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The Ethics of Resource Extraction in Space: A Normative Essay

Vincent Affatato*, Marco Conenna and Davide Roversi

Department of Space Engineering, Delft University of Technology, Delft, Netherlands

***Corresponding Author:** Vincent Affatato, Department of Space Engineering, Delft University of Technology, Delft, Netherlands; E-mail: vincentaffatato24@gmail.com

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Abstract

The expansion of mankind in Space will eventually lead to the need for resource extraction on places different from earth. For the few who would succeed, the monetary gains from space mining are promising but inevitably, such activities will bring about substantial consequences to the celestial bodies they are conducted on and to the political-economical scene of the parties involved. Thus, a new set of moral interrogatives needs to be dealt with. This paper reflects, from a utilitarian perspective, on whether it is ethical or not to exploit extra-terrestrial resources and tries to produce moral norms on the matter. The main research question is analyzed with respect to three crucial aspects: Environmental consequences, interaction with possible forms of life and the political-economical setting around resource extraction in space. Reflections, argumentations, and claims are backed up or confronted with already existing theories and positions of other authors. Altogether, we concluded that the extraction and usage of the resources of another celestial body is ethical only when: 1) It is regulated enough to avoid the destruction of naturalistic, aesthetically or culturally valuable environments; 2) It does not interfere (or at least, it tries to deal) with existing or possible future forms of life, which ought to be protected with ad-hoc legislation; 3) It is regulated to prevent tensions that would likely arise between countries that want to access specific resources-rich sites, issuing laws able to avoid conflicts and a possible economic collapse. To summarize, we identified the concept of responsible innovation as the key director for future policies that will need to be established when space resource extraction becomes a reality.

Keywords: Asteroid mining; Planetary exploration; Utilitarianism; Environment; Planetary protection; Exploitation; Space.

Introduction

Space is currently considered by many as mankind's last frontier. Despite still being relegated to Earth, humans have gone through incredible technological leaps that led to achievements such as setting foot on the Moon and landing rovers on other planets in the Solar System. On these bases it is feasible that, in a not-so-distant future, mankind will be able to expand beyond the boundaries of its currently only home planet, extending its reach in the Universe with settlements on other celestial bodies. Such an expansion would bring with it a series of logistical and practical challenges, one of many revolving around the enormous amount of resources and raw materials that would be needed to sustain the endeavor. It is reasonable to imagine that Earth alone will not be sufficient to sustain the need, so resource extraction would necessarily have to be conducted elsewhere too. More specifically, when discussing space mining and resource extraction, we mainly refer to rocky-type bodies. This category includes planets like Mercury, and Mars and smaller bodies like asteroids, comets, and meteoroids in the Solar System and in outer space. Such targets have a solid crust that contains different types of materials, minerals in particular, which solidified during their formation in the early ages of the Universe. However, the composition of their crust varies wildly: For instance, 1986 DA, which is a metallic-based asteroid in the near Earth Orbit, is believed to have substantial amounts of precious metals such as gold and platinum for an estimated value of 48 billion dollars [1]. It is therefore evident how monetary gains from the extraction of precious and rare materials are an additional driver for space mining. With prospects like this, the interests in resource exploitation activities in space are considerable and, as a consequence, a series of ethical dilemmas arise.

This essay will try to tackle the following moral interrogative: "Is it ethically acceptable to exploit the extra-terrestrial resources available in space?" The reason for this question is that, from mineral mining to other forms of resource extraction, these activities have already been shown to have a massive impact on earth. Extending them to space, the potential to generate political tension and long-term harm to environments and ecosystems is extremely high. We, therefore, deem it necessary to dive deep into the principles and values that drive humans in the extraction and management of resources in order to try and anticipate what possible outcomes would arise from such activities in an extraterrestrial world.

The main research question will be answered from the perspective of the utilitarian moral theory, focusing on three main aspects: Environmental implications, life protection, and political-economical issues related to *in-situ* extraction. Each aspect will be addressed in detail, by referring to existing theories and other authors' positions on the matter, in order to support the statements or refute possible counter-arguments. Additionally, sources will also be cited to reinforce or complete statements related to more scientific or engineering-specific subjects. Thereby, the essay aims to provide a set of norms and suggestions that would have to be applied to avoid political tensions, environmental harm and guarantee the protection of any form of life, while ensuring the possibility for mankind to make use of the resources hidden under the crust of currently untouched bodies.

Materials and Methods

Environmental Implications

One of the fundamental moral controversies related to resource extraction from another celestial body lies around the environmental implications of such an endeavor. How should mankind behave concerning its natural environment, where mining activities can generate enormous volumes of resources and substantial profits? Should humans focus more on preserving its natural state or is it ethically allowed to exploit what it has to offer with no regard to the

consequences? These are just a few of the many choices that space explorers would be faced with when settling on a new world.

In order to try and tackle the problem, it is reasonable to first look at what has been done on Earth. For centuries humans exploited its resources without worrying about environmental consequences. Lately, though, more and more attention has been posed to the need to better balance these activities, with the aim of preserving the state of the planet. Humans have realized that, in the long run, greater benefits would come from a healthy earth rather than from an unregulated quantity of extracted resources. In Utilitarian terms, more people will benefit from living on a planet that is still reasonably habitable, rather than on one that has been torn by ruthless exploitation. However, the contrast between environmental preservation and resource exploitation must be analyzed deeper when dealing with an extraterrestrial world. This is due to the fact that, in space, human interests and activities could differ substantially from those on Earth. In order to unravel their intricacies, in the following paragraphs we are going to tackle these interrogatives with respect to two main principles, already introduced by Stoner: scientific preservation and wilderness integrity [2].

Similar to what is currently being done on earth, where quarries, mines, and rigs are among the most diffused systems of resource extraction in use, other celestial bodies could similarly be exploited by humans in case of an expansion of civilization. However, many celestial bodies currently only observed from afar are believed to contain answers to several scientific questions. The possibility of setting foot on these gold mines of information would unlock incredible opportunities for science, as exposed by Stoner in its book "The Ethics of Terraforming: A Critical Survey of Six Arguments"[3]. As he explains, the insights that can be obtained by in-situ experiments, such as analyzing samples of soil or studying the stratigraphy of terrains, would be of much greater magnitude compared to what is currently obtained through remote observations. A testament to the importance of on-site scientific studies is what is currently being conducted on Mars, thanks to the rovers that are present on its surface. Their activities are helping scientists understand how and when water was present in the soil, they provide information on the hypothetical presence of life in the past [4,5], and could also be of great relevance for Earth, unlocking information about the geophysical history and evolution of our planet [6]. We believe that none of this would be possible if human activity on another heavenly body focused solely on the exploitation of resources with no regard for the preservation of the environment. Once again, Earth is the prime source of comparison. The environmental changes caused by humans since the beginning of industrialization can be seen in almost every continent. The progressive reduction of the Amazon rain forest due to deforestation or the melting of ice caps even in the regions closest to the poles caused by rising temperatures are just a few examples. If the same was done on another celestial object that would foreclose any possibilities of scientific investigation due to the irreversible alterations suffered by the environment. The uniqueness that characterizes it would quickly be lost, and all of the scientific relevant information would disappear as well (Figures 1,2).

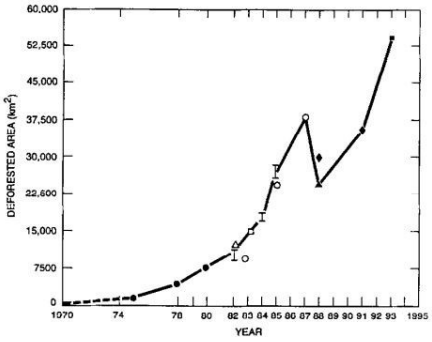

Figure 1: Yearly deforestation trend in Rondonia, Brazil.

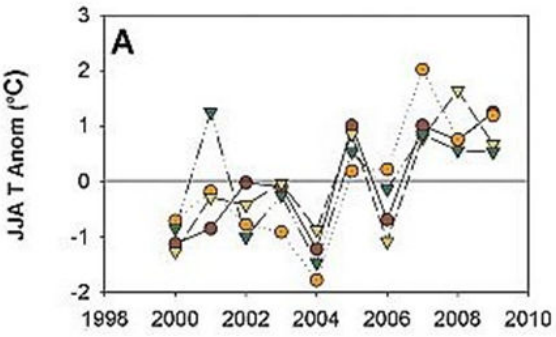

Figure 2: Annual temperature anomalies, relative to the 2000–2009 mean, at arctic research stations of Resolute, Eureka, the Agassiz Ice Cap and the Devon Ice Cap.

Note: ( ) Mission category; ( )Mission type; ( ) Types of planetary bodies.

On top of the matter related to the scientific values of natural environments in space, there is a second principle that is worth taking into consideration: Wilderness integrity. On Earth, it is a common acknowledgment that, to some degree, naturalistic environments should be preserved for their intrinsic aesthetic, historical, and cultural value. The evidence of this can be found in the large and rising number of natural reserves, protected areas, and wildlife refuges [7]. This attitude has its roots in humans striving to balance their craving for resources, needed to sustain current living standards and technological advancement, with the belief that beauty, history, and culture have the right to be preserved as well. As summarized by Rolston's rules, three main categories of natural environments should be preserved against anthropogenic activities [8]. They are:

- Places of exotic extremes
- Places of historical value
- Places of aesthetic value

It does not require an excessive stretch of imagination to realize that, like the Grand Canyon, the Great Barrier Reef, or the Niagara Falls here on Earth, similarly valuable places could be found on other worlds too. On top of this, it is feasible that, when mankind will have the capability to expand beyond Earth, long-term settlements will emerge on other celestial bodies, especially planets. Due to their extreme diversity, many unique environments will be found in these new worlds and, likely, many of them will fall into one of the three

categories mentioned above. Even so, as time progresses, many sites and regions will become historical and cultural landmarks of the settlements that were established there, similarly to what happened on Earth with sites like Pompeii or The Great Wall of China, which are now protected to the same degree as natural parks.

In order to evaluate which attitude should be taken by humans when faced with the opportunity to exploit a heavenly body's resources with the potential risk of harming its environment, the Utilitarian concept of "greatest happiness for the greatest number of people" ought to be analyzed thoroughly. It must not be overlooked that the monetary returns deriving from unconstrained mining and the establishment of a new trans-planetary resources market would be extremely large, as highlighted by Xu in the article "Environmental protection in the exploitation and use of space resources"[9].

At first, it would seem foolish to impede such activities in the name of, history, nature, or culture alone. However, to truly assess the moral dilemma at hand, a bigger picture must be considered. Firstly, the previously mentioned financial prosperity deriving from space mining would likely end up only in the hands of a few, exactly as it is the case on Earth, where wealth is all but equally divided among the population [10]. On the other hand, the very reason for which mankind has been able to advance with its technology, to reach space, and, in a not-so-distant future, to set foot on a celestial object different from Earth, is thanks to science itself. Allowing the destruction of an environment that could itself unlock additional knowledge and open more opportunities to expand further in the Universe is not only illogical but would outright violate the utilitarian principle of acting so that the consequence of those actions can bring the greatest benefit to the largest number of people. Additionally, in light of the arguments related to the principle of wilderness integrity, allowing unconstrained and irresponsible resource extraction would mean disregarding the very principles that led to the creation of natural parks and protected areas on Earth. We strongly believe that such behavior would lead, in the long run, to humans regretting their past actions, similar to what has been happening on Earth ever since the harm that unrestricted industrialization had brought to the environment became evident.

All things considered, exploiting any heavenly body for its resources, in such a way that the scientific value of its environment or the environment itself is hampered, severely altered, or outright destroyed in any way, has to be considered morally unacceptable. Nevertheless, this does not mean that any extraterrestrial object that mankind might set foot on should be left completely untouched. Resources are still necessary means for the expansion and advancement of our species and it would be unreasonable to think that Earth could be the only site of extraction and production. Technological enthusiasm is, after all, one of the key drivers that contributed to mankind's evolution and, as such, we are of the opinion that it has the right to be maintained in the future as well. Balancing the two aspects is therefore better done through reasoning. The two main ideals are, on one side, the preservation of the environment and, on the other, technological enthusiasm that carries with it the necessity of space mining and resource extraction. Common ground can be found in limiting one or the other, allowing both to coexist. However, similarly if not more than what is being done on our home planet, priority would have to be given to the preservation of scientifically, culturally, naturalistically, or historically valuable environments.

The evaluations conducted up to this point looked at environments in their broader sense. However, one of the key aspects that define any object in space and would, therefore, influence human behavior on its surface, is the presence or absence of life. As such, how space mining and resource exploitation ought to be adapted in relation to possible forms of life deserves a deeper analysis and will be thoroughly assessed in the following section.

Life-centered issues

Life-treated as existence itself, "being in the world" is an immeasurable value for mankind. There have been attempts, over the millennia, to give it a symbolic value, for example through tombs and funeral commemorations; or a monetary one, through life insurance or cost-benefits analyses. It has tried to expand its boundaries through medicine and research, creating a common imagination made of monsters like Frankenstein and ghosts, to make death less powerful. In the end, it has even been tried to give more importance to the "currency" of life itself: time. Albeit there have been these and many other advances in gratifying human lives as much as possible, we think that one fundamental aspect has been overlooked: Humans are not the only beings with a worthy existence. For a human being, it is already hard enough to consider the importance of the life of another human being, let alone of other forms of life extremely different from him or from whatever his collective imagination has even given birth to. However, if the goal is precisely to colonize new worlds and exploit their resources, one of the ethical efforts that will be necessary to make is to reshape the conception that humans have of life.

Despite, at first glance, there seems to be no correlation between the value that humans place on life and the exploitation of space resources, reality shows that this burning issue has already been the focus of discussions about space missions. In 2002, several space agencies of different countries (Europe, the US, Canada, and Japan) signed COSPAR's planetary protection policy, a document that regularized space missions in terms of contamination levels to avoid the arrival of terrestrial life forms on other planets. This aspect is crucial: the document assesses the targets of the missions (e.g. a comet or a particular planet), concerning their environmental conditions and their evolutionary history, prioritizing them (Figure 3) taking into account how likely it is that an organism brought accidentally from the Earth can survive or even proliferate if carried there by mistake [11]. The goal of the policy is to prevent "alien invaders" from affecting the evolution of another celestial body that would allow the survival of microorganisms, with unknown consequences for the alien ecosystem and for all the possible life forms present there (which could be dormant, as well as based on another kind of chemistry). Obviously, in the same way, the possible re-entry of samples on Earth is regularized to break the contamination chain.

Mission category	Mission type*	Types of planetary bodies
I	Any	Bodies not of direct interest for understanding the process of chemical evolution or the origin of life.
II	Any	Bodies of significant interest for understanding chemical evolution and the origin of life, but with **only a remote chance** that contamination by spacecraft would compromise future investigations.
III	Flyby, orbiter	Of significant interest for understanding chemical evolution and/or the origin of life, and with **a significant chance** that contamination by spacecraft would compromise future investigations.
IV*	Lander, probe	
V (U)	Unrestricted Earth*-return	From bodies deemed by scientific opinion to have no indigenous life forms.
V (R)	Restricted Earth*-return	From bodies deemed by scientific opinion to be of significant interest to the process of chemical evolution and/or the origin of life.

Figure 3: Example of target prioritization by COSPAR policy.

Note: ( ) Mission category; ( )Mission type; ( ) Types of planetary bodies.

A similar policy should be applied to the mining of extra-planetary resources, and more generally to any invasive operation. Although, so far, there have been few such activities-the lunar walks of the Apollo missions, or the collection of samples of Martian rock completed by the various rovers-if the plan to extract resources and exploit them for the colonies or the mother planet, humanity should in some way evaluate the consequences of these actions, both on the morphology and on the hypothetical biology of the exploited celestial body. The point is that, in this particular case, the classification would be much more complicated: In the case of the Committee on Space Research (COSPAR) policy, a comet has just a low probability of survival due to the lack of atmosphere, or due to its small size, which prevents the differentiation of the territory and consequently makes the classification easier. On the contrary, the mining of water from comets or asteroids would imply canceling the probability of its arrival on a planet through an impact. If the suspicion that this water can kick-start the chain of life-as it probably happened on Earth-results to be true, isn't this an indirect way to influence the evolution of a planet? Even if it is still not fully known how life has evolved on our planet, there are several hints about how vulnerable it has been to changes in its lifetime: Pretending to intervene in the timeline of another celestial body is a step that at the moment cannot yet be afforded. What if humans go and erase dormant or embryonic life forms? What if the excised resources are crucial to global changes on the planet that will only happen in the distant future? [12,13].

Furthermore, the big picture is more complex than this. Some may affirm that even the first contact with another planet can be considered deleterious, that human beings are only capable of ruining what surrounds them and, consequently, on Mars or any other planet they would do nothing but bring another ecosystem to collapse as they are with Earth [14]. However, this type of defeatism leads nowhere. Humans should use their critical thinking and their free will to act conscientiously, not settle for a nihilistic vision that would completely erase their enthusiasm for the unknown. Mankind should pursue an ethics of risk instead of an ethics of control, because its awareness of the world stops just beyond its nose, and is too tied to stereotypes and dogmas created by the human race for the human being. Despite often every diversity being automatically translated into a border, or monetary values being placed on top of everything else, will it be possible not to cover the eyes in front of the "aliens"? Will it be possible to have a scruple before modifying the home of other life forms? [14].

We believe that mankind can take these steps forward. The journey in the universe can change humans once and for all, making it a less selfish civilization. Although over the centuries there have been unbridled and bloody colonizations, these events have also led to both a technological advance and to the awareness of having taken the wrong approach. It took ages, but it got better. We are convinced that, now, the task is to put aside the anthropocentric vision and consider a more Universalist one.

Let's imagine, by way of example, the opposite case: Humans living quietly on Earth and aliens, a highly civilized form of life, discover it and decide to exploit its resources for their benefit. They are so evolved that they don't see mankind as a sentient form of life, but simply as beings that lie on their resources. If they decided to undermine those resources, without even thinking about it twice, leaving humanity essentially without a home to live in, how would it feel for the inhabitants of Earth? A feeling of powerlessness, of frustration? Now imagine if this scenario had occurred thousands of years ago: That would have likely precluded the possibility for us to discuss the subject today. It is precisely what needs to be prevented: If the purpose of the exploitation of planetary resources is so valuable (allowing all of humanity to live a more comfortable life) from a Utilitarian point of view, at the same time it should be necessary to avoid ruining the life of something that already exists or may exist in an incalculable future.

For all these reasons, a policy of exploitation will be necessary for the future if we want 1) To act ethically and correctly within the boundaries of ethics of risk and not of control and 2) To convince public opinion to act in the good, following protocols consistent with scientific knowledge and for the benefit of all the humanity, not only the richest. In the past, when it was decided to only pursue short-term economic returns, despite all the possible benefits that a new technology or the aid that a proven technology could have given to tackle a new problem, the situation has degenerated. Think about nuclear energy, which is now seen as a taboo when it could probably be the solution to energy problems of the future [15].

In trying to find what is closest to a solution, in this situation, we are convinced that a kind of trade-off is the best approach: We should consider as moral to exploit resources in space only if the possibility of annihilating dormant, present, or future life forms is low enough, or it has too low severity if compared to the aim of the exploitation, to prefer the use of these resources for our scope. In affirming this, we are therefore admitting. Firstly, the need for a study that deepens the impact of human activity on alien biology and secondly, the need for a policy that regularizes the use of the resources most transparently and neutrally possible, to enforce the fact that the exploitation returns a huge benefit for the most number of people at the expense of the lowest price to pay. One relevant example is the exploitation that is necessary to sustain a space refuge, i.e. a colony that can provide an extra chance of survival for humanity in the event of cataclysms on Earth [16]. In that case, saving billions of lives would be more important-again from a Utilitarian point of view-than caring about infinitesimally low possibilities of alien forms of life. All in all, these considerations remain pure speculation if political coordination, taking into account both the resources coming from space and their management here on Earth, is not placed at the base of our policy.

Political-Economical consequences

The space race occurring during the Cold War set the roots of today's normative framework regarding all kinds of space activities, from the most critical safety of the astronauts to ownership and the exploitation of commonly held resources issues. In 1967, the UN Committee On the Peaceful Uses of Outer Space (COPUOS), formed by representatives of all the principal space fairing nations of that time, when the possibility of extracting resources from a celestial body was considered only in sci-fi books, signed and approved the International Outer Space Treaty. The treaty legally banned the annexation and appropriation of any areas of the Moon or any other celestial body, but explicitly allowed the use and exploration of outer space [17]. By using the term "annexation", this agreement clearly prohibits all forms of sovereignty towards outer space, preventing any international power from exercising its legal authority over the future inhabitants of the target planet. However, employing the word "use" in the second expression, the Outer Space Treaty remains substantially subject to interpretation, virtually allowing any nation or private

company to exploit the natural resources of celestial bodies with no normative limitation. In such foggy normative circumstances, every participant in the space mining race could use the same rich mining spot, and the most obvious consequence of this condition would be a disastrous diplomatic war.

Starting from these assumptions and considering that soon many will take advantage of the grey zone in the Outer Space Treaty just described, the first nation developing the necessary technology to exploit the natural resources of an extraterrestrial body will likely be free to choose where to mine, how to mine, and most importantly, the purpose of mining. Could this futuristic scenario be in line with the principles of utilitarianism? Would the benefits for the most clearly outnumber the negative repercussions?

The potential consequences of Space mining on today's society are hardly imaginable. The first private company or nation to achieve this goal would most likely earn trillions in a span of few years, and such a rapid change in the structure of the world economy would most certainly create an imbalance in the international forces, consequently affecting the lives of many on our planet. Supporting this argument, a study conducted by researchers at Tel Aviv University simulated that the beginning of the space mining era would cause the fall of the economy of global raw materials. For instance, the price of gold on Earth would drop by 50%, similar to what happened to Platinum at the end of 2008, as shown in Figure 4 [18-20].

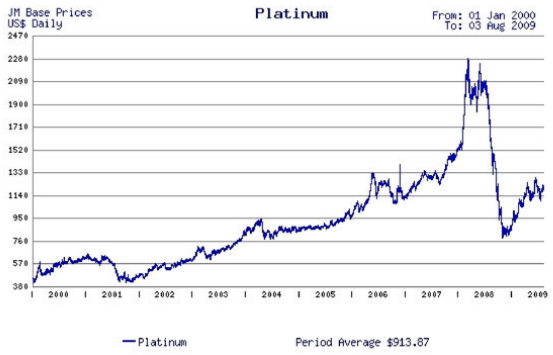

Figure 4: Daily price of Platinum in US$ from 2000 to 2009.

One more important topic taken into consideration by this research is the attitudes that different nations would show towards mining technology. The most obvious result is a significant difference between the most developed countries, which would actively participate in this economic activity and consequently would have direct access to the mining resources, and those with no meaningful space capabilities [21]. With no clear regulations, we believe that the former would dictate the entire space mining market according to the anarchic "First come, first served" rule, while the latter would try to stop this technology from being implemented as they would initially only suffer from the possible economic fall and would not earn any advantage. For this reason, the controversy on this topic is very subtle. Is it fair that only the ones with the appropriate capacities have the concrete possibility to gain complete control over such a vast economic domain? In order to satisfactorily answer this question, it is fundamental to mention that the theoretical monopoly gained by the successful companies does not necessarily clash with the values behind utilitarianism because, although only a few parties would have control over the resources extracted from the celestial body, the possible benefits would apply to the entire human race.

As already mentioned, the simulation from Tel Aviv University researchers [20] also highlighted the actions that poor countries would take toward space mining. These nations do not have the capability to reach a celestial body and extract its resources, and the impossibility of developing such complex missions is mainly caused by the complete lack of a national space agency or by a strict budget prioritization of their government that does not include space in their short-term investments. For these reasons, this revolutionary technology seriously threatens these nations' stability, and therefore they would most likely try to stop its development. They would feel cut off from the resources revolution and would have to deal with all the side effects, but most importantly they would have to quickly learn how to behave in the economic recession that would follow.

Many poor countries rely exclusively on the exportation of rare materials. For instance, the Democratic Republic of Congo is by far the first exporter of cobalt in the world, with around 2.36 billion worth of cobalt exported annually [22]. What would happen to this country if cobalt prices suddenly drop? The answer is quite simple: from one of the poorest countries in the world, ranked 10th in 2020 with only $550 GNI per capita, it would drop even further in the world's poorest countries list [23]. Furthermore, Congo is not the only nation that would suffer such tremendous consequences: global powers would also be heavily impacted. For instance, Brazil is classified first among the exporters of Niobium, and Myanmar provides 60% of China's medium to heavy rare minerals feedstock every year [24].

However, this is not necessarily the fate these countries must face. Mainly two actions could be taken into consideration to prevent the economic crisis, namely heavy regulations on space mining resources trading or some sort of adaption of the local companies to the new market. For example, what if the companies that for decades have been employed to refine cobalt in Congo would be available to cooperate with the newborn space mining companies? Thanks to the experience they have been gathering in these complementary but fundamental processes, they would not be set aside and instead be an active part of the new market. In such a manner, space mining could surprisingly become a golden opportunity to revive poor countries and drive them towards an economic boom, taking a further step in reducing poverty in some areas of the world.

As previously mentioned, this revolutionary event would not only have a huge impact on small countries, it would influence the entire world. It could represent the best opportunity of the current century for humans to grow as a civilization, but only if the right measures are taken. In this context, the key concept is "responsible innovation", intended as the process of advancing in technology, engineering, and as a species altogether, through means that take into account the ethical consequences and outcomes from the beginning, without considering morality as a separate aspect that can be dealt with later [25,26]. As a matter of fact, the proper distribution of benefits necessary to satisfy the principles of Utilitarianism heavily depends on the regulations that must be issued to promote a new fair market around the resources extracted from celestial bodies. Considering the novelty the concept of space mining represents, these regulations shall be based on some sort of "practical" space ethics, analog to the moral code which international trade laws are based upon, and therefore not exclusively theoretical postulates that would hardly be respected by the ferocious competitors involved in the world market [15].

Results and Discussion

This essay aimed to answer the question "Is it ethically acceptable to exploit the extra-terrestrial resources available in space?" This was done by analyzing the subject of resource extraction on a celestial body through a Utilitarian perspective and with respect to the consequences for the environment, for possible forms of life, and the political-economical framework in which such activities would be carried out.

When it comes to the environment, two principles were used to evaluate the morality of resource extraction: Scientific preservation and wilderness integrity. The argumentations led us to conclude that resource extraction can indeed be considered ethically acceptable but with limiting factors. The preservation of scientifically, aesthetically, culturally, or historically valuable environments should be protected even at the cost of limiting possibly profitable mining activities. This is because preserving the above-mentioned types of environments has been deemed to generate, in the long term, greater benefits and happiness for the whole of mankind. However, when possible, reasoning should be applied to evaluate if and how environmental preservation can be achieved while still allowing extraction to some extent.

Moving on to the life-related implications, the clear need for a policy as adaptive and comprehensive as possible has emerged. Such a policy should take into account the long-term effects of human intervention on every possible extraterrestrial habitat, should be based on a trade-off between the likely damage to the ecosystem and the necessity of such an intervention for our species, and even more importantly, should permit mankind to go beyond its anthropocentric point of view, protecting forms of life that may be hidden from current scientific knowledge and most fervid imagination. Only in this way, humans will be able to finally become inhabitants of the Universe instead of mere life forms on a lonely planet lost in some corner of the cosmos.

Conclusion

Finally, analyzing the political and economic issues that could arise from space mining, it became clear how specific laws are needed to regulate the import of the materials extracted, in order to avoid diplomatic conflicts between the most technologically advanced countries. Additionally, these laws would be necessary to prevent one of the largest global economic recessions humans have ever faced. The stock market of rare materials crashing would likely be followed by a rapid escalation in the disparity between the rich global powers and third-world countries, where these minerals are mainly found nowadays.

The recipients of this short essay are, firstly, all those who consider the exploitation of extra-planetary resources a simple and direct step towards the undisputed evolution of the human species. As history teaches, there have always been various kinds of problems whenever humans set foot on an unexplored territory: It has never been only about discoveries, revolutionary imports, economic expansions, and so on.

Moving on, we want to address the nations, political institutions, and private organizations that have or will have the power to shape the way space resources are accessed and extracted. The ethical side of such activities has almost always been neglected, and this has led most of the time to the impoverishment of local biodiversity, the disappearance of indigenous populations, and the unbridled enrichment of the leading powers in the field. History often repeats itself, but learning from past mistakes is useful to avoid making them again.

Altogether, the efforts ought to be directed towards policies of responsible innovation that truly base themselves on the belief that the technology driving progress is not an independent element in human activities. The responsibilities associated with it, the ethics of engineering, and of the choices behind, are all intertwined.

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Disclaimer/Publisher's Note

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