Ethical & Sustainable Features of Mining of the Lunar Surface

Arun Radhakrishnan[1], Shikshaa Sharma[2]
amongdastarz@gmail.com, shikshaa2017@gmail.com,

Keywords: *Artemis, Sustainability, Helium-3, Lunar Surface Mining, Lunar Reconnaissance Orbiter*

ABSTRACT: By 2024, nearly after 50 years, motivated by the likes of Lunar Surface Mining, NASA is once again all set to send a series of crewed spaceflight missions- Artemis, back to the Moon. This mission not only accelerates the momentum of the space race and long-term exploration and utilization of space resources (and particularly Lunar resources); it also gives rise to some important questions about the ethical, sustainable and economical aspects of lunar surface mining. Although, the participation of private players in the space industry has brought down the cost of space launches- the inadequacy of a full-fledged legal infrastructure for space policies makes it a questionable business. Rich countries with better resources such as the USA, Russia & China can have an unfair advantage over other countries if the colonization on the Moon takes place.

As demonstrated by the findings of previous Moon Missions such as the US Lunar Reconnaissance Orbiter, lunar mining could be a pivot point in the field of material science and energy generation and technology. The Moon has considerably higher precious metal content and mineral rich soil. Rare isotope of Helium known as Helium-3, that can be used in nuclear fusion reactors for high energy generation, is scarce on the Earth but is abundant on the Moon. New technology could be developed for fuel production and repair and management of vehicles- all in space. As the research progresses, it is apparent that the attention towards Lunar Mining will be escalated.

This paper shall investigate the various perspectives of this subject such as i) Revision of the Outer space treaty to be inclusive of the economic interests of the stakeholders ii) Understanding the technical mission requirements, iii) ensuring equal representation of all nations by encouraging cooperation among all nations, and iv) thereby enabling space for everyone. This would also mean identifying the ambiguities in existing space policy infrastructure and coming up with futuristic and innovation recommendations that will enable the space industry to benefit all countries. Promoting discussions regarding the ethical and sustainable aspects of the Lunar missions will ensure an inclusive disposition among all the nations across the globe and will further stimulate the essence of harmony and oneness among them all.

I. Introduction

Many Moons have passed since the Apollo Astronauts' last Lunar Landing in 1974. Comparing to the yesteryears, we see that the entire World's Political Environment has undergone a profound transformation. Geopolitical tensions between the two superpowers of the time, i.e., Soviet Union and the United States escalated quickly after World War II, resulting in a period of deteriorating relations termed by the scholars as the "Cold War." Mutual distrust and competitive rivalry rapidly spurred technological improvements that fueled the ability to create new battle lines. Space became one of the arenas in which the former two superpowers contended for Influence, Technological Progress, and Economic Prosperity. Many events shaped the Cold war, these included the launch of the first Satellite, Spacewalks, the Space Station, and grand missions of Explorations. These events serve as reminders of the tremendous innovation that is possible when political and economic incentives exist.

While the Cold War of the late 1960s eventually ended with the Soviet Union's demise, there were moments of enormous anxiety, such as the Cube Missile Crisis, that frequently drew the two superpowers to the brink of a nuclear war. However, Space was looked upon to ease tensions, and perhaps, there is no better illustration of this than the Apollo-Soyuz handshake in orbit on the eve of the 6th anniversary of the Moon landing. This historic event served as a symbol of *détent*e between the two superpowers. The cooperation seen in projects such as the Mir Space Station and Skylab, which paved the way forward in building mutual understanding and fostering international relations among the superpowers, is a precursor today to international cooperation in space projects such as the **I**nternational **S**pace **S**tation (ISS).

II. Influences of IR on Space Cooperation

While the World has since changed since the dramatic events of the ’60s, scholars of **I**nternational **R**elations (IR) assert that the World has moved from systems of power like Uni & Bi-Polar to a more fragmented reality with multiple regional organizations taking precedence in terms of power and influence. This is in sharp contrast considering that the World has become more Globalized and Interconnected with Multinational Corporations exerting influences that are beyond the sphere of influence of the nation-states that are of their main origin. In this regard, Space too is seeing the effects of the various policies and initiatives that are slowly altering the industry. While more regional space agencies are being established, and as developing nations become new entrants, battle lines are slowly being drawn which are resulting in nations forming blocs that can be argued to generate or curtail innovation.

Take for example, China's glaring absence from the **I**nternational **S**pace **S**tation or the ISS. While the ISS is distinguished by multilateral collaboration, China's absence is conspicuous. The **Wolf Amendment**, approved by the United States Congress in 2011, prevents NASA from utilizing federal funding to engage in direct, bilateral collaboration with the Chinese government. This legislation, which sprang from the US's mistrust of human rights violations, is a bad example since alienating China has resulted in their stratospheric rise in terms of strengthening internal Chinese capabilities. The rapid execution of the Chinese space agenda in terms of Robotic Interplanetary Missions, Sample Return missions, and the construction of its Multi Module Space Station - the Tiangong or "Heavenly Palace”. These developments are all indications that the next decade will see the foray of Chinese interest in space.

However, with the recent success of the Change-5 probe on the opposite side of the Moon, and mission objectives to scan for Helium-3 in future missions, it is worth mentioning that there is also a long-term Lunar exploration roadmap is being charted in these preparations. These missions are certainly going to require long term International collaboration. The recently announced collaboration with the Russian Federation on jointly establishing the **International Lunar Research** Station suggests that multilateral cooperation among other ally governments will be the norm.

According to reports, the **China Manned Space Agency** has given preliminary clearance to load more than 1,000 scientific experiments onto the Tiangong space station, and it is encouraging global involvement through the United Nations. Other regional powers such as India have expressed their intent to participate in the Chinese endeavor leaving aside the geopolitical differences.

These recent occurrences show that nation-states that do not share the same ideology as the United States and its allies frequently end up constructing their goalposts and advancing agendas that produce conflict. This suspicion and alienation with current trends can fuel technical innovation, as was shown

during the 1960s when the fight of ideologies led to great advances in space. However, given the situations in which there are more stakeholders and new entries, any misstep by either party can result in long-term consequences.

III. The Debate About Artemis

The Artemis agreement, signed in October 2020, establishes Standards, and Regulations for nations wanting to collaborate with NASA on long-term Moon Exploration. Thirteen countries are a part of this accord with Poland being the most recent addition to the list at the time of writing this piece. While these developments will undoubtedly aid in the acceleration of a Cis-Lunar Economy, there is growing opposition in the space community to the Artemis agreement, as the US promotion of the accords outside of "**normal**" channels of international space law such as the **UN C**ommittee **on** the **P**eaceful **U**ses of **O**uter **S**pace (UN-COPUOS) will be a source of concern for some states. The nature of the agreement, which is mostly *"US-centric"* and "*bilateral",* as defined by some of the governments who refuse to sign the deal, is another cause for worry, since several sophisticated spacefaring nations such as Russia, China, India, France, and ESA are conspicuously absent. Diplomats agree that the agreement that leads to the application of quasi legal regulations may limit the potential development of various members while strengthening the prospective position of the US. However, it is worth noting that no other announced collaborations come near to the Goal of the Artemis program in terms of providing a clear pattern of *International Agenda, Cooperation, and Technological Interoperability* towards a sustained vision of Lunar exploration.

IV. The ambiguity of the OST

A broader International approach to Lunar Exploration is thus required, but unless nation-states can address the issues that arise as a result of disagreements, there is a risk that the race for resources on the Moon will be lost due to the first-mover advantage of those states with the technological and economic means to overcome the barriers impeding exploration. Lunar mining has long been a topic of discussion, dating back to the commercial exploration of the Moon, with various essential studies and technologies envisioned and developed to better understand the way forward. As a result, states that invest in technology and resources to harvest resources on the Moon are obliged to keep the results for themselves rather than giving them equally to other countries. This is the logical choice since much of the early initiatives require long term funding, planning, technological advancement, and the political will. However, as shown in the case of the Artemis accord, the Wolf Amendment etc., these legislations demonstrate that bilateral agreements and penalties motivated by political will frequently result in a system that favors only states with comparable philosophies and ambitions. This is in direct contradiction to Outer Space Treaty which states that:

*"In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty" – **Article IX**, OST*

Countries that were to land on the Moon and initiate long-term exploration often tend to have a first-mover advantage in terms of establishing outposts on favorable locations which are reserved for the minerals of interest. This first-come, first-serve basis can lead to scenarios that can be considered when unfair and improper utilization of resources, or infringing on other potential planned sites which can lead to conflicts of interest between nation-states.

It is also highly contrary to the principles of exploration provided by the Outer Space Treaty which states that:

"Exploration and use of outer space, including the Moon and other celestial bodies, will be carried out for the benefit and in the interests of all countries, regardless of their level of economic or scientific development, and shall be the domain of all people." – ***Article I, OST.***

V. Scientific Exploration or Exploitation

While the Outer Space Treaty talks about the freedom of scientific research in outer space, including the Moon and other celestial bodies. It also provides that States shall assist and promote international collaboration in such research. Under this provision, countries' obligations to share benefits are legally obligatory. States Parties who disagree on what constitutes 'the interests of all nations' and how to share benefits, on the other hand, may depend significantly on their good faith. There is further uncertainty in comprehending the "*Freedom of Scientific Exploration,"* because scientific exploration of resources is frequently a precursor to long-term mineral extraction, and may not preserve the values of sustainability in good faith. On Earth, this may be shown in the situations of strip mining and oil extraction. However, one can take a page from the mining of resources of the seabed. It is observed that such resources thus extracted by private parties are often considered as a property of the establishment, and thus private missions which are exploratory may be granted permission to keep the “first resources”. However, as the economic benefits become more tangible, and the benefits attain realization in the public domain, safeguards, and mechanisms to prevent exploitation must be observed and curated.

The authors would like to draw to attention the situation in terms of emission cuts and climate change that is present at the forefront of the global discussion. While most global forums and treaties attempt to recognize the issue of emissions, there is always a difference when it comes to punishing and taking action against nations who are responsible for emissions, For example. According to UN figures, the wealthiest 1% of the world's population by income accounts for around 15% of emissions. This statistic is more than double the proportion of the lowest 50%. The fundamental concern with climate disparity is that it has the potential to intensify conflict since wealthier nations fail to penalize or implement decisive measures that limit people's high lifestyles, which cause high emissions in the first place.

Countries in development frequently lack access to newer technology, resulting in the use of limited old technologies. This frequently causes issues since those with a first-mover advantage are in an unfair position in terms of establishing dominance, and being restrictive to nations attempting to raise their quality of life often creates a wider split, both in terms of socio-economic growth. In this case, it is evident that "**The Interests"** of many nation-states cannot be defined, and until there is a globally approved definition that benefits all parties, there is always the possibility of unfair, immoral concerns developing from Lunar resource exploitation. The technologically advanced nations would also be null in terms of sharing access to technology with other nations as no country would be obliged in their best interests to share the fruits of labor and research unless there are mechanisms that can ensure greater economic and political rewards.

VI. Ensuring Sustainability of Outer Space

The precautionary principles of the Outer Space Treaty that deals with sustainability States that:

Parties to the Treaty are *"expected to undertake research and exploration of outer space, including the Moon and other celestial bodies, to prevent dangerous pollution and detrimental environmental changes caused by the entrance of alien substances"*

Recently, there has also been a rising trend toward addressing not just the subject of environmental preservation and protection in outer space, but also attempting to minimize dangerous contamination to the greatest extent feasible. In today's world, space sustainability is a major problem. Concerning forward contamination, the precautionary principle is motivated by the fragility of the space environment itself, as well as our overall lack of understanding of that environment. Avoiding contamination is always preferable to dealing with it once it has occurred. In terms of backward contamination, we must likewise exercise caution to maintain the Earth's ecology.

The **C**ommittee **o**n **S**pace **R**esearch (COSPAR), for example, created the **P**lanetary **P**rotection **P**olicy (PPP) as a global guideline for minimizing organic and biological contamination in space research. **Category V** of PPP encompasses all Earth-return missions. The **'Restricted Earth Return'** subcategory strongly prohibits any harmful effect upon return, and strict confinement and fast analysis are necessary following the trip. In addition to the Planetary Protection Policy, the proposed international legal regime on space mining might be related to equivalent provisions in the **D**raft **B**uilding **B**locks (DBB) for the Development of an International Framework on Space released by the Hague International Space Resources Governance Working Group.

Another aspect of the Outer Space Treaty provides that before undertaking any activity or experiment in outer space, including the Moon and other celestial bodies, a State Party to the Treaty must consult with other Parties to the Treaty to ensure that the activity or experiment does not interfere with other States Parties' peaceful exploration and use of outer space, including the Moon and other celestial bodies.

The Weaponization of Outer Space that is being envisaged by many countries, and the formation of the US Space Force are all matters of deep concern. While nukes on the moon were spoken about and thought about in the Outer Space treaty which states that:

"States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner. – ***Article IV, OST***

While this section specifically talks against the demilitarization of outer space, it doesn't imply that those engaging in activities can't arm themselves towards the protection of sites, and also conduct maneuvers of self-defense in the wake of danger. The recent ASAT tests by the Russian Federation, India, and China promoted by geopolitical pressures and influences have sparked a lot of discussion in the industry towards moving towards legislation that curtails such activities. While the first ASAT test was conducted in 1959, In recent times, it is becoming more and more problematic as Outer Space becomes more and more crowded with commercial activities. The risk and the damages posed by foreign debris can spark international conflict, and may cause counter activities that will increase hostilities.

As more and more space-faring nations begin to showcase capabilities, there needs to be amends towards curtailing the weaponization of outer space. This becomes a matter of great concern as exploration activities become more prominent. There is a possibility that self-defense activities can be carried out in the likes of **Freedom of Navigation Operations** that are presently conducted by certain countries on the World's oceans.

Kessler syndrome, i.e., the cascade of debris due to multiple impacts in orbit is the greatest danger, as the Low Earth Orbit becomes crowded with satellites and the detonation of any kind of kinetic energy weapon creates a lot of foreign object debris. This poses a great risk to manned space flight as more human centric Low Earth Orbit outposts are being envisaged by private entities. To better map the orbital debris, and hotspots, **S**pace **S**ituational **A**wareness or SSA is a growing area of interest. Towards this, there is a global emergence of companies that emphasize sustainability in Orbit. The projected launch and deployment of numerous satellite constellations in the coming months underscores the need for a more regulated and coordinated approach. While there are incentives, these are military, and it remains to be seen whether open access to all players can be granted. However, in the instances when sovereign nations indulge in acts of profanity, and perhaps issues arising in the future from rogue private elements which threaten the future of space exploration, there needs to be transparency, and accountability in terms of domain awareness that must be available to the public domain to ensure scrutiny and liability. There is also the high possibility that once the lower orbits of the Earth become filled with orbiting satellites and junk, many human-based space orbital structures, such as space stations, could find a new place within the lunar orbits. The possibility of the emergence of Lunar Space Stations, and its integration towards being a catalyst for Cis-Lunar growth become more tantalizing.

VII. The Concerns of the Lunar Environment:

The Data provided by spacecraft such as the Lunar Reconnaissance Orbiter or LRO has identified plenty of potential sites with rich mineral resources that hold promise for future exploration. Based on the inputs by similar spacecraft currently on Lunar Orbit, it is evident that the processing of regolith on the moon by **I**n-**S**itu **R**esource **U**tilisation (**ISRU)** would provide a steady supply of propellants and useful byproducts, allowing for long-term colonization not only on the terrestrial surface but also to support extensive missions an orbital platform.

However, it is worth noting that the issue of lunar dust and debris, which may be released in the event of improper extraction or failure of separation apparatus, would perhaps create a debris field that may pose a threat to spacecraft orbiting the Moon at the lower levels. This problem could lead to the potential for conflict as the dust and regolith could lead to not only difficult and dangerous conditions for human settlements but also the ruin of historical landing sites from the Luna and Apollo eras.

There is also the concern of environmental contamination that may arise due to the leakage of nuclear fuel sources like RTGs, which are commonly used in deep space missions. While technologies can be implemented in mining to lessen the impact of lunar mining on the surface, the high-speed dust and regolith ejected by the frequency of rocket landings that are required to maintain a logistics supply chain could exacerbate the issue. Returning space crafts may also carry radioactive and extraterrestrial material, which may lead to contamination on Earth. While these matters all require the highest diligence and safety protocol to be followed, proper documentation and open-source sharing of the knowledge learned is essential to ensure proper transparency and accountability. The adherence to the provisions laid by the COSPAR's Planetary Protection Policy and, revisions based on new

knowledge is thus of paramount importance, and will certainly alleviate some of the concerns regarding the environment.

Perhaps then, there is no better time to lead the world in a global renaissance to envisage cooperation in the matters of data sharing, handling of outer space disputes, and ensuring technologies that promote the protection of the lunar surface. To embody a collective effort, is to secure the interests of all participant stakeholders without discrimination in terms of political, economic and technological power. This approach could also ensure the appropriation in terms of resource sharing, as **Article II** of the OST specifically prohibits *"the ownership of any nation over the moon"*. But this principle or appropriateness doesn't apply to private exploration. It could be approached in the same framework as it is done for deep-sea exploration in international waters wherein the private entity is guaranteed legal protection towards the ownership of the resource that is extracted. However, as enterprises of the highest order which are often backed by vast sovereign funds, National interests may be superseded over the original intent of harmless exploration. This is particularly evident as countries like Luxembourg, and the USA pass out state legislation in the form of National Space policies, and industry guidelines that allow for the industry to develop towards the realization of goals like Extraterrestrial Resource Extraction. While taking a Laissez-faire is certainly a step forward towards the maturation of such technologies, it may lead to a detrimental effect on the entire industry in the long run as it creates an imbalance of power. The creation of a global deep science VC fund to support companies that are engaged in the exploration and resource extraction would be a step forward in minimizing political overhead.

VIII. Considering a Cultural Aspect:

When we speak about the inclusion of all the stakeholders, another matter that needs to be considered is the cultural aspect and the significance the Moon occupies in our society. Many cultures hold the Moon sacred. Moon as a deity and of a symbol of a rich cultural personification is seen in many mythologies and is of vital importance towards those who view it under a sacred view. Scientific projects of grand importance have often come in scrutiny, and have faced opposition from cultural, and ecological activists who claim infringement to their belief system or of the dangers posed by such activities carried out without considering the long-term impact to those who are natives of the particular place. For instance, the Thirty Meter Telescope faced massive backlash and protests as it was to be built on Mauna Kea, a site that is sacred to Native Hawaiians. The telescope's opponents argue that they want to protect the mountain and that it already houses many observatories that have damaged their cultural sacredness. While the protests towards the TMT Project so far have been nonviolent, one can expect significant backlash or even the instance of extremism towards projects that ultimately aim to extract resources from the Moon. In this regard, there needs to be a forum wherein their sentiments must also be respected, and at the same time communicate effectively with all the stakeholders, the impact resource extraction from the Moon can bring, both the positive and detrimental aspects. Cultural opinions must be looked at with utmost consideration, and every actor engaged in the activity of Lunar Mining must consider the ethical and sustainable aspects of this activity.

IX. Conclusion

Finally, we must examine if the commercial exploitation and exploration of the Moon can be envisioned as serving the larger interest of all humanity. While the products of Space Research have always been used to settle scores and escalate tensions in the early phases, Space as a tool has also

been utilized to ensure the benefit of life on Earth. The current, data-driven civilization we belong to is a prime reminder that we are at the pinnacle of using the gifts of space exploration towards a much bigger purpose, far more reaching than the visions conceived by the early pioneers of these technologies.

As the continuous march of exploration and knowledge continues, let us recall a comment from the famed astronomer, Dr. Carl Sagan, who reflected on the irony of the Apollo Astronauts' token put on the Moon, which declared "*We came in peace for all Mankind*."

At a time when "*the United States was dropping 7 12 megatons of conventional bombs on little states in Southeast Asia, we congratulated ourselves on our humanism,"* Sagan remembered. *We would do no harm on a lifeless rock."*

Exploration can then proceed only if we can resolve the issues of ethics, sustainability, and morality in our activities, and if we can ensure that it is done for the benefit of all the inhabitants who call our planet “Home”.

X. References

1. *United Nations treaties - UNOOSA*. (n.d.). Retrieved November 22, 2021, from https://unoosa.org/pdf/publications/STSPACE11E.pdf.
2. Fengna Xu 2020 IOP Conf. Ser.: Mater. Sci. Eng. 738 012014
3. Clifford, C. (n.d.). *The '1%' are the main drivers of climate change, but it hits the poor the hardest: Oxfam report*. CNBC. https://www.cnbc.com/2021/01/26/oxfam-report-the-global-wealthy-are-main-drivers-of-climate-change.html
4. David, L. (2019, July 10). *Science and sustainability may clash on the moon*. Scientific American. https://www.scientificamerican.com/article/science-and-sustainability-may-clash-on-the-moon/
5. *Final building blocks released by Hague international space resources governance working group*. (2019, November 13). Promoting Cooperative Solutions for Space Sustainability | Secure World. https://swfound.org/news/all-news/2019/11/final-building-blocks-released-by-hague-international-space-resources-governance-working-group
6. *Impact of Dust on Lunar Exploration*. (n.d.). NASA. https://www.nasa.gov/centers/johnson/pdf/486014main_StubbsImpactOnExploration.4075.pdf
7. *Q&A: Kealoha Pisciotta, on Mauna Kea and conflicts of astronomy*. (n.d.). Physics Today. https://physicstoday.scitation.org/do/10.1063/PT.6.4.20191023a/full/
8. *Space resources are the key to safe and sustainable lunar exploration*. (2020, September 10). NASA Blogs. https://blogs.nasa.gov/bridenstine/2020/09/10/space-resources-are-the-key-to-safe-and-sustainable-lunar-exploration/
9. *The wisdom of Carl sagan*. (2018, March 22). Academy of Ideas | Free Minds for a Free Society. https://academyofideas.com/2013/11/the-wisdom-of-carl-sagan/