlawfulness*.[2] This could have important implications for the further development of space law in the direction of making more harmful activities explicitly unlawful. At the same time, Astro-Green Criminology would offer an opportunity to thoroughly address some basic philosophical questions that are crucial for the determination of the future legal framework, such as:

[1] Deva Prasad 2019: 166.

[2] Takemura 2019; Lampkin 2020.

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"What is and what should be the purpose of human activity in outer space in the future?"[3] A legal framework developed in such a way would consequently enjoy a higher level of legitimacy and would be more aligned with the interests of all humankind.

In the first part of this Chapter I elaborate briefly on the emergence of New Space and its relation and contribution to threats to sustainability in the form of environmental harm. In the second part I describe the development of the discipline of Astro-Green Criminology, which was based on numerous calls for the expansion of criminological research beyond the scope of what legislators defined as "criminal" or "unlawful", to include activities that are not criminalised or otherwise prohibited by the law, yet which are able to produce extremely harmful effects. In the third part I outline some of the shortcomings of the existing legal framework and then demonstrate how developing the field of Astro-Green Criminology can complement the current efforts to amend the legal framework by providing new perspectives, methodology and insights on that topic. I conclude with some remarks outlining the perspectives for future research.

ENVIRONMENTAL HARM CAUSED BY SPACE TECHNOLOGY, THE EMERGENCE OF NEW SPACE AND THE PRESSING ISSUE OF THE SUSTAINABILITY OF SPACE ACTIVITY

The deployment of space technology has been, since its beginnings in the 1950s, accompanied by great enthusiasm and hope, as it led to unimaginable discoveries and possibilities that have enriched scientific, technical and social development.[4]

[3] Lampkin 2020: 250.

[4] The most notable events at the beginning of the space age, namely, Sputnik I becoming the first successfully launched satellite, Yuri Gagarin becoming the first person in outer space and the Apollo 11 successfully landing on the Moon with Neil Armstrong being the first human ever to step on its surface, have been highly publicised, used for the promotion of respective governments, and later on incorporated into the national spirit, ideology and

Despite its numerous benefits, however, this development simultaneously resulted in various forms of environmental harm.[5] Environmental damage in outer space is caused by several different forms of contamination, including,[6] but not limited to radiological contamination through nuclear experiments,[7] physical contamination through the proliferation of numerous space objects and space debris,[8] chemical contamination through rocket gas and fuel emissions,[9] and recently even the threat of biological contamination of outer space with terrestrial organisms.[10] What was perhaps once easily overlooked, as it was overshadowed by the great enthusiasm surrounding space technology, has now become impossible to ignore: environmental harm, caused by this technology, has drastically increased in the last 50 years and nowadays poses a severe risk to humanity as well as to the future of space exploration.[11]

According to a study conducted by the European Space Policy Institute (ESPI), the image of the space sector has been drastically transformed in recent years. The main reason for this change are the new entrants to the space sector, which are using new processes, business models and solutions, challenging the formerly prevalent approaches to space programmes.[12] This trend marks the transition from the old "slow, bureaucratic, government-directed, and completely top-down" space regime, to a situation that has yet to be precisely defined but which is often referred to as 'New Space'.[13] While the distinction between the previous situation and the current one is perhaps not so clear as sometimes

culture of both the USSR and the USA, their influence extending far beyond their borders. See, for example, Siddiqi 2010: 426–427; Shreve 2003: 69–74.

5 Gaston et al. 2023: 290; Ryan et al. 2022.

6 For more on this see Qizhi 1988.

7 Such tests resulted in electromagnetic pulses and dangerous debris. Yan 2023; Dupont 2004: 100–105. On the general negative environmental effects of nuclear tests see Prăvălie 2014.

8 Stubbe 2018: 3; Tallis 2014: 86–88.

9 Ross–Vedda 2018: 2–5; Ryan et al. 2022.

10 Rettberg et al. 2019.

11 See Hamilton 2022; Kellman 2014.

12 ESPI 2017: 3.

13 ESPI 2017: 1.

presented, it cannot be denied that the space sector has undergone some drastic changes in the recent past and has been transformed by numerous trends, by which I mean large-scale shifts in various areas of the global arena of space activities. Besides the increasing number of private actors in the space sector (both established companies and new startups), other trends defining New Space and differentiating it from the old system are, for example, the increasing number of spacefaring nations, innovative public procurement and support schemes, new industrial approaches, disruptive market solutions and others.[14]

New Space has brought new challenges, that now coexist with all the unresolved issues from mankind's earlier ventures in space, which is perhaps most worrying in terms of the environmental harm caused by space activities, posing a severe threat to their long-term sustainability. While some level of harm is inevitable, it can be avoided, or at least to some extent significantly reduced, through cautious mission planning. However, the increased involvement of private actors in space activities has seen a greater emphasis on private interests (usually in a form of economic benefits) over the long-term interests of equity and sustainability.

The 2019 accident of the Israeli Beresheet rocket can serve as an important example in this regard. The incident was widely described as posing a threat of biological contamination of the Moon, as it broke down and crashed uncontrollably onto the lunar surface while carrying a cargo containing samples of human DNA as well as thousands of tardigrades – microscopic animals that are resilient to extreme habitats.[15] The concern has been raised that the tardigrades would survive the crash and would contaminate the lunar environment, arbitrarily interfering with the future of outer space.[16] The criticism raised with regard to that event were that the Beresheet program was prioritising commercial interests over environmental safety and sustainability. The programme was described as a commercial initiative and the decision to include tardigrades was claimed

[14] ESPI 2017: 2; Denis et al. 2020: 433.
[15] Oberhaus 2019.
[16] Oberhaus 2019.

to be an undocumented[17] private decision which the launching state was not aware of.[18] It has been further alleged that the program used certain components of questionable quality, which were "relatively inexpensive" and "had not been tested in space" prior to the mission.[19] Due to one of the main trends of New Space, namely, the increasing involvement of non-state actors in outer space, concerns are growing about the sustainability of space activities and the environmental protection of space being jeopardised by an increasing prioritisation of commercial interests.

THE EMERGING FIELD OF ASTRO-GREEN CRIMINOLOGY AS A RESPONSE TO THE CHALLENGES POSED BY NEW SPACE

In this part I will briefly present the development of criminological research in the last few decades, as a response to emerging social challenges. Firstly, I will discuss the expansion of criminology beyond the subject of *criminal law* and secondly the expansion of the criminological gaze *beyond our planet*.

Criminology beyond criminal law

For almost a century, theoreticians have argued that Criminology must look beyond its traditional subject of examination – criminality, as defined by criminal law. The development of critical criminology encompasses a set of new perspectives in the field, based mainly on the rejection of the official (i.e. the legislator's) definition of crime as a self-evident and exclusive object of criminological study.[20] Instead, they recognise that deviant behaviour which

[17] The fact that the state allegedly did not know about such a risky private decision that could potentially result in a breach of space treaties opens an important question regarding the extent of state responsibility for private conduct, as described in further detail in Gailhofer–Scherf 2022; Chirwa 2004.

[18] Cirkovic 2022: 337.

[19] Nevo 2020.

[20] Sykes 1974: 207; Meier 1977: 462–464.

harms society is much broader than this narrow official set of criminalised acts, which are designed in accordance with the interests and values of the more powerful part of the population.[21] Based on this recognition, that criminal law does not sufficiently address deviance in its entirety, critical criminological theories call for a broader consideration of these damaging phenomena, often defined through the notion of social harm, irrespective of its (criminal) legal status.[22]

Social harm does not yet have a universally accepted definition, but is most often understood as a set of harmful effects preventing people from meeting their needs.[23] It remains a matter of dispute whether the subject of social harm should be tackled within the scope of (critical) criminology, or by another young scientific discipline: zemiology, but it is becoming more and more clear that this broader approach brings significant advantages to the scientific examination of harmful behaviours.[24] The first expansion of criminological research that is relevant for this article is therefore the shift in focus from the notion of *crime* towards a broader term of *social harm*.

Based on a similar premise, another criminological discipline has emerged: green criminology. Building upon the theory advocating the expansion of the criminological interest to social harm, green criminology has more recently focused its attention on the environmental aspect, trying to seek ways of expanding regulatory frameworks so as to prevent or mitigate avoidable and avertable *environmental* harms.[25] The main concerns of green criminology are thus environmental crimes, but on a broader scale it also addresses other threats to environmental rights, ecological justice, the exploitation of natural resources and their relation to power structures within society.[26]

[21] Sutherland 1983; Hillyard–Tombs 2004: 13; Curtis 2003: 147–149.
[22] Tombs 2018; Paoli–Greenfield 2018; McGregor 2019: 352.
[23] Tombs 2018; Copson 2011.
[24] Felices-Luna 2010: 252.
[25] See Lynch 1990: 3–4; Boukli–Kotsakis 2023.
[26] White 2008: 170–171; White–Heckenberg 2011: 95–98; Boukli–Kotsakis 2023.

Criminology beyond our planet Earth

Astro-Green Criminology is a newborn scientific discipline, built upon numerous endeavours mentioned in the previous sections, all of which recognised that criminology must expand its focus from criminalised activities to also include activities that are non-criminalised, but which are equally or even more harmful. In line with the approach taken by green criminology, it focuses predominantly on environmental harm. In 2019, Takemura Noriyoshi proposed what he called "a new perspective against space capitalism", relying on a premise that the new space economy is indeed the pathway to a new era for humankind, but if done incorrectly, repeating the mistakes human civilisation has made on Earth while subjecting its environment to extreme exploitation and pollution, the longer-term sustainability of our existence will be jeopardised.[27] He proposed the establishment of a new discipline named Astro-Green Criminology, as a necessary research tool for ensuring that space exploration and space exploitation are conducted in an environmentally and ecologically safe and sustainable manner.[28] In the scope of his proposal, Takemura exposes a blind spot in the perspective of space exploration planning and its regulation: the absence of a comprehensive discussion regarding some important preliminary (eco) philosophical questions, such as: What are the legitimate purposes of human space exploration?; Does outer space, including the celestial bodies thereof, have any intrinsic value in and of itself?; Are humans justified in expanding their habitat outside of our initial planet?; What is a just distribution of benefits received from the space exploration?; and so on.[29] Without answering these questions, the lack of philosophical basis for the current legal framework and the actual activities being performed within it will result in both their legitimacy and their sustainability being undermined.

[27] Takemura 2019: 8.
[28] Takemura 2019: 15.
[29] Takemura 2019; elaborated upon by Lampkin 2020: 250.

Building upon Takemura's call for the establishment of a new discipline, one year later Lampkin conceptualised and attempted to legitimise the development of Astro-Green Criminology by demonstrating its capacity to build upon several other theoretical approaches (including ecophilosophy), as well as its ability to shed light on some overlooked concepts related to space exploration.[30] Most importantly, he mapped[31] its terrain of research, focusing on the (environmental) issues, including the problem of space debris in Lower Earth Orbit (LEO), the extraction of minerals and energy resources from extraterrestrial bodies, emissions stemming from launching and operating space objects, the endangerment of heritage sites of cultural significance (such as the 1969 Apollo 11 landing site on the lunar surface), as well as future usages of outer space such as space travel/tourism[32] and space colonisation.[33] He suggests that astro-criminological research should tackle not only law-breaking and criminal actions in outer space, but also harmful activities in a broader sense, as well as the aspect of the victims of space-related crimes and harms.[34] Examples of potential research into space crimes and harms are: research on the power relations of and between subjects engaged in the exploration and use of outer space, unfair competition, the abuse of rights, intent or negligence in the creation of harms, the legitimacy of space operations, the democratic deficit in the regulatory framework of space activities due to the lack of participation of (both global and national) civil society, the philosophical basis for future space operations, the lack of enforcement mechanisms for noncompliance with the law, and many others.

[30] Lampkin 2020: 239, 249–251.

[31] His mapping could later on be expanded as space activities will progress and as new challenges will probably arise.

[32] In this regard, the existing lack of effective and comprehensive space traffic management rules needs to be emphasised.

[33] Lampkin 2020: 243.

[34] Lampkin 2020: 240.

Addressing the shortcomings of the existing legal framework

The legal framework governing space activities is extremely diverse – consisting of international treaties,[35] customary international rules[36] which are often indicated by widely-accepted UN resolutions and other documents, soft law regulations,[37] policies,[38] national legislation[39] and *sui generis*[40] acts. For many decades, the United Nations Committee on the Peaceful Uses of Outer Space (hereinafter UN COPUOS) has been the leading body in drafting space legislation, following a multilateral process. However, this has changed

[35] The most known treaties governing outer space activities are: the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the Outer Space Treaty); the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (the Rescue Agreement); the 1972 Convention on International Liability for Damage Caused by Space Objects (the Liability Convention); the Convention on Registration of Objects Launched into Outer Space (Registration Convention). Often, the 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) is listed as one of them, however, it must be noted that due to a very small number of states parties, its relevance has been put to question.

[36] Due to the high number of states parties to it, as well as a strong international support for its preceding resolutions adopted by the United Nations General Assembly, it has been claimed that most, if not all provisions of Outer Space Treaty are to be considered customary international law. See Jakhu–Freeland 2016: 3. Besides that, rules of customary international law can apply by means of Article III of the Outer Space Treaty, as explained in the text below.

[37] By this category I mean an alternative to international binding legal documents (such as the aforementioned treaties) – non-binding legal principles aiming to establish standards and best practices for space activities. These are, for example, recommendations, guidelines and technical standards, adopted by international organisations or other bodies, that are not legally binding but operate on a voluntary basis, such as the Space Debris Mitigation Guidelines (see below). See Byrd 2022: 830–831.

[38] Several states have adopted space policies, setting out the main goals and ambition for the following decades. See, for example, the evolution of the U.S. space policy, as described by Raghuvanshi 2023.

[39] Several states have adopted specific national laws to regulate space activities. For more, see the chapter on national legislation below.

[40] By *sui generis* acts I mean the documents with disputed or unclear legal relevance, such as the Artemis Accords.

in recent years. While in the second half of the last century it was indeed able to reconcile the interests of different states and to lay, on the basis of certain ideological or philosophical considerations, a solid foundation for space law by adopting several legally binding mechanisms, it is failing to do so today for a variety of reasons. A lack or even total absence of important factors such as political will, consensus between states, formal input and discussions with private sector precludes it from adopting new space treaties and amending existing ones, and by limiting its role to creation of soft law mechanisms, this situation put its leadership in the law-making process in jeopardy.[41]

On the other hand, the advent of New Space has seen the emergence of new ways of *sui generis* regulation, sometimes even as a "side-effect" of particular space missions. A good example of the latter is the Artemis Accords, a set of principles aimed at enhancing international cooperation on future lunar activities through a set of bilateral agreements between the United States and other partner nations.[42] Even though in its own terms, the Accords are merely a political commitment, several commentators and critics have warned that their true purpose might be to establish a new interpretation of international space law, favouring commercial and private interests.[43] If that is indeed the case, the Accords would establish a new way of legislating on space, bypassing or even replacing the traditional multilateral law-making process in the UN COPUOS.[44] This could become problematic because of the concern that such agreements, concluded in private negotiations behind closed doors are lacking the type of transparent discussion that can balance different interests, examine power relations and resolve ethical and philosophical dilemmas regarding their content.[45]

[41] See Kendall–Brachet 2023; Peter 2021.

[42] NASA 2020.

[43] Cogan 2023: 133–134; Byrd 2022: 805–806.

[44] Nelson 2020: 4–5; Peter 2021.

[45] It could be argued that this new way of legislating would be done in a more time-efficient manner when compared to the traditional law-making process. However, there exists a very realistic threat that this would be achieved on the cost of its transparency and legitimacy.

Based on the examination of the current situation, it can be anticipated that private (and other) entities will continue to engage in space activities and strive to go beyond the current technological limitations with or without an effective legal framework.[46] In order to ensure that space activities will be conducted in a sustainable manner despite the challenges brought by New Space, the current legal framework will have to be amended accordingly. Whether this takes place through the traditional route within the UN COPUOS or in some alternative way, in order to ensure sustainability such amendments will have to find a balance between different and even contradictory interests. Furthermore, they will have to be based on a stronger ideological foundation, resulting from a thorough discussion of (eco)philosophical issues connected to such topics as the intrinsic value of outer space, justifications for human expansion of their habitat beyond our home planet, how to ensure a just distribution of benefits received from the space exploration, and others.[47] After such an ideological basis is established, the discussion could move towards more concrete legal questions: How is the concept of sustainability understood amongst multiple players in the field, including both those spacefaring nations with a long tradition of space activity and the states that have only recently joined this category, private actors, non-governmental organisations, and finally, civil society? How should the burden of ensuring sustainability be fairly distributed between them? Which legal areas and legal rules show the greatest potential for ensuring that sustainability is continuously strived for, and what are their current shortcomings?

In the process of answering these questions, Astro-Green Criminology can play an important role. It can provide a research field in which the ideological basis of (eco)philosophy can effectively be translated into law, and can, with its harm-oriented approach, assess the effectiveness of particular legal solutions in mitigating harm.[48] In the following two parts of this chapter, I will highlight some of the shortcomings, caused or enhanced by certain

[46] Byrd 2022: 839–840.

[47] Takemura 2019; elaborated upon by Lampkin 2020: 250.

[48] Lampkin 2020.

New Space trends, of particular legal mechanisms when it comes to ensuring the sustainability of present and future space activities, and demonstrate how the perspective of Astro-Green Criminology can play a concrete role in addressing these weaknesses.

Lack of concretisation and effective implementation of the main principles of international space law enshrined in the Outer Space Treaty

The Outer Space Treaty (OST) laid important foundations for all future documents on space law, as it set out the basic principles governing the activities in outer space. As an international treaty, however, it is only binding on the states that are parties to it, and even though it has been established[49] that most of its provisions represent customary international law and are thus binding upon all states, they are not (yet)[50] directly[51] binding on private actors. Despite the fact that the reach of the OST is for this reason limited, in the following section I will examine some of its provisions which are relevant from the perspective of ensuring the sustainability of space activities. I will

[49] Jakhu–Freeland 2016: 3.

[50] It has been claimed that private actors are in certain cases subjects to international law; a general consensus has not yet been reached on this view. See Gailhofer–Scherf 2022; Chirwa 2004.

[51] It could be argued that private actors are somehow *indirectly* bound by the OST through its Article VI, which provides that states bear international responsibility for national space activities, including the activities of private actors. However, the effect of this provision is currently disputed, as there exist two different interpretations of the nature of the obligation therein. According to the first view, Article VI regulates merely primary obligations of states to supervise and authorise space activities, which are then fulfilled when states follow through with adopting measures establishing authorisation and supervision procedures, but according to a second, stricter view, Article VI represents a *lex specialis* rule to secondary rules of state responsibility, causing a direct attribution of private activities to appropriate states. See Ramuš Cvetkovič 2021: 19–20. It can therefore be concluded for now that the role of states in ensuring that private actors conduct their activities in accordance with the OST will have to be further clarified in the future.

demonstrate that sustainability, despite not being specifically mentioned in the OST, is not completely overlooked by it, as it can be implicitly found in many of its principles, although in order to be fully implemented in practice, it would require concretisation[52] and effective enforcement.

The starting point of this analysis is Article I of the OST, which dictates that outer space must be free for exploration and use by all states without discrimination of any kind, on the basis of equality and in accordance with international law. As established at the very beginning of the OST, this commitment to the freedom of exploration and use of outer space is thus one of the main principles of international space law. It simultaneously consists of two interrelated notions – a right and an obligation. Firstly, states have the right to freely explore and use outer space, and secondly, by doing so, they are also obliged to exercise their freedom in a way that does not impair the freedom of other states, as only in this way can the freedom principle be fully respected.[53] Several authors have identified an intriguing potential link between this freedom and the principle of sustainability, as only by ensuring that space activities are carried out in a sustainable manner can the freedom to further explore and use outer space be preserved.[54] Unsustainable practices, such as those which cause significant environmental harm that is difficult or impossible to undo, may thus pose a violation to Article I.

The first shortcoming of this freedom, however, is that the obligation not to impair the freedom of other states is not ensured by a direct enforcement mechanism.[55] The reason for this is not only the general absence of effective

[52] Some of the terms in the OST can be concretised in the process of their interpretation in accordance with the Vienna Convention on the Law of Treaties (VCLT). However, I argue here that while such a process is indeed extremely helpful for providing some clarity on some of the principles enshrined in the OST, especially when *ex post* assessing whether certain activity was in compliance with the OST, it is difficult to expect that one would rely solely on interpretation in *ex ante* planning of their activities. This is why more concrete rules need to be adopted, in order to guide the activities in the right direction from the start.

[53] See De Man – Munters 2018. See also Aganaba-Jeanty 2016: 5; Doucet 2019: 145.

[54] Palmroth et al. 2021.

[55] Doucet 2019: 145.

enforcement mechanisms of international law,[56] but also that no concrete threshold is provided for determining what kind of harmful effect constitutes an impairment of this freedom, and therefore what kind of activities (if any) are inconsistent with it.[57] It would be reasonable to suggest that this dilemma might be resolved by applying other principles of international law, such as the principle of proportionality. While Article III of the OST states that States "shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law", it remains a matter of dispute whether this means the application of international law in toto or merely the application of certain international principles that are in line with the legal regime and the nature of outer space.[58] Therefore, it is not entirely clear which principles and rules of international law can actually bring about the concretisation of Article I of the OST.

However, Article I needs to be read together with the rest of the OST. In this regard, Article IX of the OST carries important weight, as it provides guidance on certain limitations on space activities that are necessary in order to preserve the freedom enshrined in Article I.[59] Namely, Article IX stipulates that when conducting exploration of outer space, states must act so as to avoid its harmful contamination or the occurrence of adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial

[56] For more about difficulties of enforcement of international law see Katselli Proukaki 2009.

[57] It is not clear whether activities that may produce excessive amount of space debris, such as megaconstellations or ASAT tests have already reached the threshold of violation of Article I. Larsen argues that it can be deduced from the language of Article I that the use of outer space must be conducted in a way that enables continuous scientific exploration aimed at a better understanding of the universe. Larsen 2021: 547. Based on his argument a claim could be made that the minimum threshold for the activity to be in compliance with Article I is that it does not impair scientific exploration.

[58] Ribbelink 2009: 67.

[59] Gupta and Agasti claim that the purpose of Article IX is primarily to ensure the free exploration of outer space for all countries. Gupta–Agasti 2022: 10–11.

matter. Moreover, it obliges states to conduct international consultations in cases when they have reason to believe that an activity or experiment planned by them or their nationals in outer space would cause potentially 'harmful interference' with the activities of other states in the peaceful exploration and use of outer space. By addressing this threat, Article IX contributes to defining the threshold of potentially unlawful harm, by introducing the terms "harmful contamination" of outer space, "adverse changes in the environment of the Earth" due to contamination from outer space and "harmful interference" with other space activities. The shortcoming, however, is that these terms are not further concretised and thus remain open for interpretation.

It is disputed whether certain activities resulting in environmental harm, such as space object collisions, ASAT tests, or the mining of space resources are or would be considered a violation of these principles.[60] In order to establish that a certain activity is not in compliance with Articles I or IX of the OST, its scope and content needs to be clearly defined, including the threshold of harm required to be reached in order to be marked as a breach. While some significant efforts[61] have already been made to find more concrete definitions, and those efforts are extremely welcome and important, such an approach is not the only way. And since it can be reasonably estimated, based on the difficulties in the law-making process in UN COPUOS, that these efforts are not likely to soon be translated into binding international legal rules, ways of seeking alternative approaches to ensuring sustainability are needed.

For that reason, an alternative, harm-oriented perspective, of the kind provided by Astro-Green Criminology could be valuable, as it would move beyond asking the question "what kind of harm is required for an activity to

[60] See, for example, articles elaborating upon the issue of whether ASAT tests are prohibited under the current legal framework, such as Strobeyko 2019; Koplow 2009.

[61] Including, but definitely not limited to, Pershing 2019; Listner 2022; Cheney et al. 2020.

be considered legally relevant[62] or unlawful?"[63] to instead asking "what kind of unlawfulness should be ascribed to the perpetrated harm?".[64] Astro-green criminological research would investigate what kind of legal responses are appropriate for the level of harm caused by a particular activity – administrative sanction, international responsibility or civil liability – and whether that level of harm indicates that the activity should be criminalised or defined as unlawful in another way. Furthermore, through the use of the methodology of criminological research, an evaluation of the effectiveness of such individual legal responses and sanctions could be conducted. Astro-Green Criminology can thus be seen as a bridge between factual evaluation and legal regulation, and it could contribute to determining the most appropriate direction of legal regulation. Lastly, it can also be applied inside the legal discipline, as it can help to define the level of threshold needed for proving that there has been a violation of Articles I or IX of the OST.

Another important provision of the OST contributing to ensuring the sustainability of outer space exploration and use is Article II, which prohibits national appropriation of outer space, including the Moon and other celestial bodies, by claims of sovereignty, by means of use or occupation, or by any other means. Several states have claimed that the prohibition of appropriation does

[62] By 'legally relevant' harm I mean harm that is able to provoke some kind of legal consequences. An example of this would be determining, for example, whether a certain harm falls under the definition of "damage" recoverable under the Liability Convention [Article I(a) defines damage as "loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations"]. As can be observed, many examples of environmental harm, not directly resulting in aforementioned cases of damage, fall out of its scope.

[63] By 'unlawful' harm I mean harm that is legally obliged to be prevented or avoided, such as 'harmful contamination' mentioned in Article IX of the OST, or 'significant harm' threshold as defined by case law regarding customary no harm principle.

[64] Here, the word 'harm' is to be understood outside of the existing legal definitions. This does not mean that the two categories will not sometimes overlap – ideally, they should overlap to a great extent, but it predominantly means introducing to the research a broader category of harm, not limited by currently established legal thresholds.

not extend to space resources, but only concerns territorial claims, and have thus, based on such argumentation, decided to adopt legislation allowing their private companies to extract and appropriate the resources mined in outer space.[65] The Artemis Accords, a recent document issued for the purposes of the NASA-led Artemis space mission, even contain a provision stating that the extraction of space resources does not inherently constitute national appropriation under Article II.[66] These facts suggest that despite the prohibition of national appropriation contained in Article II of the OST, certain activities aimed at extraction and the consequent appropriation of space resources could occur in the future. Many experts, however, have warned that such activities could potentially produce harmful effects.[67] From the perspective of sustainability, more detailed regulation, especially on an international level, is needed.[68]

Before such legislation can be prepared, however, a consensus regarding the legitimacy of such activities needs to be reached. This can be achieved through the formulation of an ideological basis built upon the discussion about the question of whether and to what extent humankind can interfere in outer space and which aspects should be protected and preserved for future generations or life beyond planet Earth. This is a question of ethics and could be discussed within the scope of (eco)philosophy. Astro-Green Criminology can build on that discussion and, based on its conclusions, could evaluate whether an extraction of space resources would represent environmental harm beyond an acceptable level, or in other words, it can help to determine what kind of extraction of resources (if any) can be deemed sustainable. On that basis, it can

[65] The states which currently have in place such legislation are: the USA (see U.S. Commercial Space Launch Competitiveness Act), Luxembourg (see Law of 20 July 2017 on the exploration and use of space resources), Japan (see Act 83 of 2021 on the Promotion of Business Activities for the Exploration and Development of Space Resources) and the United Arab Emirates (see their Federal Law No. 12 of 2019). For more on the argumentation regarding the complexity of such actions with Article II of the OST see Wrench 2019: 440–444; Fecht 2015.

[66] NASA 2020: Section 10.

[67] De Zwart et al. 2023: 156; Xu 2020.

[68] Hofmann–Bergamasco 2020: 6.

suggest paths forward for more concrete legal regulation, containing specific safeguards aimed at ensuring the sustainability of space activities and preventing limitless extraction according to the "first come, first serve" principle.

Even though the OST is binding on its states parties, and by means of its customary nature also on other states, it also has a certain relevance for the activities of non-state actors. Article VI of the OST dictates that states bear international responsibility for all national activities in outer space, whether such activities are carried out by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the OST. Furthermore, it stipulates that the activities of non-governmental entities in outer space require authorisation and continuing supervision by the appropriate state. One way of implementing this obligation by the states is to draft and adopt appropriate national legislation to establish the procedures for the authorisation and continuous supervision of private space activities. Some states parties have already done this, but many have not.

States may often, however, find themselves in a difficult situation where they are forced to find a fine balance between different and often contradicting interests. Namely, on the one hand, they need to fulfil certain requirements stemming from the OST and other sources of law binding upon them, including rules aimed at the prevention of environmental harm and the protection of the long-term sustainability of space activities, while on the other hand they are responsible for safeguarding their own economy, which means protecting its ability to attract foreign investments and ensuring the competitiveness of their private actors in the global space sector.[69] Astro-Green Criminology can enable research aimed at identifying and evaluating the power relations of various stakeholders, as well as determining the level of unacceptable environmental harm and the level of diligence required when handling certain space activities that should not be overridden by private interests.

Article VII of the OST and the subsequent international Liability Convention (LIAB) establish that launching states are liable for certain damages

[69] See, for example, Linden 2016.

caused by their space objects. Articles II and III of the LIAB determine further that liability is absolute if the damage is caused on Earth or to an aircraft in flight, and that it is fault-based if the damage is caused in outer space. Despite the wide acceptance of these provisions, they have not been widely applied in practice. First, there are frequently factual difficulties in proving which space object (or a part thereof) was the one causing the damage, and consequently causality cannot be established.[70] There are numerous pieces of space debris in lower Earth orbit, many of which are smaller than 1 cm. Second, neither Article VII of the OST nor the LIAB prescribe any guidance on how to establish fault, leaving the determination of this to an interpretation of a due diligence standard in accordance with several technical guidelines and other documents.[71]

Regarding liability, Astro-Green Criminology can offer an additional perspective on the aspects of fault, namely, intent, negligence and the lack of due diligence regarding the harmful damage caused by a space object. Based on such analysis, it can evaluate which level of fault would need to be criminalised or which is already sufficient to invoke a legal response.

Difficulties in enforcement of soft law mechanisms

Despite the existence of several soft law mechanisms aimed at ensuring the sustainability of space activities, the most relevant for the topic at hand are the UN COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities (hereinafter: LTS Guidelines).[72] The Working Group tasked with drafting these guidelines has built on existing initiatives and the work of other bodies, in order to bring them together and provide a consolidated set of voluntary best practice guidelines that could be applied by all relevant stakeholders, from States to private sector entities, in order to enhance the long-term sustainability of human activities in outer space.[73] The LTS guidelines

[70] Lampertius 1992: 448, 445; Dennerley 2018: 284; Pedrazzi 2008.
[71] Dennerley 2018: 291–301.
[72] UNOOSA 2021.
[73] Martinez 2021: 99.

recognise that the proliferation of space debris, the complexity of space operations and the emergence of large satellite constellations are posing a threat to sustainability. In this sense these guidelines go further than the aforementioned OST principles, as instead of abstract formulations the guidelines recognise concrete risks that have emerged in recent years. Accordingly, the guidelines call for the adoption, revision and amendment of national regulatory frameworks adopted under the obligations set out in Article VI of the OST, with the aim of listing sustainability as one of the primary goals of space legislation (see guideline A.1). Particular emphasis is given to the aim of minimising the impacts of human activities on Earth as well as on the outer space environment (see guideline A.2). The LTS Guidelines reaffirm some previously existing soft law documents, such as the ISO technical standard and the Space Debris Mitigation Guidelines (hereinafter: SDMG)[74] (see, for example, guidelines A.2 and B.7).

The SDMG is another soft law mechanism of great importance for sustainability. Recognising the dangers posed to environment, human life and property by the increasing amount of space debris, they aimed to limit the quantity of debris released through normal operations (see guideline 1), minimising the potential risk of break-ups (see guideline 2), limiting the chances of accidental collisions in orbit (see guideline 3), avoiding the intentional destruction of space objects and other harmful activities (guideline 4), etc. Moreover, the SMDG is not the only initiative aimed at minimising debris. The most recent document addressing this problem was issued by the European Space Agency (ESA). Entitled *Zero Debris Charter,* the document aims at strengthening the endeavours of the ESA member states to stop generating space debris by 2030, by recommending actions such as the avoidance of the intentional generation of space debris, the anticipation and mitigation of its adverse impacts, and others.[75]

However, the reach of these soft law mechanisms is limited. The main problem with them is the lack of enforcement, as they often specifically state that they do not create any new legal obligations on states, or the language used contains non-obligatory terms such as *inviting, welcoming* and *encouraging* the

[74] UNOOSA 2010.

[75] ESA 2023.

implementation of the content. This means that not only do space actors lack the equal capability to implement them, but there is also no explicit requirement for their implementation, as compliance with such mechanisms is voluntary.[76] Nevertheless, they might gain a legally binding character when incorporated into national legislations (see the next sub-section).[77]

The main importance of soft law mechanisms is thus the concretisation of existing legal principles and the acknowledgement of certain issues stemming from the emergence of New Space. However, these mechanisms alone cannot be the overreaching solution, and they need to be translated into more concrete, directly enforceable legal rules. This is another example of an area where Astro-Green Criminology could play an important role. By shifting the focus from the study of unlawfulness to the study of harmfulness, it decreases the significance of the fact that these guidelines do not have direct binding legal effect. Instead, the focus shifts to their content, which is oriented towards harm prevention. Demonstrating the value of such guidelines in ensuring sustainability, Astro-Green Criminology can thus provide arguments for increasing their legal value – either through transposing them into national legislation or adopting a binding international treaty of such content.

Lack, incoherency and broadness of national legislation

An important part of the legal framework governing space activities is national legislation of space-active states, by means of which states carry out and concretise their obligations under the OST and other international treaties, as well as implementing certain soft law mechanisms. However, it must be noted that not all of them have actually done so in practice. There are approximately 70 space-active states, and of those only slightly over half have put in place some kind of national legislation on space activities.[78] The first shortcoming of the legal framework on a national level is the absence of space legislation in

[76] Martinez 2021: 103.
[77] Martinez 2021: 102.
[78] See HDI Global 2022; UNOOSA 2023.

a significant number of space-active states. Several differences can be observed between the existing national laws of space-active states, despite the existence of a Model Law on national space legislation issued by the International Law Association (ILA), which includes standardised provisions regarding the authorisation and supervision of national space activities, including those conducted by private actors, the operation, transfer and termination of such activities, compensation for damages, environmental[79] protection, etc.[80]

Very few national laws make direct reference to sustainability. Some of them list environmental protection as a condition for receiving a licence (for example Australia,[81] Austria,[82] Belgium,[83] Denmark,[84] Finland,[85] Slovenia,[86] the USA[87] and several others) or a reason for its withdrawal (Luxembourg[88]) or refer to

79 Article 4 of the ILA Model Law states that one of the conditions for authorisation is that the activity does not cause environmental damage to the Earth and to outer space, and that it is carried out in such a way as to mitigate to the greatest possible extent any potential space debris. Furthermore, the obligation to conduct environmental impact assessment is enshrined in its Article 7.

80 Hobe 2013.

81 Article 18 of the Space Activities Act 1998, No. 123, 1998 (as amended, taking into account amendments up to Act No. 8 of 2010) (Australia).

82 Article 4 of the Federal Law on the Authorisation of Space Activities and the Establishment of a National Registry (Outer Space Act), BGBl. I No. 132/2011 (Austria).

83 See Article 5 of the Law of 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects (consolidated text as revised by the Law of 1 December 2013 [B.O.J. of 15 January 2014]) and then the Royal Decree implementing certain provisions of the Law of 17 September 2005 on the activities of the launching, flight operations and guidance of space objects form the legal basis of the regulation of space activities (Belgium).

84 Part 3 of the Outer Space Act (Act 409 of 11 May 2016) (Denmark).

85 Section 5 of the Act on Space Activities (63/2018) (Finland).

86 Articles 4 and 5 of the Space Activities Act, Official Gazette of the Republic of Slovenia, 43/22 (Slovenia).

87 Title 51 Section 4(3)(a) of the U.S. Commercial Space Launch Competitiveness Act 2015 (Public Law No. 114-90) (USA). This Act also dictates that environmental impacts of launch activities must furthermore be considered as mandated by the specifically referenced National Environmental Policy Act (NEPA) (see Title 14, Chapter III, Parts 415.31 and 415.33).

88 Article 9 of the Law of 15 December 2020 relating to space activities (Luxembourg).

the environmental aspect in some other way (for example Kazakhstan[89] or the U.K.[90]), but most of them do not mention environmental aspects explicitly. It can be observed from this that legislations differ significantly in how and to what extent they follow and transpose non-binding soft law guidelines. Some states decide to transpose the international documents in their entirety, as for example Austria[91] and Slovenia,[92] which transposed SDMG into their laws, thereby according a legally binding nature to their provisions.

The uncoordinated and unharmonised national legislative approaches, resulting in varying national legislative frameworks, may become problematic for the long-term safety and sustainability of space activities. More specifically, if some of these national frameworks will be more beneficial to private actors (for example by setting fewer requirements for the granting and continuation of authorisation), there will be strong incentive for private entities to move to that jurisdiction *(forum shopping)*.[93] In order to protect their economies, other states will be pressured to lower their standards to match that regime, and that wish to obtain such short-term benefits could result in a spiralling "race to the

[89] See the Law of the Republic of Kazakhstan on Space Activities, 6 January 2012 No. 528-IV (Kazakhstan). Article 3 mentions a principle of compensation for damage done to the environment, while Article 27 is concerned with the safety of space activities.

[90] The Secretary of State *may* consider the environmental aspect when deciding upon a licence authorising a space activity. See Article 5 of the Outer Space Act of 1968 (UK).

[91] See Article 5 of the Federal Law on the Authorisation of Space Activities and the Establishment of a National Registry (Outer Space Act), BGBl. I No. 132/2011 (Austria), which demands compliance with "state of the art and in due consideration of the internationally recognised guidelines for the mitigation of space debris".

[92] Article 5 of the Space Activities Act, Official Gazette of the Republic of Slovenia, 43/22 (Slovenia) states that space activities must "envisage measures for limiting the generation of space debris in accordance with the applicable UN Space Debris Mitigation Guidelines and for limiting adverse environmental effects on Earth or in outer space or adverse changes in the atmosphere".

[93] Doucet 2019: 145.

bottom"[94] in which sustainability will draw the shortest straw.[95] The role of Astro-Green Criminology would be to point out such potentially dangerous trends, and to expose certain unsustainable practices. Criminological research and its methodology could provide important insights into whether states effectively exercise their obligation to authorise and supervise space activities, and whether this is done indiscriminately and impartially, and in a detailed and comprehensive way. This is especially important, as it has already been observed that the denial of social harm is a very frequent occurrence, and part of a wider culture perpetuating harm, using techniques such as "state–corporate gaslighting" – a tactic by which state authorities and corporate representatives deny the existence of pollution produced by a particular activity and its harmful effect on humans and/or environment.[96]

National laws provide for various sets of sanctions for violations of their provisions. Most of these take the form of monetary sanctions, usually a monetary fine defined on the basis of the type of offence as well as considering whether a perpetrator is a natural or a legal person.[97] Some of them include the option of a prison sentence, usually up to 1 year of imprisonment, sometimes more.[98] Research in the field of Astro-Green Criminology can examine the effectiveness of various sanctions, suggesting further improvements in the area. In particular, by deploying criminological methods, it can use various avenues

[94] It must be noted that Article VI of the OST could play an important role in mitigating this effect, as the direct responsibility of states for the conduct of their private actors could motivate states to adopt stricter regulation. However, since it is not clear whether Article VI of the OST in fact entails the direct attributability (and thus responsibility) of the conduct of private actors to the relevant states (see Gailhofer–Scherf 2022; Chirwa 2004), such lack of clarity regarding the nature of Article VI can negatively affect the aforementioned motivation of states.

[95] Doucet 2019: 145.

[96] Boukli–Kotsakis 2023.

[97] See, for example, Article 19 of the Law of 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects (consolidated text as revised by the Law of 1 December 2013 (B.O.J. of 15 January 2014) (Belgium).

[98] Article 14 of the Law of 15 December, 2020 relating to space activities (Luxembourg), for example, sets the limit for imprisonment sanction up to 5 years.

to analyse the effectiveness of sanctions from the perspective of the offender (this is a penological perspective, evaluating the effectiveness of different approaches, such as liability, monetary fine, prison sentence, etc.), as well as from the perspective of the victim (victimological perspective, evaluating the promptness and the appropriateness of the compensation received).

Lastly, the problems arising in the wake of New Space will also require new ways of legitimising space activities. As sustainability is surely an important part thereof, other methods will need to be deployed in this area. Anglada-Escudé, for example, strongly advocates more civic participation through greater inclusion of various social stakeholders, such as civil society representatives, as well as the broader public.[99] Astro-Green Criminology can examine whether the legal frameworks created enjoy democratic legitimacy amongst the population.

CONCLUSION: THE ROLE OF ASTRO-GREEN CRIMINOLOGY IN FUTURE REGULATION OF SPACE ACTIVITIES

The brief legal analysis of space law conducted in this Chapter, which is not in any way conclusive and overreaching, but rather demonstrative, has exposed numerous shortcomings which are making space law in a large part ineffective in the face of the rapid proliferation of challenges arising from New Space. This is the reality of the situation, and this reality demands that we start looking for additional new ways and perspectives of tackling this issue.

In this endeavour, Astro-Green Criminology can play a significant role by shifting the perspective from a strict legal analysis, focused on 'what is compliant with the existing legal framework and what is not?', towards asking 'what is harmful and how should it therefore be appropriately regulated?'. In that way, starting from the bottom up (from the factual analysis to the creation of legal framework), the examination of harms can be conducted without being subject to the limitations inherent to the examination of the legal framework. In other

[99] Anglada-Escudé 2022: 1360.

words – an examination of harm can be conducted thoroughly, without first having to prove that such harm indeed reaches the threshold which is required for it to be considered 'unlawful'. This does not mean that the analysis of harm is separated from the analysis of the applicable legal framework. On the contrary, identifying deviant behaviours that are harmful, but which are not yet criminalised or otherwise legally regulated, can serve as an important basis both for the modification of existing law and for the creation of future political and legal responses.

Furthermore, Astro-Green Criminology could provide an important forum for further discussions regarding the future of space law, as the shortcomings of the current legal systems are not purely issues of law, but are the product of an ideological background and lack thereof, as well as a result of numerous relations of power and interests, and must be regarded and examined as such. This means exposing the complex power relations between space players and the legislator, including the conflicts of interest that may exist within the law-making processes.

Moreover, building upon the findings of (eco)philosophy, criminological research can provide answers to the necessary preliminary questions of why and how space exploration should be conducted, and thus begin to address the striking absence of a concrete theoretical and ethical background in current and especially in planned space activities, such as space tourism, space mining and space colonisation.

The criminological analysis of harm can pave the way towards better and possibly stricter legal regulation of space. This entails not only international law, but also national administrative proceedings, liability claims, and, in some cases, also criminal law. Astro-Green Criminology can deploy the methodology used in criminological research to assess the effectiveness of these legal approaches. A comprehensive legal framework with effective sanctioning ability is the only way to ensure that space activities are carried out in a sustainable manner. Previously, most of the regulatory framework of space law, especially the documents adopted in the first thirty years of the space activities, was not drafted with sustainability in mind. Sustainability was often merely an afterthought

in both space exploration and the development of space legislation.[100] The current situation, however, with the increasingly overcrowded Lower Earth Orbit (LEO), the enormous amount of space pollution and the growing number of space players and planned missions, demands a shift in perspective towards a more sustainable way of law-making.

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[100] Dhopade et al. 2023.

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