Commercial asteroid mining is coming now – lower costs and improving tech make it economically viable – and the legal basis is already in place in multiple countries– that helps acquire water for rocket fuel and rare earth metals

Gilbert 21 alex gilbert, is a complex systems researcher and a PhD student in space resources at the Colorado School of Mines. "Mining in Space Is Coming." Milken Institute Review, April 26, 2021, www.milkenreview.org/articles/mining-in-space-is-coming. [Quality Control]

Space exploration is back. after decades of disappointment, a combination of better technology, falling costs and a rush of competitive energy from the private sector has put space travel front and center. indeed, many analysts (even some with their feet on the ground) believe that commercial developments in the space industry may be on the cusp of starting the largest resource rush in history: mining on the Moon, Mars and asteroids.

While this may sound fantastical, some baby steps toward the goal have already been taken. Last year, NASA awarded contracts to four companies to extract small amounts of lunar regolith by 2024, effectively beginning the era of commercial space mining. Whether this proves to be the dawn of a gigantic adjunct to mining on earth — and more immediately, a key to unlocking cost-effective space travel — will turn on the answers to a host of questions ranging from what resources can be efficiently.

As every fan of science fiction knows, the resources of the solar system appear virtually unlimited compared to those on Earth. There are whole other planets, dozens of moons, thousands of massive asteroids and millions of small ones that doubtless contain humungous quantities of materials that are scarce and very valuable (back on Earth). Visionaries including Jeff Bezos imagine heavy industry moving to space and Earth becoming a residential area. However, as entrepreneurs look to harness the riches beyond the atmosphere, access to space resources remains tangled in the realities of economics and governance.

Start with the fact that space belongs to no country, complicating traditional methods of resource allocation, property rights and trade. With limited demand for materials in space itself and the need for huge amounts of energy to return materials to Earth, creating a viable industry will turn on major advances in technology, finance and business models.

That said, there’s no grass growing under potential pioneers’ feet. Potential economic, scientific and even security benefits underlie an emerging geopolitical competition to pursue space mining. The United States is rapidly emerging as a front-runner, in part due to its ambitious Artemis Program to lead a multinational consortium back to the Moon. But it is also a leader in creating a legal infrastructure for mineral exploitation. The United States has adopted the world’s first spaceresources law, recognizing the property rights of private companies and individuals to materials gathered in space.

However, the United States is hardly alone. Luxembourg and the United Arab Emirates (you read those right) are racing to codify space-resources laws of their own, hoping to attract investment to their entrepot nations with business-friendly legal frameworks. China reportedly views space-resource development as a national priority, part of a strategy to challenge U.S. economic and security primacy in space. Meanwhile, Russia, Japan, India and the European Space Agency all harbor space-mining ambitions of their own. Governing these emerging interests is an outdated treaty framework from the Cold War. Sooner rather than later, we’ll need new agreements to facilitate private investment and ensure international cooperation.

What’s Out There

Back up for a moment. For the record, space is already being heavily exploited, because space resources include non-material assets such as orbital locations and abundant sunlight that enable satellites to provide services to Earth. Indeed, satellite-based telecommunications and global positioning systems have become indispensable infrastructure underpinning the modern economy. Mining space for materials, of course, is another matter.

In the past several decades, planetary science has confirmed what has long been suspected: celestial bodies are potential sources for dozens of natural materials that, in the right time and place, are incredibly valuable. Of these, water may be the most attractive in the near-term, because — with assistance from solar energy or nuclear fission — H2O can be split into hydrogen and oxygen to make rocket propellant, facilitating in-space refueling. So-called “rare earth” metals are also potential targets of asteroid miners intending to service Earth markets. Consisting of 17 elements, including lanthanum, neodymium, and yttrium, these critical materials (most of which are today mined in China at great environmental cost) are required for electronics. And they loom as bottlenecks in making the transition from fossil fuels to renewables backed up by battery storage.

However, the legal framework that strikes the best balance of providing economic incentives for mining while preventing unbeneficial land claims requires a doctrine of appropriation – the plan prevents that

Meyers 15 Meyers, Ross. J.D. candidate at the University of Oregon Law School. "The doctrine of appropriation and asteroid mining: incentivizing the private exploration and development of outer space." Or. Rev. Int'l L. 17 (2015): 183. Italics in original. [Quality Control]

The doctrine of appropriation is a reasonable rule for adjudicating asteroid claims, and it could easily be modified to apply to asteroid mining. In the context of water rights, the doctrine of appropriation requires that the claimant be a landowner in order to claim the right to use a water source. It does not make sense, however, for the international community to grant complete ownership over asteroids toa single entity, so the landowner requirement of the rule should be removed. A similar modification would need to be made to the "beneficial use" language of the doctrine.

In the context of water rights, an appropriator obtains rights only to water that he or she can reasonably put to beneficial use. The metals contained in asteroids have a high level of marketability. For that reason, a mining entity could potentially put any amount of obtained metal to beneficial use, in the sense that the resources can be sold. This, however, would defeat the purpose of the rule, which is to limit such unreasonable claims. To ameliorate this problem, the doctrine of appropriation could be modified to define "beneficial use "constructively by providing that beneficial use is assumed for any resources that have been removed from the asteroid that the mining entity can reasonably hope to transport to market in a return journey. With the astronomical cost of undertaking a trip to such an asteroid, this modification would limit mining entities to only what they can carry back, thereby leaving the untapped resources available to other entities capable of making the same trip. Considering the size and profitability of metal deposits on asteroids, this modification to the doctrine of appropriation would not be overly burdensome to corporate interests. At the same time, it would satisfy the economic imperative of promoting the rapid development of asteroid resources.

By changing the landowner requirement, and qualifying the “beneficial use" language, the doctrine of appropriation would be essentially ready for application to asteroid mining claims. The only other changes necessary would be some additional requirements that are common to other space related provisions, like those found in the Outer Space Treaty of 1968. For example, a reporting requirement or clause guaranteeing asylum for other astronauts. A functional rule might read something like this:

State parties or private entities may, upon actual possession, lay claim to natural resources found on or below the surface of asteroids. Rights to appropriate are given in order of seniority, starting with the first party to land on the surface of the asteroid and establish control over the resources, be it water, methane, metal, or any other beneficial substances. A party will be said to have established control over a resource once he has mined the substance and removed it from the asteroid. A senior appropriator may use as much of the asteroid's resources as he can take from the asteroid and put to beneficial use, and may continue to enlarge his share until another junior appropriator begins to appropriate resources from source for beneficial use. For the purposes of this Agreement, "beneficial use “refers to the amount of resources that an appropriator has removed from the asteroid that the actor may reasonably hope to bring home in a return voyage. Resources in excess of what an appropriator can reasonably hope to transport to market in a single voyage do not qualify as having a beneficial use, and are therefore not yet claimed. This means that the extraction of metal from an asteroid does not serve to provide ownership if the appropriator plans on letting the resources languish until another voyage is undertaken to secure the resources and bring them back to Earth. Junior appropriators receive rights in the source of resources (the asteroid) as they find it, and may prevent the senior appropriator from enlarging his share to the junior appropriator’s detriment under a no-injury rule. No state party will attempt to hinder other parties from landing on or using the asteroid, and parties will assist other entities on an asteroid, should they need emergency assistance. Mining claims on asteroids will be reported to the Secretary-General of the United Nations, and state parties agree to release the location of the asteroid, and any scientific findings to the United Nations, the general public, and the scientific community. In the event that the asteroid is on a collision course with any other celestial body, all state parties agree to follow the course of action suggested by the United Nations. Should the United Nations decide the asteroid must be destroyed, no state party may claim liability for resources contained within the asteroid, but not yet captured. This provision applies only to asteroids as classified by the scientific community, and does not apply to planets, comets, meteorites, or any other celestial body not mentioned.

There is no doubt that asteroids may be extremely beneficial to mankind, both as a source of resources and as a jumping-off point to far off locations in space. The human-race has progressed scientifically and technologically to the point that space travel is within commercial reach, and the need for new international laws governing the ownership of space has never been more apparent. The Outer Space Treaty of 1968made great strides in developing rational rules for space and many of its provisions should be maintained in their original form. However, by allowing ownership of asteroids under the doctrine of appropriation, the international community can incentivize the exploration and development of space in a way that reflects the needs of society in general, without vesting an absolute monopoly in a single entity. The doctrine of appropriation helped drive American westward expansion, and its application to space mining would help drive the human race in its expansion into the space, the final frontier.

Climate change causes resource wars- it’s an impact magnifier and causes cycles of suffering

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Mr Ibrahim is not the only one to see a link between climate and war. Globally, the proportion of people who die violently has been falling for decades, as poverty has tumbled and wars between states have become rarer. But many fret that climate change will be so disruptive that it will make future conflicts more likely. Some fear that as the Arctic sea-ice melts, Russia, China and America will scramble for the sea lanes that will open up and the minerals that may lie beneath. Others worry that, as temperatures rise, thirsty countries such as India and Pakistan or Egypt and Ethiopia will fight over rivers they share with their neighbours. However, the most immediate threat is of civil wars, not inter-state ones, and one of the most vulnerable regions is the Sahel, an arid strip below the Sahara desert. Here, the roots of many conflicts lie in competition over dwindling fertile land. In Mali, for example, struggles over resources between farmers and herders as the population rises have escalated into ethnic cleansing. Mahamadou Souleymane, a Fulani herder, fled his village last year when militiamen from the Dogon ethnic group attacked. “They were our friends from our great, great grandfathers,” says Mr Souleymane. But one day last year, they came with automatic rifles and machetes. “They cut off hands, arms and penises, and took them away.” They told the villagers that if they did not leave, “no one will survive. We will kill everyone.” So “we ran into the bush,” recalls Mr Souleymane. Green campaigners and eager headline-writers sometimes oversimplify the link between global warming and war. It is never the sole cause. But several studies suggest that, by increasing the frequency and intensity of extreme weather events, including floods and droughts, it makes conflict likelier than it would otherwise be. In a meta-analysis carried out in the early 2010s, Solomon Hsiang, then at Princeton University, and Marshall Burke, then at the University of California, Berkeley, found “strong support” for a causal link between climate change and conflict (encompassing everything from interpersonal to large-scale violence). They even tried to quantify the relationship, claiming that each rise in temperature or extreme rainfall by one standard variation increased the frequency of interpersonal violence by 4% and intergroup conflict by 14%. History offers several examples of climate change appearing to foment mayhem. An examination of Chinese records spanning a millennium found that the vast majority of violent eras were preceded by bouts of cooler weather. The team behind the study argues that lower temperatures reduced agricultural production, provoking fights over land and food. Some see the recent civil war in Sudan’s Darfur region as the first modern climate-change conflict. In 2007 theun Environment Programme argued that desertification and dwindling rainfall had made supplies of food and water less secure, which may have helped spark the rebellion that Sudan’s government put down with a campaign of genocide and mass rape. However, just as one can never be sure that any individual hurricane would not have happened without global warming, one can never prove that a given war would not have occurred without it. Environmental forces interact in unpredictable ways with human greed, opportunism and cruelty—and sometimes with mankind’s better angels, too. And the environmental forces themselves are complex. Consider Syria. Between 2012 and 2015 three academic papers argued that climate change had been a catalyst or even a primary driver of the civil war. Headlines blamed it for the waves of refugees reaching Europe. The argument was that human emissions had caused or exacerbated a severe drought in Syria in the late 2000s that triggered mass migration from farmland into cities, contributing to tensions which ultimately led to war. The headlines were too simplistic, as headlines often are. Climate modelling led by Colin Kelley, then at the University of California in Santa Barbara, estimated that greenhouse-gas emissions made the drought twice as likely. That is significant, but need not mean that in the absence of climate change, there would have been no drought and no war. Syrians had many reasons to revolt against their ruler, Bashar al-Assad, a despot from a religious minority who enforced his rule with mass torture. The conflict around Lake Chad is also a tangled tale. Its roots can be traced back to a deadly drought in the 1970s and 1980s. Many have blamed that drought on industrial emissions of greenhouse gases. But climate models suggest they did not in fact play a big role in the drought. The recurrent failure of monsoon rains was caused by cooler temperatures in the north Atlantic, which pushed the rains too far south. The cooling was itself caused by a mixture of natural and human factors, notably air pollution above the ocean—a striking reminder that greenhouse-gas emissions are not the only way in which human activity may alter the climate. A report published this month by Adelphi, a Berlin-based think-tank, shows that Lake Chad is no longer shrinking. Its authors examined 20 years of satellite data and found that the southern pool was stable for the duration. The northern pool is still shrinking slightly, but total water storage in the area is increasing, as 80% of the water is held in a subterranean aquifer, which is being replenished, as is moisture in the soil, as the rains have returned. This has big implications for plans to alleviate tension in the region, says Janani Vivekananda, who led the research. Earlier this year government ministers dusted off a decades-old proposal to divert billions of cubic metres of water from tributaries of the Congo River, down a 2,400km canal and into the Lake Chad basin. The latest findings suggest this would do little good, at enormous cost. Things fall apart Despite all these caveats, climate change clearly can play a part in fostering conflict. The Sahel is warming 1.5 times faster than the global average, owing to greenhouse-gas emissions. In future, most models suggest, it will experience more extreme and less predictable rains over shorter seasons. In a region where most people still grow or rear their own food, that could make millions desperate and restless. Traditional systems for sharing resources can break down if farmers suddenly have to adapt to different growing seasons or herders need to move their cattle at different times. Around Lake Chad, people are concentrated in a much smaller area than before, says Fode Baba Condé, who leads the unhcr’s mission on the Chadian side of the lake, including the camp at Dar es Salaam. Many confrontations between farmers and herders result, he says. Cattle that used to wallow in the lake can now die for lack of water; those that survive may trample farmland. Yusfa Issa, a 60-year-old, came to Dar es Salaam camp from Brasserie, a Chadian village of farmers and fisherfolk. He laments the old days, when people would share food. “Now people won’t give you a potato, onion or cassava…There is nothing left.” His village is just 10-15km away, but too dangerous to go back to, he says. Climate models predict that, as global average temperatures rise, dry regions will get drier and wet regions will get wetter, with more extremes and greater variability. Poverty makes it harder for farmers to adapt. Trying something new is always risky—and potentially catastrophic for those with no savings to fall back on. In conflict zones, farmers who once had the means to plant several different crops may only be able to plant one. They end up with all their seeds in one basket. On the shores of Lake Chad, violent clashes between government forces and armed opposition groups have created zones that are off-limits to civilians, says Chitra Nagarajan, a researcher for the Adelphi report, who spent two years conducting surveys in all four littoral countries. Conflict and environmental change disproportionately bring suffering to women. “We are seeing high levels of divorce, high levels of domestic abuse,” says Ms Nagarajan. “Men are migrating, leaving the women to fend for themselves.” The x factor Conflict itself makes the poor even poorer, and more vulnerable to the vagaries of a changing climate. Fearing murder, pastoralists cannot take their herds to places with water and vegetation. The unhcr’s Mr Condé says that fishermen can no longer go into the deep lake to fish. Government troops block them, and Boko Haram is still on the prowl. Fighters steal farmers’ crops. All the farmers can harvest is wood, which they sell as fuel. In a bitter twist, doing so accelerates desertification, further degrading the land. Climate change makes conflict more likely but not inevitable. The Sahelian drought of the 1970s and 80s was felt across the region, but the violence began and has been most intense in a particularly ill-governed part of Nigeria. Likewise, the drought that preceded the Syrian civil war also affected Jordan, Lebanon and Cyprus, none of which imploded. Lebanon took in 1.5m refugees with barely a complaint. The Adelphi report confirms that the Lake Chad conflict had many causes besides climate variability, including bad governance, corruption, rising inequality and religious extremism. Similarly, the origins of Syria’s war are complex. It was a revolt against a blood-drenched tyrant who had recently slashed fuel and fertiliser subsidies. But, as Charles Iceland of the World Resources Institute (wri), a research organisation, points out, a horrible drought preceded the outbreak of hostilities, and “it isn’t logical to say that it contributed less tension or the tension stayed the same.” The question is in what circumstances environmental stresses can tip a precarious peace into violence, and how to respond. Governance can make the difference. Badly governed or poor countries find it harder to cope with climate change, especially when, as often, they have weak institutions. The Netherlands and Bangladesh both face similar environmental challenges: low-lying coastlines and frequent floods which will become more frequent and more extreme as sea-levels rise. The Netherlands has the political, technological and financial means to cope; much poorer, Bangladesh may not. No sensible person expects a Dutch civil war because of climate change; in Bangladesh, the risk of such a conflict is not trivial. Aaron Wolf of Oregon State University and his collaborators have catalogued 2,606 instances of international conflict and co-operation over water between 1948 and 2008. In 70% of cases, countries co-operate. The biggest risk of conflict comes when an upstream country builds infrastructure, such as a dam, without an agreement on how to soften the downstream impact. Many of these dams are built because climate change is making water scarcer, or because of a move away from fossil fuels towards hydropower—ie, a secondary link to climate change. More light than shade Mr Wolf says that conflict is most likely when the change outpaces institutional capacity to adapt: “The problem is not the dam but the dam plus the absence of an agreement for how to deal with it.” At a meeting this year of the Planetary Security Initiative, a consortium of think-tanks, delegates from Mali gave their own illustration of this, drawing on the degradation of the Inner Niger Delta whose waters support farmers, pastoralists and fisherfolk. Ancestral agreements had created a system of shared commons. “Before, there were traditional mechanisms, a calendar that everyone respected. When the farmer was done, the pastoralist could bring his animals to graze the same land,” said Diallo Tata Touré, president of a commune in the delta. But as the supply of water to the delta has been depleted by irrigation upstream, these pacts have disintegrated, fuelling outbreaks of violence. Another dam thing “Pastoralists enter the delta earlier because their animals are hungry. They cross farms and fish-nurseries. The different groups are in conflict where before there was peace,” said Karounga Keita, a Malian economist, at the meeting. “All this is because the flooding area is reduced by dams and irrigation upstream.” There is concern that the proposed $280m Fomi dam upstream of the delta in the Guinean highlands will make matters worse. Conflicts between agriculturalists have existed for centuries, says Seydou Doumbia, a Malian official, but have never resulted in a security crisis. “Not until now.” Mr Iceland and his colleagues at the wri, in collaboration with nine other organisations, are working on a predictive tool for future conflicts, with a focus on water stress. The team has fed large historical data sets of risk factors for conflict (social, economic, demographic and geographic), in addition to a number of water indicators (precipitation, groundwater availability, length and severity of droughts) to machine-learning software to generate a model that predicts the probability of conflicts. In October 2018, wri’s Manish Bapna presented preliminary results to the un Security Council. Using data from 2016, the model was able to predict instances of water conflict in 2017 with 83% accuracy. Academics may squabble about the specific causes of past conflicts, and develop complex models to forecast future ones. But there is consensus that tensions, and so the potential for bloodshed, will be heightened by climate change. And conflict, in turn, makes it harder to prepare for or respond to climate change. How to save for a rainy (or dry) day if men with guns keep stealing your savings or burning down your grain stores? Saleh Isaka, a Chadian village elder, remembers when his people used to graze thousands of animals on land where the Dar es Salaam camp now stands. Three years ago, Boko Haram attacked. They were armed with automatic weapons and they stole away all the animals, as well as women and children. “Now we are suffering. It’s hotter than before… Everything is dead,” Mr Isaka says, gesturing into the bone-dry distance..