ISRU: LESSONS LEARNT FROM MINING GOVERNANCE IN AFRICA

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Abstract

As global space developments progress along a steep, upward curve, the questions of international law surrounding the exploitation and use of space resources wax stronger. Plans are currently developing, through State and non-State channels, for the extraction of water and other minerals in outer space, celestial bodies, and the Moon. In response to this, the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) held discussions around the theme of exploration, exploitation and utilisation of space resources. In June 2021, the UNCOPUOS Legal Subcommittee announced a new working group on Space Resources. This begs the question as to how different regions will respond and express interest in space resources along the Research, Technology and Innovation curve of space development. As of June 2021, at least 20 African countries are considered space-faring, which is, having launched a space programme or satellite. As of January 2021, 21 States have ratified the Outer Space Treaty (OST), 16 have ratified the Rescue Agreement, 16 have ratified the Liability Convention, 7 have ratified the Registration Convention, and only 1 country, Morocco, has ventured to ratify the Moon Agreement. These trends highlight varying levels of political will amongst African countries to promote the development of national or continental space initiatives through policy, and reinforces the reactive vis-à-vis proactive policy stance that dictates space industry development in Africa. More so, it brings into contrast a general lagging behind in Moon policy and dialogue, towards the development of lunar exploration as an integral part of a nation's space programme and integration into the global space economy. However, one encouraging development, despite the regulatory lacunae in some national space programmes, is the rise of NewSpace companies and with it, commerce in space. The private sector has witnessed an unprecedented boom in the previous year alone, with a total of no less than 280 NewSpace companies. These companies are involved in various up-stream and down-stream market segments from remote-sensing, satellite connectivity and satellite components manufacture, to propulsion systems, satellite data services, and even space tourism. There is indeed an interest to explore new business models in the space industry. One of these companies, Hypernova Space Technologies (Pty) Ltd, based near Cape Town, South Africa,

developed capabilities that could support in-space infrastructure and space resource utilisation opportunities, for instance, through the development and deployment of their cathodic arc technology for plasma thrusters and other in-space applications. Such innovative enterprises recognise that long-term lunar and extra-planetary exploration will involve direct resource utilisation from the Moon, and other celestial bodies. This new development brings the potential of 2 things, first, the integration of the African continent into the global space economy, which must necessarily include lunar exploration, and secondly, the proposal for an integrated public and private sector approach to lunar resource development for the globe, and addressing the associated administrative challenges. These developments drive the author to consider in-situ resource utilisation from an African perspective to consider how the continent can best contribute to either Research, Technology or Innovation, with an emphasis on the former. Through semi-structured interviews, desk research and comparative industry analysis, the author concludes that there are lessons to be learnt from the past, in the way Africa, and the rest of the space industry, will engage in developmental exercises on the Moon, particularly those involving the extraction and use of space resources. What the author deems as the pitfalls, progress, and promises of resource development can be found in Africa's history of resource utilisation, as the mining capital of the world, and from which the continent's policy approach can be derived as a case study for a viable economic model for space mining. In the past, rampant corruption, nationalistic procurement laws and environmental degradation have proven endemic to terrestrial mining activities. But on the converse, immense beneficiation, development and regional integration have also been achieved. Both instances are worth review. Drawing lessons from the successful and unsuccessful attempts on Earth, may prove to be our silver bullet in space, and as global space aspirations take on a new direction, one facing our planet's closest celestial companion, the question to be asked, then, is what can Africa contribute towards this new endeavour, to have its voice heard in the space community of nations? In light of the soon-to-come establishment of the African Space Agency, and the publication of the African Space Strategy and Policy, which is geared towards a united Africa for space innovation, the time is ripe for consideration of a continental lunar roadmap, which outlines Africa's lunar exploration needs, and states its contributions. The author finally affirms, that where African states may not as yet be able to contribute in terms of technology and innovation, it more than makes up in its capacity for research, and that this comparative exercise will not only spur more African countries to engage in lunar exploration, but help guide a coordinated approach to resource development on the Moon. This research will highlight Africa's experience, competency and overall response to multi-stakeholder policymaking, and attempts to fill the current lunar policy by considering an economic model that addresses the possible lunar needs of an emerging and integrated African continent, and a determined and curious globe.

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1. Introduction

"The beginning of the next lunar cycle.
A shadow of potential, and then a sliver of light."

"Human beings have not set foot on the surface of the Moon since 1972. Only 24 people have travelled to the Moon, and only 12 have ever set foot, and all of them, American men. Now, we are on the cusp of a return to our closest celestial companion, and with this anticipation, is the rising expectation that emerging nations and marginalised groups will be at the fore of humanity's renewed interest in the Moon."[1]

Humankind has expressed a desire to return to the Moon. This will represent a renewed interest in lunar exploration and development, as humankind investigates its potential to be an interplanetary species. Humanity's innate desire to explore can never fully be satiated, but it may be fostered in such a way that brings about mutual benefit to all, particularly regarding the use of lunar resources. In this regard, the Moon becomes an important regulatory focal point.

As we enter the next phase of exploration of the Moon, we also need to explore ourselves. How might we reimagine our vision extending to the Moon? Any innovation we begin with must be developed to make it constructive, and yet also allow it to reflect the complexity of our societies on Earth. This becomes an immediate and practical question when applied to space resource utilisation (SRU) and in situ resource utilisation (ISRU) on the Moon.

According to Ehricke: "Geosocio-economically useful lunar development requires adoption of a development strategy designed to balance investments and returns as attractively as possible."[2] This paper discusses a variety of economic and investment strategies which could be employed towards long-term sustainability on the surface of the Moon, drawing from the African continent's experience with mining industry development for key lessons. This project proposes that the future of ISRU hinges on humanity's ability to rewrite the mistakes of the past, and adopt a proactive rather than a reactive strategy to this endeavour. This is to say that we need an internationally coordinated and dedicated policy for resource extraction, enforced by a polycentric model of governance

[1] NASA-Science "Who has walked on the Moon?" (28 April, 2021) Available at https://solarsystem.nasa.gov/news/890/who-has-walked-on-the-moon/.
[2] KA Ehricke "A socio-economic evaluation of the lunar environment and resources-III: Selenospheric economics and cislunar/terrestrial market analysis" Acta Astronautica (1984) v 11 p. 111.

1.1 What have we learnt from space so far?

Outer space is a highly tenuous environment, meaning it is particularly susceptible to adverse changes. This would not be the first time that humanity has had to carefully manage such a domain. In 1895, the great chemist Svante Arrenhius was beginning to derive theories which suggested that human activities may have a bearing on CO2 emissions, and thus a warmer climate.[3] Even prior to this, around 300 BC, the Aristotelian Theophrastus had already begun to make observations on how draining marshes near Thessaly lead to cooler temperatures, and clearing forestry in Philippi lead to a warmer climate.[4]

Since then, earth observation systems have helped us to monitor and confirm that climate change was a human risk, by more precisely observing atmospheric, oceanic and terrestrial climate variables alike.[5] Sustainability in space, as on Earth, requires wise use of the environment. Space has been a teacher for us in this regard in the past. Important discoveries were made through investigations of other planetary bodies. Climate change was discovered by studying temperatures and atmospheres of planetary bodies in our solar system. For example, discovering that Venus followed the same pattern as what has begun to occur on Earth - i.e. increased climate chaos because of a greenhouse effect from CO2. This is the kind of Earth science we need right now, and it stems from our work in space. [6] A fundamental tenet of this paper is preserving environmental integrity, and emphasising the role economics plays in fostering this.

Systems for living from local resources are prerequisite to any kind of long term space activities. Localisation of space economies make them financially viable, and thus space resource utilisation is the central interest of many governments and companies with lunar missions. With a long history of human society, resource use and mining, the African continent offers a rich context for learning. Space and Earth have many things in common, and Africa - the birthplace of humankind - has many lessons to teach us about how to succeed in our next chapter of exploration across not just international boundaries but interplanetary space.

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[3] M Barral “Svante Arrenhius, the man who foresaw climate change” OpenMind BBVA (19 February 2019) Available at https://www.bbvaopenmind.com/en/science/leading-figures/svante-arrhenius-the-man-who-foresaw-climate-change/ [Accessed 4 August 2021].

[4] A Doyle & D Cutler “Timeline: How the world found out about global warming” Reuters (12 November 2012) Available at [https://www.reuters.com/article/us-climate-talks-history-idUSBRE8AL0LE20121122 [Accessed 4 August 2021].

[5] United Nations Office for Outer Space Affairs “Space & Climate Change: Use of space-based technologies in the United Nations Systems” (2011) p. 8.

[6] R G Prinn, B Fegley, Jr, “The Atmospheres of Venus, Earth, and Mars: A Critical Comparison” Annual Review of Earth and Planetary Sciences, Vol. 15:171-212 (Volume publication date May 1987)

2. In-Situ Resource Utilisation

Considering how the private sector is taking the lead on current industry development concerning resource utilisation (and space exploration in general), this paper offers a critical analysis on how both the public and private can coordinate to bring about greater synergies in national space programmes. The author supposes that a bottom-up approach works best for multi-stakeholder environments. This approach recognises that private and civil sectors assert their needs for growth, and the government creates the enabling environment. The bottom-up approach recognises the role of a central authority with decentralised branches, but actively involves diverse stakeholders in the implementation, monitoring and evaluation of development.

This paper provides a predominantly government-led structure for governance, recognising that according to Article 6 of the Outer Space Treaty (OST), nation states retain jurisdiction over the activities of their national corporations, and thus it places in the hands of governments the responsibility to ensure private-sector enabling environments, and channels for productive cooperation through public-private partnerships. The primary focus of this paper: To link African knowledge and experience with space and lunar development, and explore in-depth the key issues surrounding ISRU, towards a viable economic strategy.

ISRU is thus defined as the method of harvesting local materials as inputs for local industrial development. There are 3 main benefits for engaging in ISRU, namely:

- Local Production - Local production of propellant for reusable flight vehicles will lead to cost-reduction of lunar surface missions;
- Cost Reduction - The United Launch Alliance has studied the potential cost reduction of satellite transportation to higher Earth orbits through propellant delivery from the Moon, and;
- Exploration Gateway - The capacity to fuel and refuel spacecraft in the cislunar or Lower Earth Orbit (LEO), as a gateway to Mars and beyond.[7]

The ability to locally manufacture rocket propellant on the surface of the Moon may very well be the greatest allure. When considering the production of rocket propellant, oxygen ranks as the primary input,[8] in addition to its future contribution to the general sustenance of human, plant and perhaps even animal life on the surface of the Moon. Oxygen will likely be drawn from the water ice located at the Moon's poles, which may also be a hydrogen source.[9] Lunar regolith

[7] European Space Agency, European Space Research & Technology Centre "Towards the use of lunar resources" July 3rd-5th, 2018 p.5.
[8] R Gordon et al "Costs and benefits of lunar oxygen: Engineering, operations and economics" Resources of Near-Earth Space p. 19.
[9] See fn 6.

(soil) may one day prove to be an alternate and direct source of oxygen and hydrogen in the alternative.[10]

ISRU in its most basic form entails using resources to facilitate space exploration. Most recently, the Moon was found to have additional stores of water in previously unimaginable domains of its surface, thus pointing to the capacity to derive enough water to support life. There are a vast number of other different resources that can be derived, such as platinum group metals, rare earth elements, and even gases and water ice found mainly at the poles. Transporting materials from Earth is costly, but ISRU helps with locating valuable resources (such as helium-3) closer to the base of operation where they may be useful. In a nutshell, we need ISRU to help us with material production, ranging from life support devices, propellants, construction materials as well as energy to power spacecrafts.[11]

There are many types of resources that need to be used in concert to realise the vision of a sustainable human presence on the Moon. For this reason, there is such a delicate intersectionality of various social and economic sectors that we simply cannot leave to the sole determination of entities or state practice, or worse, leave ambiguous. Intentional and thoughtful leadership is required pertaining to space resource governance.

3. The Need for Effective Resource Management

Without proactive resource management we risk repeating the atrocious mistakes of the past. History has shown that exploring new terrain has often been accompanied by inequity, misgovernance of resources and environmental degradation. Before embarking on effective means for resource management, it is paramount to first discuss what resource management actually entails.

Resource management is defined as "the management process of pre-planning, scheduling, and allocating your resources to maximise efficiency."[12] Resource management helps us to conserve vital materials to fulfil a project or task, which in this case, could involve anything from research and development, exploration, innovation or commercialisation. Resource management is thus vital to sustainability of development efforts in outer space.

Historically, resource utilisation has been an arena of high-competition stakes, so how we manage resources is important, as space resource management in particular may quickly become a "geopolitical battle ground" should we delay in negotiating an overarching framework to guide national laws and resultant

[10] Ibid.
[11] L de Gouyon Matignon "In-situ resource utilisation" Space Legal Issues (13 June 2019) Available at https://www.spacelegalissues.com/in-situ-resource-utilization/#:~:text=According%20to%20NASA%2C%20%E2%80%9CIn%2D,available%20in%2Dsitu%20resources%E2%80%9D. [Accessed 22 ay 2021].
[12] B Hansen "What is resource management and why is it important?" Wrike (27 Septembeer 2018) Available at https://www.wrike.com/blog/what-is-resource-management/ [Accessed 23 May 2021].

interests. Doing so would help avoid instances in which some actors may step outside international law to gain a significant advantage through resource access.

In managing resources, a thorough consideration of stakeholder interests must ensue. These interests span from national, environmental, social, cultural and economic, and they each require thoughtful space governance intervention. When looking at resources through a security lens especially, the urgent need for Transparency & Confidence Building Measures (TCBMs) come into play to protect national and international interests. Resource Management Frameworks could be considered a TCBM as they help to stabilize the relationships between actors through clear protocols.

Space resource management is not completely without regulation, in fact, ISRU activities may be read into Article 1b of the Treaty which declares that "Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States."[13] In recognising the call to act with due regard to corresponding international interests, this provision continues to affirm that use and exploration by States must occur "without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies."[14] From the foregoing, ISRU activities occurring on the Moon, in any area, and conducted in the purposes of use and exploration, are permissible in terms of the Treaty.

A further caveat requires that non-discrimination and equality apply. To this end, it's paramount to consider the possible geopolitical tensions which may arise, and have often, in the course of States exercise of freedom of use and exploration of the global commons. At the height of the cold war, 132 countries came together to agree, through the OST, to treat outer space in a different manner than had been done for global commons in the preceding 500 years.[15] This treaty was drafted in foreseeing the dangers of recreating another frontier for colonisation, militarisation, and even resource extraction.[16] In light of such developments as the 2015 US Space Act, and increased sovereign endeavours on the Moon and beyond, a critical study of geopolitics will also become important; that is, an analysis of different forms of power, how they are manifested, and their respective contingencies.[17]

To this end, the African mining industry provides a useful case study for balancing multiple stakeholders in a commercial resource development context. Beginning first with the pitfalls, it may be wise to glean what may result, if robust resource management tools are not developed.

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[13] Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967 Available at [Accessed 6 August 2021].
[14] Ibid.
[15] JM Klinger "Critical Geopolitics of Outer Space" Routledge Vol 26 (2021) 661-665, p. 661.
[16] Ibid.
[17] See Fn 15, p. 664.

3.1 Managing stakeholders' interests in the African mining industry

Africa has 16.72% of the world's population, and is home to about 30% of the world's mineral reserves according to the African Development Bank. The region also has the largest mineral output in the world, but mineral production only makes up 8% of the global total.[18] Several industry challenges have arisen in maximising resource outputs due to a lack of coordinated mineral exploration governance across the region, which sees various degrees of development from country-to-country. Many regions succumb to the so-called resource curse, where countries underperform economically despite having a large resource base. The following challenges must be read with a space development lens, noting instances where a space resource curse may develop. The main challenges include:

1. Socio-Environmental Impacts - Air pollution, land and forest degradation have led to clashes with local community members. A lack of social license to operate is the most common premise for tense relations between corporations and the indigenous communities. (On the converse, how to establish a social license to operate in outer space has yet to be authoritatively determined, but this is a seminal policy point, as the preservation of the global commons is both an interest and right of all humankind).
2. Low-Industrialisation of the Industry - Resources remain under-explored due to a lack of expenditure for exploration activity, which is between USD5-65 per square kilometre. (Bearing in mind that to sustain innovation in outer space requires actors to generate returns on investment, promoting technical capacity through interoperability still remains a challenge in the space industry, particularly for emerging space nations).
3. High Degree of Dependency - Over dependency of mineral resources and products have led to economic stagnation of many African countries. (Actors in the space industry should be encouraged, then, to diversify their products and services to achieve market longevity).

The space industry can take note of some challenges which can lead to the so-called "resource curse" or inability to make sustainable pecuniary gain from resource development, which have hinged on the failure to localise economic linkages such as:

- Appropriate policy and legal frameworks, i.e., securing permit licenses for exploration rights. The commercial regulation landscape requires urgent standardisation across jurisdictions;

[18] African Development Bank "Mining Industry Prospects in Africa" (20 December 2012) Available at https://blogs.afdb.org/fr/afdb-championing-inclusive-growth-across-africa/post/mining-industry-prospects-in-africa-10177[Accessed [22 Agugst 2021].

- Adequate access to exploration areas - in Africa, countries such as Ghana, Mozambique and DRC Congo have created corridors or zones to provide sanctuary and security of tenure for mining operators. Likewise the space industry may have to designate lunar prospecting zones for operating companies, to manage competition, and to manage the environment.
- Boosting technical capacity and access to appropriate technology – where some countries such as Sierra Leone, Liberia and Mozambique require the acquisition of separate licenses to operate heavy mining machinery, it may also be required in space to authorise the use of certain equipment to manage environmental degradation.
- Sufficient and alternative financing models – development finance is an impediment to innovation in both terrestrial and extraterrestrial activities, particularly for emerging space nations. Models could include regional stock exchanges or other mechanisms for raising equity finance, as opposed to debt-finance.

While resource development has been able to drive immense foreign direct investment into the region, and foster massive trade facilitation, the negative trade-offs have often outweighed beneficiation. Power manifestations by big mining corporations are a large feature of the African industry, most exemplified in the controversies surrounding the Central African Mining & Exploration Company (CAMEC), which is considered one of the foremost mining corporations in Africa, but with a marred history concerning a lack of social and environmental safeguarding. To this end, the industry needs to be weary in allowing large private players to dominate industry practices, by steering the policy discussion. Below, two case studies are advanced to investigate the impact of government-led, bottom-up policy-making in the African mining industry.

3.2 Case Study: Madagascar & Zimbabwe

The total value of Madagascar's mining industry is about USD$650 million per year, however, outdated tax policies, commodity price fluctuations, and government shortcomings have resulted in a stagnation of the sector.[19] In Zimbabwe, mineral exports account for 60% of Zimbabwe's export earnings, and the industry contributes about 16% to GDP, despite this, the country has lost about USD$1.8billion total mineral revenues due to informalisation of the sector, which also infringes on the country's ability to attract vital foreign investment for development financing.[20] These are two African countries with a large resource base, that have experienced difficulties in maximising resource wealth, and required country-specific policy-intervention.

[19] London School of Economics "Sustainability Impact Assessment in Support off Negotiations with Partner Countries in Eastern and Southern Africa in view of Deepening the Existing Interim Economic Partnership Agreement" Mining Case Study (18 January 2021) pg. 7.
[20] *Ibid* p. 4.

The challenges of these two case studies can be linked back to the lack of a robust legal framework which addresses, amongst other issues, exploration, production, beneficiation, marketing, and management of the sector.[21] However, under the function of the Africa Mining Vision (AMV), both nations have been able to leverage regional regulations for national benefit in resource-utilisation.

3.2.1 Madagascar

It has been recognised that building a strong policy foundation is the bedrock for sustainable resource utilisation in Madagascar. Progress stimulated by the AMV has resulted in the drafting of a Mining Code of Conduct. This process has so far reflected the multi-stakeholder nature of the resource development industry, by including government officials, private sector experts, members of academia and representatives from civil society.[22] This policy is paying special attention to: Maximising state revenues; Supporting community development; Ensuring proper management and rehabilitation of the environment; Promoting domestic manufacturing; Creating jobs and valorisation of national skills, and; Establishing proper governance of the mining sector.[23]

This reform has been accelerated during the COVID-19 pandemic due to the highly sensitive nature of the industry, which, like the space sector, is vulnerable to supply chain disruptions. To alleviate these, the nation has made meaningful progress in policy on contract disclosure, license allocation and registry, and general legal frameworks to support mine operators.[24] The author states that it would not be untoward to opine that these aspects are likewise vital for progress and to wit, transparency in resource utilisation policy in extra-terrestrial settings, which, in the terrestrial realms, have served to boost Madagascar's Extractive Industries Transparency Index.

3.2.2 Zimbabwe

According to the Zimbabwean Geological Survey unit, Zimbabwe is host to more than 100 minerals, particularly along the Great Dyke, which is a 550km stretch of highly mineralised zones. It also happens to be the world's third largest producer of platinum, and the world's fifth largest producer of lithium. As with resource development in outer space however, the Zimbabwean mining industry is struggling with a lack of regulation, particularly legal frameworks which speak to its needs to promote traceability, surveillance and transparency of mining activities,[25] all of which may prove instrumental in coordinating peaceful uses of space.

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[21] *Ibid p.* 11.
[22] *Ibid* p. 14.
[23] *Ibid* p. 14.
[24] Extractive Industries Transparency Initiative "Madagascar – Country Profile" (15 February 2021) Available at https://eiti.org/madagascar.
[25] Hiotee "The potential of mining sector in Zimbabwe" (30 March, 2021) Available at https://www.hiotee.com/the-potential-of-mining-sector-in-zimbabwe/.

Through the AMV, some companies, such as Zimplats, Unki and Mimosa, have been able to revamp their operations through digitalisation. Productivity and economic projections have been positively impacted by promoting safety and sustainability through technology.[26] Digital interventions are revamping the way in which people, equipment and sites are supervised, which may also be focal points for resource management on the Moon and beyond. And in the same vein, institutional governance in the Zimbabwean mining industry has agreed that sustainable exploration, processing, marketing and management of resources must shift from a government benefit to a societal benefit, which curiously rings a bell.

Following from the progress made so far, there are three main areas to which the Zimbabwean mining industry can hope to find remedy through the AMV namely: Redefining and improving business policies; Formalising processes and operations, and; Monitoring of illegal activities. Again, the core of the AMV's function is in promoting transparency, and promoting a basis for accountability through responsible innovation.

3.2.3 Viability of the Africa Mining Vision

Major corporations such as Anglo-American, Rio Tinto and Alcoa, have a substantial mining presence in Africa, highlighting the validity of the framework's ability to balance both national and international interests. The AMV has also succeeded in managing countries' performance in tackling emerging global policy issues in the mineral sector such as tax evasion and avoidance, contract transparency, the disclosure of beneficial ownership, and transfer pricing by multinational firms. Prior to this, Africa lost US$11bn in 2010 alone due to trade mispricing by multinational companies operating in the mineral sector.

At the heart of the AMV, countries are encouraged to implement Country-Specific provisions which encompass policy provisions addressing national needs, similar to the stipulation for nation states to interpret and domesticate international space treaties and principles into national laws. When considering that humanity's return to the Moon signifies a collective effort, one must begin to question what value Africa can add to this discussion, in order to consider this a truly global endeavour. The author supposes that the answer lies in the three nodes of space use and exploration. The aerospace industry is characterised by three core nodes:

- Research;
- Technology, and;
- Innovation.

Countries such as the United States, Germany and Russia are synonymous with industrial innovation (e.g. SpaceX pushing the frontier of extra-planetary

[26] *Ibid.*

exploration), and France and Canada are synonymous with technology (e.g. Canada's Canadarm advancing technological pursuits on the ISS). This is not to rank these actors in any particular order however, as they are all critical enablers for space development. In the same breath, the author would state that Africa, well known as the extractive industry capital of the world, is in prime position to contribute to the development of an economic governance framework centered around resource utilisation, through sound economic research.

For this reason, the author relies on precepts from the Africa Mining Vision as a guide, and translates it to an aerospace context, with minor technical adjustments, to address the needs of the developing ISRU industry. This is justified by the continent's immense experience in deriving resource wealth, coordinating technologies, balancing stakeholder interests and as well, developing a thriving industry with expected setbacks.

In response to the above case study challenges, the African Union Commission (AUC) promulgated the African Mining Vision (AMV) to support greater competition, innovation and economic management in the African mining industry, and ultimately create a resilient and regionally coordinated sector. What then, can we learn from this?

4. Drawing Resource Management Lessons from the African Mining Industry

The Africa Mining Vision is the continent's cardinal framework for achieving "inclusive, sustainable mineral-based structural transformation". This is a continental policy instrument made operational through national actors, policies as well as mechanisms. It is a positive outline of the best aspects of the mining sector's frameworks. Among some of its stipulations include:

a. Broad-based growth through a knowledge-driven sector;
b. A sustainable, well-governed, environmentally friendly, socially responsible mining ecosystem;
c. A mining sector that unites Africa's finite mineral resource endowments, one that is diversified, and also incorporates both high and low-level industrial minerals at both commercial and small-scale.
d. Harnessing the potential of private-sector mining operations to promote local and national entrepreneurship in order to improve livelihoods towards socio-economic development; and
e. A mining sector that is a major player, and competitive in the national, continental and international capital and commodity markets.

Much like the goals of this report, the AMV was conceived as a move towards inclusive and PPP-led resource development. Much lessons can be wrought from this vision, which expresses an intention to create a "transparent, equitable and optimal exploitation of mineral resources to underpin broad-based sustainable

growth and socio-economic development."[27] This is an admirable mission even in the space context.

From the foregoing, promoting transparent, equitable and optimal use of space resources would require:

- Decentralising procedures required for acquiring resource development rights;
- Assuring a legal regime that grants resource developers sufficient duration of rights, area to conduct operations, and security of tenure, and;
- Providing accessible legal, institutional, technical and financial support through international cooperation in dispute resolution, technology development, research, technical standards and the generation of financial resources.

5. Economic Strategies for Managing Resource Development

The core ambit of the African resource management framework is benefits-sharing which echoes prevailing discussions on space resource utilisation in particular, and space exploration in general. To achieve effective benefits-sharing through economic policy requires a careful management of the factors of production at each stage of the developmental process, namely:

a. Supplier Engagement - Each entity will always know their suppliers best, but it's important to establish norms for supplier selection processes which speak to sustainability and supply chain management, this is in the interests of Corporate Social Responsibility (CSR). Supplier development has a bearing on the product development process, and thus on the expectations of space resource products amongst the community, which is expected to have a positive or negative impact on an actor's future Space Sustainability Rating. Green suppliers can help maintain CSR or SSR, and should be considered.

   Supplier development is at the heart of industrial strategies, so much so that aerospace companies such as the Airbus Group implement corporate policies which seek to reduce logistical risks.[28] This move is in recognition of suppliers forming an essential stakeholder unit within the space industry value chain, as they deliver the final product whose value will be subject to public perception.[29]

[27] London School of Economics "Sustainability Impact Assessment in Support off Negotiations with Partner Countries in Eastern and Southern Africa in view of Deepening the Existing Interim Economic Partnership Agreement" Mining Case Study (18 January 2021) pg. 4.
[28] P Haillete & F Plandé "Supplier Development Applied to the Space Industry" M2 TBS – Achats & Supply Chain Management (February 2015) Available at https://chaire-sirius.eu/documents/e7beed-haillette-plande-2015-supplier-development-applied-to-space-industry-unknown.pdf [Accessed 27 August 2021] p. 2.
[29] Ibid.

As more external stakeholders enter the industry (both public and private, institutions and individuals), and internal stakeholders contribute to operations (competitors, clients, regulators and suppliers), it's multi-stakeholder nature becomes ever more pertinent to manage. Watts and Hahm (1993) have noted that supplier development, "involves a long-term cooperative effort between the buying firm and its suppliers to upgrade the suppliers' technical, quality, delivery and cost capabilities and to foster ongoing improvements", and accordingly a high-value product which maximises benefits and minimises drawbacks.

Due to the space industry being a high value-added industry, and the production of space infrastructure being unitary (rockets, satellites etc)[30], focusing a Supplier Development strategy which optimises cost, quality and delivery of performance in meeting end user needs cannot be understated.[31] Airbus manages its supply chain by assigning a dedicated team to work with suppliers which may be struggling with the pace of production in particular, paying attention to smaller suppliers as well, who form an integral component of the value chain.[32] In this way Airbus fosters flexibility and continuity of production processes and ultimately reduces logistical risk. This is an instance of agile project management.

b. Local Procurement/Local Supplier Development - As opposed to the private sector-led instance above, this is a government-led initiative which focuses on boosting the performance of the domestic supplier industry. This is achieved through the upskilling and reskilling of goods and service providers, as well as access to development finance. Governments should prioritise sourcing of goods and services from local suppliers (local here is taken to refer to terrestrial space system suppliers), to boost domestic industries, where applicable.

The global economy is changing by the day, and thus open to economic and social shocks alike (particularly during the COVID-19 pandemic), affecting global supply chains.[33] This would lead to the building of domestic capabilities. Where local suppliers are underdeveloped, "Made-In" initiatives are recommended, where governments make a commitment to boosting local manufacturing capabilities through capacity-building. By doing so, a balance is made between corporate spending and economic development. Similar initiatives have been implemented in India, as well as China, where

[30] See fn 23.
[31] Ibid.
[32] See fn 23, p. 14.
[33] Central Trading Agency "The Way Forward for Procurement in the Aerospace Industry" (31 October 2016) Available at https://omniprocurement.com/insights/all/13-aerospace/11-the-way-forward-for-procurement-in-the-aerospace-industry.

the latter has invested USD 300 billion into the 'Made in China' 2025 plan, which has a focus on high-tech products including satellite and other space technologies.

c. Business linkages - This involves leveraging partnerships in a variety of formats such as 'backward linkages', (the relationship between an entity and its suppliers as per prior points). This is a coordinated effort between all actors in space, including civil society, academia, private sector and government. Concerning the latter two, Small to Medium Enterprises (SME's) and other private sector participation/partnership with government can make significant contributions to the aerospace industry. This is best exemplified by NASA's use of private sector support from SpaceX and other outsourced, local suppliers.

   In a study initiated to assess the feasibility of "developing an evolvable, economic and sustainable lunar surface infrastructure using a public-private partnerships approach", a Lunar COTS concept was derived. This study was drawn from the best practices established by NASA's Commercial Orbital Transportation Services (COTS), for economic transportation of commercial cargo to the International Space Station (ISS) [34]. The success of the COTS program hinged on its private-sector-oriented acquisition model, which crafted an equal balance of costs and risks shared between public and private partners.[35] Through Funded Space Act Agreements, industry partners were given more leeway to act, with less oversight, which translated to more innovation, with less restrictive reporting requirements. The strategy also made provisions for addressing the risks involved, and ultimately channelled investments towards fostering competitiveness for mutual benefit.[36]

In a nutshell, these economic strategies are aimed at building lunar space ecosystems for development and space exploration. The success of the African mining vision is hinged, on "ensuring compliance of industry players with the highest standards of corporate governance, and environmental, social and material stewardship", as well as "improving the quality of the business environment, increasing private sector confidence and participation, and reducing entry barriers and operating costs to achieve external economies of scale."[37]

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[34] A Kaluthantrige, H Modi, H Vertadier & A Zuniga "Building an Economical and Sustainable Lunar Infrastructure to Enable Human Lunar Missions" (2019) Presented as a paper at the 70th International Astronautical Congress (IAC) Washington D.C. United States, 21-25 October 2019, p. 1.

[35] A Kaluthantrige, H Modi, H Vertadier & A Zuniga "Building an Economical and Sustainable Lunar Infrastructure to Enable Human Lunar Missions" (2019) Presented as a paper at the 70th International Astronautical Congress (IAC) Washington D.C. United States, 21-25 October 2019, p. 4.

[36] Ibid.

[37] African Union "Africa Mining Vision" (February 2009) Available at https://au.int/sites/default/files/documents/30995-doc-africa_mining_vision_english_1.pdf p. 11.

Winning economic strategies are the basis of the Africa mining framework. One of the fundamental principles of the AMV is creating competitive advantage for the private sector, through, as discussed above, value-added downstream products and services, an emphasis on the building of domestic capabilities, the establishing of critical institutions for oversight, and finally, spotlighting the impact of regional cooperation to determine industry standards.[38]

Much like the African mining industry, the space industry is also becoming acutely aware of the limits of government-dominated space development, which has so far negated the impact of a lack of economic policy in outer space affairs. The former, while placing emphasis on state-owned companies, was not able to cater to supporting institutions, and ultimately, this led to a decline in the efficacy of sourcing vital investment and opportunities for innovation and development. Countries such as Gabon, Botswana, Niger, Guinea and Ghana, have since witnessed successful turnaround due to the ability to foster joint ventures between the private and public sector, as is encouraged by this proposed framework and report.

Botswana is one of the countries which have managed to benefit from its resource potential by focusing policy measures aimed at economic resilience. According to the International Monetary Fund, efficient revenue management and sound economic policy have kept the mining economy relatively stable. In this way, Botswana was able to transform itself from an impoverished nation to a middle-income country, ranking within the top 50 in the world in terms of governance (again highlighting that economic stability is fomented by adequate governance structures). In 2021, Botswana's diamond industry witnessed a 7.7% growth,[39] and as of 2020, despite a pandemic-induced contraction, mining Gross Domestic Product stood at approximately USD 169,000 in the fourth quarter, from USD181,000 in the third quarter.[40]

Common factors in the African mining policy which has enabled this turnaround include:

- Stable and transparent regulation detailing rights and obligations of stakeholders;
- A competitive and well-defined fiscal regime which priorities ROI to both public and private sector stakeholders;
- And effective support, monitoring and evaluation of industry players.

The author proposes that these factors are worthy of translation and implementation into a space resource utilisation context.

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[38] Ibid.

[39] Reuters "Botswana sees 7.7 % growth in 2021 on diamond industry recovery " (20 October 2020) Available at https://www.reuters.com/article/botswana-economy-idUSL8N2HB406

[40] Trading Economics "Botswana GDP from Mining" (2013-2020) Available at https://tradingeconomics.com/botswana/gdp-from-mining.

6. Translating Terrestrial Resource Management Principles to the Extra-terrestrial

6.1 Primary considerations

The following challenges have been identified in regards to resource management by the main mining nations in Africa namely: Democratic Republic of Congo (DRC), Namibia, South Africa, and Zimbabwe).[41] Identifying possible challenges and acting proactively is a key step to avoiding the mistakes associated with resource extraction in the past. By promoting the alignment of national mining policies with its provisions, the AMV enhances policy coherence and stability in mining sector regulation, which is important for transparency, competitiveness and promoting mining sector investments. What follows is an application of these principles and lessons to the space industry for proactive policy-formation.

a. Social licence to operate

As a starting point, attaining the requisite social license to operate (SLO) is essential to ensuring equity, fairness, inclusivity, beneficiation and sustainability in the products and profits reaped from terrestrial mining activities. An SLO is designed as a series of measures agreed between a mining corporation and the local community on how the former is expected to conduct its activities.[42] This is due to the need for mining corporations to take on greater environmental consideration and commit to respecting the environmental needs of those who share a connection to the ecosystem.

As it pertains to outer space, establishing a lunar SLO does not seem quite so straightforward, as it would first have to be determined to whom this due regard is owed. Secondly, which measures are agreed and how they are to be enforced would be a follow-up consideration. With regards to the former, one might read into the Article 1 provision of the Outer Space Treaty, which designates outer space, and all celestial bodies (including the Moon) as the province of all humankind. By extrapolation, it would mean that humanity is the community to which due regard is owed by corporations wishing to extract resources therefrom.

As regards the measures that would be agreed on, again one may have recourse to the Outer Space Treaty, which again espouses fundamental

[41] London School of Economics "Sustainability Impact Assessment in Support of Negotiations with Partner Countries in Eastern and Southern Africa in view of Deepening the Existing Interim Economic Partnership Agreement" Mining Case Study (18 January 2021) pg. 4.

[42] A Salmeri "A Social License to Operate for Lunar Resource Activities: Towards a Fair and Sustainable Era of Space Exploration" Presented as a paper at the 701st International Astronautical Congress (IAC) Washington D.C. United States, 21-25 October 2019, p. 2.

principles of governance pertaining to the need to avoid environmental harm, or "harmful interference", along with the obligation to conduct activities in a peaceful manner, and with due regard to corresponding interests of other states (and implicitly actors). This economic framework might form a portion of such measures, as economics has since begun to evolve to include environmental economics, which is an understanding that the efficient management of ecosystems has a positive return on economic performance.

b. Benefits-sharing

As alluded to prior with the Botswana case study, benefits-sharing of the fruits of resource utilisation is as contentious as it is auspicious. Article 1 of the Outer Space Treaty (OST) reminds us that the use and exploration of outer space should be done in the interests of all humankind.

Despite over 2,000 technology spin-offs that have come about since the first Apollo mission,[43] many would argue that much of space science and technology has yet to trickle-down to the least space-faring of nations. The way to offset this claim is to view benefits-sharing as broadly as possible, transcending skills and technology transfer alone, but going so far as to include employment creation, shareholder titles, fiscal benefits. It stands to be reckoned how communities without active space programmes may benefit from such an intervention. However, in a national space programme context, these measures can best be exemplified through clearly outlining a community beneficiation programme. Such a programme would also be in accordance with the tenets of the Moon Agreement, which assures the protection of the rights of all people to share in the resources of outer space, for developed and developing countries alike.

Drawing from the analogous regime applied in terms of the rights of Indigenous peoples in Arctic resource projects, international standards provide a guide for the right to receive benefit from such projects, and actively participate in the development and decision-making process of these initiatives.[44] In this case study, the preferred model for resource development is one which involves the target community in all stages of strategic planning, with an emphasis on promoting the community's ability to contribute to the actual planning and project implementation, and most especially, to receive more tangible benefits from resource development.[45]

[43] Nasa Spin-Offs Available at https://spinoff.nasa.gov/.

[44] E Wilson "What is benefit sharing? Respecting Indigenous rights and addressing inequities in Arctic resource projects" MDPI (2019) p. 1.

[45] Ibid.

The target community in the context of outer space, would consist of all of humankind, in accordance with Article 1 of the OST, which designates this global resource as a common heritage.[46] In the area of space law and policy surrounding resource development, there is a notable gap in international regulations, with the US, Luxembourg and now Japan implementing their own national laws to fill the lacuna. While acknowledging that laws often take significant periods of time to achieve international support and ratification, the role of custom as a source of binding authority cannot be overlooked. What also cannot be overlooked is the need to involve all actors in the policy and industrial development process.

6.2 Secondary considerations

a. Managing unfair competition
Competitive practices hamper the growth of the terrestrial mining sector. Benefits derived from mining projects are not channelled towards local development, and this would indicate a need for a Transparency mechanism/index, even in space. This would also help eliminate the chances of unfair competition and practices within the space industry. Recognising again that outer space is competitive terrain for not only commercial, but also military interest, States are reminded to apply strategic restraint on military activities in terms of international laws pertaining to the use of force. To counter the national security fears and threats justifiably held by a number of States, would require the implementation of "eyes in the sky' or geo-intelligence systems which can adequately monitor and verify surface activities on the Moon.

b. Procurement
Supply chains are susceptible to market shocks (especially as has been noted during unforeseen events such as the COVID-19 pandemic). Market and compliance risks impede the productivity of extractive industries. Reducing strict local content requirements will ultimately mitigate these risks. A core element of ESA's industrial policy concerns the rules relating to geographical distribution, or fair return, which policy is made in line with the ESA Convention (relating to industrial policy) of making strategic use of procurements to increase the competitiveness of both the European and international market. To this end, the Council at Ministerial has supported, since 1997, the SME initiative, to foster the participation of SME's in ESA procurement. The Agency has also made a commitment to harmonise national policies with regional industrial policies, particularly in such areas as Navigation. According to ESA "the main rule adopted by the Agency since its Council at Ministerial level in March 1997 is that the ratio between the share of a country in

[46] Ibid.

the weighted value of contracts, and its share in the contribution paid to the Agency, must be of X per cent (e.g 0,98%) by the end of a given period. That ratio is called the industrial return coefficient." This is otherwise known as ESA's geo-return policy, aimed at developing local capacity to meet market demands.[47]

Local procurement also has a bearing on the value addition that a resource utilisation project brings to the immediate economy. These can either be characterised as employment opportunities, skills transfer, technology, investment, or is not only isolated to revenue derived from the activity itself.

6.3. Establishing resource utilisation norms

The development of international laws can be a pain-staking process, taking months and often years to achieve widespread, international support. In the instance of community-oriented resource development, the author proposes that establishing custom through accepted best practices is a worthy interim governance mechanism, until such time as the space community of nations can table a potential treaty on space resource utilisation. Article 38(1) of the Statute of the International Court of Justice states that customary law is "(1) a general practice (2) accepted as law."[48]

The jurisprudence surrounding Article 38(1)(b) has lead to the interpretation of 2 elements to assist the court (and by extension other entities) in determining the existence of customary international law, namely: State practice and *opinio juris sive necessitatis* (from here onwards, *opinio juris*).[49] In the Nicaragua case, the ICJ explained further that:

> "For a new customary rule to be formed not only must acts concerned 'amount to a settled practice', but they must be accompanied by *opinio juris sive necessitatis*. Either the States taking such action or other States in a position to react to it, must have behaved so that their conduct is evidence of a belief that the practice is rendered obligatory by the existence of a rule of law requiring it. The need for such belief... the subjective element, is implicit in the very notion of *opinio juris sive necessitatis*."[50]

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[47] ESA "Industrial Policy and Geographical Distribution" Available at https://www.esa.int/About_Us/Business_with_ESA/How_to_do/Industrial_policy_and_geographical_distribution.

[48] United Nations, Statute of the International Court of Justice, 18 April 1946, available at: https://www.refworld.org/docid/3deb4b9c0.html [accessed 15 September 2021].

[49] Ibid.

[50] Case Concerning Military and Paramilitary Activities In and Against Nicaragua (Nicaragua v. United States of America); Merits, International Court of Justice (ICJ), 27 June 1986, available at: https://www.refworld.org/cases,ICJ,4023a44d2.html [accessed 29 September 2021].

7. Key Policy Takeaways

Recognising these opportunities and challenges from the past, the following policy recommendations are drafted to address each of these broad themes. A robust economic governance framework for ISRU on the Moon and other celestial bodies will:

- Align supplier development policy with governmental industrial and education policy and ensure sustainability and integration with overall economic state plans;
- Create requirements for a Transparency Index/mechanism to ensure property rights, legal compliance and foster mutual accountability amongst stakeholders within the aerospace ecosystem. Supporting mechanisms could include space-based observation and verification. For example, using lunar constellations to provide oversight of natural resource management challenges by tracing micro and macro-scale changes is recommended. These recommendations support oversight and enforcement structures;
- Support decentralised research initiatives to sustain widespread management options for contributing to a productive and resilient ecosystem. This would also include incorporating diagnostic tools – Multilevel Analytical Framework (MLAF), Critical Hierarchy Approach and Indigenous Knowledge tools employed to diagnose challenges through multi-stakeholder participation and observation, and;
- Democratise access and benefits in space. Being a tech-based industry, much of democratisation depends on nation's intentions to foster capacity-building through interoperability (e.g. sharing launch pads, subsystems, launchers, habitats, and gateways).

Policy implementation has remained a challenge in certain quarters of the space industry. Thus policy is only truly effected through practical policy implementation steps, which could include the following:

a. A general Legal and Institutional Framework - These would include sound Contract, Licensing, Registration and Underwriting protocols across the industry, which have at their core, the intention to enforce the rule of law, democracy, and property rights (both tangible and intangible).

b. Geographic Information Systems - This involves the collection and analysis of observation data to create maps. Geographically-referenced data will assist in environmental monitoring and evaluation of the resource utilisation sites, and thus would require lunar remote-sensing satellites and constellations for oversight.

c. Fiscal and Revenue Management – The promise of sustainable resource utilisation looks to be a game-changer for space development, and signals

a need to develop revenue and public finance management systems, due to the fact that resources, especially on the Moon, are finite, and thus may be prone to conflict. Tax and revenue distribution strategies will help to prevent the depression that typically follows the resource boom when there is little revenue management, as has been noted in a number of resource-rich countries (otherwise known as the resource curse).

d. Linkages, Investment and Diversification – Bilateral (or multilateral) Investment Treaties (BITs), coupled with trade liberalisation measures, such as the reducing of technical and non-technical barriers to trade within the aerospace industry would serve to align economic interests. This will foster greater regional collaboration and support the fundamental international space law principle on international cooperation.

e. Private-Sector Involvement – This involves reform centering around company laws (start-up laws are highly recommended), including registering a company name, insurance for business activities and processes for acquiring the necessary licenses and permits to operate (such as a satellite launch license in the case of a space start-up in the satellite industry). In light of the increase of private sector involvement in outer space, an international protocol for private sector participation is vital, with the potential for these best practices to solidify into binding and enforceable customary international laws.

   Similar laws have been developed by the OECD to regulate how the private sector supports infrastructure development in various industries. Compliance with these laws ensures that the start-up can maintain a good public image, and build customer trust, which feeds into a company's ability to source funding and achieve political and public support. It also fosters standardisation amongst national actors, and does away with the potential for 'forum-shopping' wherein some national laws become more attractive to private sector companies as they are viewed as less restrictive. This will ultimately foster harmonisation of legal and technical standards, and as a final goal, sustainability.

f. Environmental and Social Concerns – This will fall on governments to enforce mandatory Environmental Impact Assessments (EIAs) prior to commencing resource extraction activities, which will help align economic development with environmental management.

8. Final Recommendations

Now that the plethora of economic strategies have been discussed in detail and exhausted, one might ask, what would be the benefits of embarking on such an exercise? Ultimately, linking resource management to the lunar economy

through a robust framework will boost the lunar resource economy's ability to expand:

a. Fiscal Linkages – Using revenue to boost a wider lunar economy.
Paying taxes matters in any economy. The World Bank Group has opined that paying taxes is a "key ingredient" between the citizenry and the economy and helps maintain the social contract thereto. This is because taxation is a means of paying for public goods and services.[51] The long-term sustainability of resource utilisation will be rooted in the space economy's ability to reinvest revenue back into the space value chain.

b. Spatial Linkages – Creating critical infrastructure to enable resource extraction.
This concerns the spatial distribution of manufacturing industry segments, and concerns the way in which the extracted materials are linked to the processing site. Processes of efficiency would dictate that the preferred situation would be to have both the extraction and manufacturing processes to be located within close proximity of one another (for instance adjacent zones in the Moon's South Pole, Aitken basin).

c. Backward Linkages – Development of the local suppliers to the resources sector.
This segment involves the sharing of knowledge, information and resources (including financial) between companies and their suppliers. Essentially, if production increases on the forward end of manufacturing, this should have spin-off benefits for the supplier/manufacturer earlier on in the value chain. This is the idea of paying it backwards. An example of a backward linkage is the development of excavation mining.

d. Forward Linkages – Resource utilisation for building value systems/value addition.
If backward linkages means paying it backwards, then forward linkages are simply a mechanism for the development of advanced processing industries further along the space value chain. An example of a forward linkage would be the development of rocket propellant.

e. Knowledge Linkages – Skills development/transfer and technological innovation.
Research and development in ISRU processes can only grow if there are inter-sectoral linkages. Therefore, there needs to be mechanisms in place to promote the knowledge-sharing between industry actors, as well as between industry and academia, and finally, between academia and the broader public.

[51] OECD "Fundamental principles of taxation" (2014) p. 30.

9. Conclusion

Economics concerns the way in which people make decisions, more specifically how decisions are made about resource distributions. It is hoped that this report and proposed framework can make an impact on the way in which we allocate both pecuniary and non-pecuniary resources to and from space resource utilisation, in the interests of sustainable development in space.

To conclude, a final synopsis on some underlying principles of import may suffice. A core aspect of sustainability revolves around affordability. The core aim of this framework is to ensure long-term sustainability of lunar exploration through cost-reduction. In fact, the Secure World Foundation (SWF), has defined sustainability as "ensuring that all humanity can continue to use space for peaceful purposes and socio-economic benefit now, and in the long-term."[52] Sustainability is an important consideration, as the safety, security and peace of outer space determines access to space, and ultimately democratisation.[53]

Of equal import, and emphasised sufficiently throughout this paper, is the need to effect the sharing of benefits. In accordance with Article 1 of the Outer Space Treaty, the exploration and use of outer space should be done in the interests of all countries. That is to say, that the spin-offs from research, development and exploration of outer space, should in some way, shape or form, trickle down to even the least of space-faring nations, in line with Article 1 of the OST, which states that "the exploration and use of outer space…shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development," before emphasising that outer space is the province of all humankind.[54] Africa would most benefit from this, and it is an equal aspiration that this report proves it's competency to lend its voice to space development matters, at least on research, even where technology and innovation are yet still a hope on the horizon.

That said, transfer of technology, knowledge and even resources and human capital is quite necessary to keep space a truly democratic affair. An interesting case study to note here, would be the prompting to respect indigenous rights and addressing inequities within Arctic resource projects. To this end, benefits-sharing has come to mean everything from taxation and revenue distribution, job creation, ownership of companies and shares, as well as

[52] Secure World Foundation "Space Sustainability: A Practical Guide" p. 4 Available at https://swfound.org/media/206407/swf_space_sustainability_booklet_2018_web.pdf [Accessed 29 May 2021].

[53] Secure World Foundation "Space Sustainability: A Practical Guide" p. 6 Available at https://swfound.org/media/206407/swf_space_sustainability_booklet_2018_web.pdf [Accessed 29 May 2021].

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negotiated agreements for community development programmes.[55] Here, the role of civil society organisations, such as For All Moonkind, is greatly emphasised. Civil society acts as a voice of the people, and has a better chance of raising awareness at a grassroots level. Ultimately they can help the private sector and government understand the needs of the community, towards reputation-based incentives and thus meet public policy goals.

And finally, the principle of International Cooperation. Now more than ever, space exploration requires us to have the political will to foster meaningful collaboration with other states. Cooperating in space gives us the ability to foster trust, which in turn fosters accountability, which in turn fosters sustainability. In economics speak, fostering international cooperation can assist us in improving:

- Monetary efficiency;
- Programmatic and political sustainability, and;
- Workforce stability.[56]

Thus in conclusion, as we expand human capabilities beyond Lower Earth Orbit (LEO), a performance-based study, such as was recommended during the Bush administration as part of its Vision for Exploration,[57] is necessary. Why? As noted by the Scholar DA Young, the decision-maker should be presented with a process which "directly addresses the top-level requirements early in the policy design process, in order to evaluate the highest reliability and lowest cost architectures, without being distracted by the performance details of the architecture."[58] Such an evaluation examines the performance, reliabilities and costs in a concurrent methodology towards efficient and effective policy design.[59] From this, a call to action is the move towards an international protocol on resource utilisation, followed by an international treaty in due course, to help guide states in transparent, equitable and optimal utilisation of space resources.

As a final clarion call, it suffices to say that the way in which we handle our behaviour on the Moon will undoubtedly set precedent for how we explore outer

[55] E Wilson "What is benefits sharing? Respecting indigenous rights and addressing inequities in Arctic Resource Projects" MDPI p. 1 Available at file:///C:/Users/User/Downloads/resources-08-00074.pdf [Accessed 29 May 2021].
[56] DA Broniatowski "The case for managed international cooperation in space exploration" Center for Strategic and International Studies p. 1 Available at http://web.mit.edu/adamross/www/BRONIATOWSKI_ISU07.pdf [Accessed 29 May 2021].
[57] DA Young "An innovative methodology for allocating reliability and cost in lunar exploration and architecture" A PHD presented to the Academic Faculty at the Georgia Institute of Technology (May 2007) p. 16 Available at [Accessed 18 May 2021].
[58] DA Young "An innovative methodology for allocating reliability and cost in lunar exploration and architecture" A PHD presented to the Academic Faculty at the Georgia Institute of Technology (May 2007) p. 17 Available at [Accessed 18 May 2021].
[59] DA Young "An innovative methodology for allocating reliability and cost in lunar exploration and architecture" A PHD presented to the Academic Faculty at the Georgia Institute of Technology (May 2007) p. 17 Available at [Accessed 18 May 2021].

space, after all, “once you’ve made it to the Moon, you are halfway to anywhere in the solar system”.[60] To that I say, *per aspera ad astra*.

Africa’s mining success has largely hinged on the role of the legislature, ISRU’s success will ultimately hinge on the role of the space legislator.

[60] Mina Takla (Astropreneur & Aerospace Engineer), Co-Founder & CEO at CosmoX Inc.