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The need of an ethics of planetary sustainability

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Abstract

The concept of sustainability is widely acknowledged as a political guideline. Economic, ecological, social and cultural aspects of sustainability are already under discussion. Current space mining efforts demand that the discussion become a broader one about 'planetary sustainability', including the space surrounding Earth. To date, planetary sustainability has mainly been used with reference to Earth only and I will extend it here, elaborating on a similar NASA initiative. This article (1) sketches the contemporary economic–political initiatives which call for a special reflection of Earth's location in space, and then (2) discusses the meaning of the concept of sustainability in this context. Next, (3) I relate the discussion to the issue of planetary and environmental protection, before, (4) finally, presenting a philosophical and theological perspective that seems particularly able to broach the issue of the multiple dimensions of sustainability in this context. This is the concept of constructive-critical realism. My overview of the topic concludes with (5) a summarizing outlook.

Research Article

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The concept of sustainability is widely acknowledged as a political guideline. Economic, ecological, social and cultural aspects of sustainability are already under discussion. Current space mining efforts demand that the discussion become a broader one about 'planetary sustainability', including the space surrounding Earth[1]. This article (1) sketches the contemporary economic–political initiatives which call for a special reflection of Earth's location in space. The Luxembourgian space mining initiative will be portrayed in some detail, to serve the purpose of documenting a test case for the argumentation. The article then (2) discusses the meaning of the concept of sustainability in this context. Next, (3) I relate the discussion to the issue of planetary and environmental protection, before, (4) finally, presenting a philosophical and theological perspective that seems particularly able to broach the issue of the multiple dimensions of sustainability in this context. This is the concept of constructive-critical realism (CCR). My overview of the topic concludes with (5) a summarizing outlook.

I am aware, however, that the arguments presented here can only be a start for the consideration of sustainability in planetary dimensions[2], or potentially even as a core element of more general 'astroethics' (Peters 2014; cf. Impey *et al.* 2013).

Contemporary initiatives call for reflection

'We still have the power to choose – irreversible harm has not yet reached catastrophic levels … This planet's sustainability calls for a new relationship, viable over time, between humankind and our habitat, a relationship placing humanity in the forefront, precisely at the outset of a new age that will be marked by wisdom, knowledge and information, shared globally' (UNESCO, 2003: 5).

With these inspiring words, UNESCO, 2005–2015 the leading UN-Agency for Education and sustainable development, has propagated a 'planetary sustainability'. Here, I will expand this idea and use the term in a more encompassing manner, aiming at including the space surrounding Earth when invoking the planetary vocabulary. I am convinced, in the developing Space Age the issue of sustainability must be reframed in this way. Obvious to the scientist, Earth does not float in an empty void, but is part of a universe, surrounded by billions of billions of space objects. Actually, also the UN are aware of this, as their *Committee on the Peaceful Uses of Outer Space* (UNCOPUOS) had established within its *Scientific and Technical Subcommittee* a *Working Group on the Long-term Sustainability of Outer Space Activities* which addressed thematic areas, including sustainable space utilization supporting sustainable development on Earth (UNOOSA, 2017). Additionally, the *Office for Outer Space Affairs* (UNOOSA) has launched a new framework strategy called Space2030, advocating

[1]This work results from a project pursued as research fellow at the Center of Theological Inquiry (CTI) Princeton/NJ, sponsored by NASA grant NNX14AR81G, and within the collaboration of the COST Action TD 1308 'Life – ORIGINS'. Cf. the German article Losch (2016).

[2]A book on topic is the aim of a current project, cf. www.planetarysustainability.unibe.ch.

space as a driver for sustainable development. 'We want to make sure that space technology and applications are used to bring concrete benefits to all humankind, paying special attention to the future space-faring and developing countries while also carefully considering the long-term sustainability of outer space activities for current and future generations.'[3]

All these efforts aim at working together 'towards building better lives on Earth' (Di Pippo 2017). Similarly, NASA launched in 2014 an initiative with the title 'planetary sustainability', whose vision statement includes three main objectives:

1. A world in which all people have access to abundant water, food and energy, as well as protection from severe storms and climate change impacts;
2. Healthy and sustainable worldwide economic growth from renewable products and resources;
3. A multi-planetary society, where the resources of the Solar System are available to the people of Earth. (NASA 2014).

This vision combines the two traditional dimensions of NASA's engagement, with space science and with Earth science, and it is in this twofold manner that the idea of a planetary sustainability shall be explored within this paper. *So in pursuing my approach, I follow NASA's use of the term 'planetary sustainability' as the most encompassing one.*

Why is this extension of the concept important today? Following the shock of Sputnik and after NASA finally landed humans on the Moon, NASA, ESA and their competing and cooperating space agencies undertook exploration missions to Mars or even more distant areas. Today, private companies invest mainly in satellite launches and space tourism; nevertheless, there are private enterprises (e.g. Elon Musk's *SpaceX*), which help to supply the International Space Station (ISS). With the current plans of companies such as *Planetary Resources* or *Deep Space Industries* to exploit near Earth objects (e.g. asteroids), the Space Age is on the verge of entering a new phase[4]. The *SPACE (Spurring Private Aerospace Competitiveness and Entrepreneurship) Act of 2015*, as signed by US President Barack Obama in November of that year, opened to US citizens the opportunity 'to engage in commercial exploration for and commercial recovery of space resources" (§ 51302 (3)). Those space resources are abiotic resources including water and minerals (§ 51301).

One can ask, whether these activities oppose the international *Outer Space Treaty* (1967), because according to this contract the use of space is only allowed 'for the benefit and in the interests of all countries' (art. I). A disclaimer at the end of the SPACE Act denies claims of sovereignty for celestial bodies. It is not clear why, in contrast, extraction rights should be unproblematic. The USA can refer to another paragraph of the *Treaty*, which says 'outer space shall be free for exploration and use by all States' (art. I), because they interpret the recovery of minerals needed for space mining as a simple 'use'. This seems to be a possible interpretation, as the *International Institute of Space Law*[5] published on 20 December 2015 a statement on this topic, which says: 'In view of the absence of a clear prohibition of the taking of resources in the *Outer Space Treaty* one can conclude that the use of space resources is permitted. Viewed from this perspective, the new United States Act is a possible interpretation of the *Outer Space Treaty*. Whether and to what extent this interpretation is shared by other States remains to be seen.'[6]

The Luxembourgian government shared this interpretation and has taken action. On 3 February 2016, it 'announced a series of measures to position Luxembourg as a European hub in the exploration and use of space resources. Amongst the key steps undertaken, as part of the *spaceresources.lu* initiative, will be the development of a legal and regulatory framework confirming certainty about the future ownership of minerals extracted in space from Near Earth Objects (NEO's) such as asteroids. […] Such a legal framework will be worked out in full consideration of international law. Luxembourg is eager to engage with other countries on this matter within a multilateral framework' (The Government of the Grand Duchy of Luxembourg 2016a). Probably it also tried to relate to the spirit of the *Outer Space Treaty* with these wordings. According to recent critics, who voiced the concern that the new US law and the Luxembourg initiative are nothing but a classic rendition of the 'he who dares wins' philosophy of the Wild West[7], the Luxembourgian initiative initially answered: 'Luxembourg is carefully considering these discussions. While there may be similarities in U.S. thinking, the Luxembourg Government prefers to liken potential legal similitudes to deep-sea fishing in international waters: Fishermen don't own the oceans and they don't own the fish, but they have the right to put nets into the water and bring fish onto their ship decks. And once the fish are on deck, they own the fish.' If multiple countries follow a similar aim, 'these countries would need to discuss and find a bilateral or multilateral solution. It would be in the interest of all involved players. Luxembourg will encourage bilateral and multilateral agreements between the concerned countries to find a way to deal with this. One solution to investigate is to follow the example of the International Telecommunications Union, regulating the access to the frequency spectrum and orbital positions on the geostationary arc.' One must know, however, that these texts were published on an older version of the

[3]The Space2030 framework will be built upon four pillars:
Space accessibility: all communities using and benefiting from space technologies;
Space diplomacy: building and strengthening international cooperation in space activities;
Space economy: development of space-derived economic benefits;
Space society: evolution of society and societal benefits stemming from space-related activities.
Di Pippo (2017)

[4]Cf. the European Space Agency's (ESA) description of 'Space 4.0': "a time when space is evolving from being the preserve of the governments of a few spacefaring nations to a situation in which there is the increased number of diverse space actors around the world, including the emergence of private companies, participation with academia, industry and citizens, digitalization and global interaction." ESA (2017).

[5]http://www.iislweb.org/. For the apprehensive point of view of Deep Space Industries, see Kfir (2017).

[6]The statement goes on as follows: 'This is independent from the claim of sovereign rights over celestial bodies, which the United States explicitly does not make (Section 403). The purpose of the Act is to entitle its citizens to these resources if "obtained in accordance with applicable law, including the international obligations of the United States". The Act thus pays respect to the international legal obligations of the United States and applicable law on which the property rights to space resources will continue to depend.

It is an open question whether this legal situation is satisfactory. Whether the United States' interpretation of Art. II of the Outer Space Treaty is followed by other states will be central to the future understanding and development of the non-appropriation principle. It can be a starting point for the development of international rules to be evaluated by means of an international dialogue in order to coordinate the free exploration and use of outer space, including resource extraction, for the benefit and in the interests of all countries.'

[7]This was raised as a potential critique by a meeting of members of the *COST Action TD 1308 Life-Origins' White Paper Working Group* with Luxembourgian officials on 9 March 2016. Regarding the 'Wild West scenario', cf. the account of the cultural narrative of US Spaceflight by Billings (2007).

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website and are 'no longer valid'[8], which is an interesting development in argumentation.

The envisioned space mining is of course not yet in place, but the necessary legislation has been passed, and money is invested. A first action taken was the organization of a workshop on the topic of 'Asteroid Science Intersections with in-Space Mine Engineering (ASIME)' in Luxembourg on 21–22 September 2016,[9] before one saw on 11 November 2016 the draft of a space law which 'guarantees private companies the right to resources harvested in outer space in accordance with International Law' (The Government of the Grand Duchy of Luxembourg 2016c). Luxembourg's interest is clearly of an economic character, as it also announced a 25 million euro investment cooperation with *Planetary Resources* on 3 November 2016b (The Government of the Grand Duchy of Luxembourg 2016b).

I refrain from judging here on the legality of the issue, and want to leave these to the respective experts and legal bodies. I do report the details concerning the Luxembourgian initiative so detailed here, because they appear as a possible issue: interestingly, Luxembourg's quasi-second legislative chamber, the Council of State, had expressed several formal oppositions to the space mining project. The responsible official is even reported 'to have confirmed his objective … to ask for a revision of the question of property in the Outer Space Treaty. He wants the UN to create a legal framework which would allow companies worldwide to act in this domain' (Huberty 2017; cf. Allen & Overy 2017; Conseil d'etat du grand-duché de Luxembourg 2017). Nevertheless, Luxembourg's Chamber of Deputies passed the law on 13 July 2017 (Planetary Resources 2017).

Now, can space mining really present a solution for pressing resource shortages on Earth? Or is it simply nothing but a temporary delay of the problems? This needs to be discussed. Luxembourg's initiative states that 'its goal is to ensure that space resources explored under its jurisdiction serve a peaceful purpose, are gathered and used in a sustainable manner compatible with international law and for the benefit of humankind' (The Government of the Grand Duchy of Luxembourg 2017).

Can the idea of sustainability be applied on human space activities this way? The increasing human use of space[10] certainly demands reflection on its application on our space environment[11]. Hence, the concept of sustainability shall now be analysed further. We have, however, to keep in mind that it could also conflict with other ethical principles. What about the environmental integrity of outer space, for instance (cf. Bohlmann, 2011)? How important, generally, is the extension of planetary sustainability beyond Earth, and how far should it be extended?

Dimensions of sustainability

The term 'sustainability' is often used to describe an entanglement of *economic* and *ecological* development, which means to use resources in such a limited way that they can recover over time from our use and hence remain available for us. While this seems possible for fishing, it may not be possible for mining. The term was first prominently used by the so-called Brundtland commission in 1987. According to this commission's official definition, which shall be used here, sustainable development is a 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs', while these needs are 'in particular the essential needs of the world's poor' (World Commission on Environment and Development 1987: 16.41). Sustainability[12] in political perspective therefore is a concept that includes besides the *economic–ecological* dimensions also an important *social* dimension from the start.

This eco-social perspective may be a heritage of the early discussion of the theme in context of the Ecumenical Council of Churches. Already in 1974, therefore, more than a decade before the Brundtland commission, in Bucharest an ecumenical world conference on 'Science and Technology for Human Development' took place. At this conference, the term 'sustainable and just society' was first used (Lienemann 2007:101).[13] From here we can understand why there is a social dimension of justice within the concept of sustainability according to the Brundtland commission. According to Pope Francis' encyclical letter *Laudato si*, we have to acknowledge, 'that a truly ecological approach *always* becomes a social approach; it must integrate questions of justice in debates on the environment, so as to hear *both the cry of the earth and the cry of the poor*' (Francis 2015: 35 (§ 49)).

Several further aspects of sustainability are discussed. Relatively new is the idea, that there is also a *cultural* dimension of sustainability, without which there could be 'important issues of sustainable development that are missed' (Soini & Birkeland 2014: 215). There are, however, different ways in dealing with this cultural dimension. For a start, we regard it here as an *additional pillar* of sustainability (Hawkes 2001). The UNESCO World Heritage Sites could present a concrete example for this perspective, as they sustain human-made *and* natural configurations for the *cultural memory* of humankind. If we follow the NASA directive and include the Solar System in our account of sustainability, we could therefore ask, whether the heritage sites should include the Apollo landing site as well – or Olympus Mons on Mars, the highest mountain of the Solar System?[14] This could present a conflict case for space mining, as the mount's territory could contain precious minerals[15].

The basic idea included in the NASA initiative, that a sustainable economic activity on Earth should be thought through within the context of the increasing space flight, shall here be developed further, albeit in an even broader sense. While NASA's vision for planetary sustainability aims at making 'the resources of the solar system … available to the people of Earth' (NASA), one should also consider, whether, e.g. the 'biospheres' of other planets have a right to exist *as they are now* 'when biospheres collide' (Meltzer 2010). As they are now, they could at least have a cultural, if not scientific value. This raises the astrobiological issue of planetary and environmental protection[16]. It includes the

[8]According to Paul Zenners, Conseiller de direction, Ministère de l'Économie. Email to the author from 01.08.2017.

[9]For results, see the White Paper produced at the workshop: Graps (2017).

[10]Another pressing problem in these regards is certainly space debris, which shall, however, not be the focus of this article.

[11]The 17 UN sustainable development goals include life on land, below water and the climate of our atmosphere, yet the space surrounding earth is missing United Nations (2015).

[12]'Sustainability' and 'sustainable development' are used interchangeable in the first overview, which this article represents. For a suggestion how to differentiate the two, see Niebert (2016).

[13]Science and technology for human development (1974). For Brundtland's reception of this see Niles (2002).

[14]Cf. the idea of a planetary park system for Mars: Cockell and Horneck (2004).

[15]I want to thank Erik Persson for this example.

[16]Cf. the recommendations of a COSPAR Workshop for Ethical Considerations for Planetary Protection in Space Exploration, Rummel et al. (2012).

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question, whether only an actual habitat should be protected or also a *potential* habitat, understood either as a candidate for a future habitat or as an unknown actual habitat. It is rather difficult to exclude the potential existence of life on a celestial body totally (Persson 2014). Maybe already on our voyages to Mars we can find traces of extraterrestrial life. On Earth also, life forms have been discovered (so-called extremophiles), that flourish in environments inadequate or even deadly for *human* life. '[F]rom the data we have currently, we can say confidently that there are conditions present on or in other Solar System bodies that do not exclude the possibility of Earth life surviving there'(Meltzer 2010:xvi); besides Mars, especially Jupiter's Moon Europa has to be mentioned, which has an ocean below its icy surface (cf. Catling 2013: ch. 6). The concept of planetary sustainability shall here be understood in such a way that to a certain extent it also includes the protection of planets (and Moons) as *potential habitats* in both meanings mentioned.

This, of course, means balancing different sorts of values, which may contradict the recovery of space resources. In general, the idea of sustainability is often understood as a contrast to unlimited expansion fantasies. One should not overlook, however, that an expansion of the human habitat into space in the long run is necessary for our survival. If sustainable development is a development 'that meets the needs of the present without compromising the ability of future generations to meet their own needs', in my opinion one has to have this long-term perspective in mind. A collision of an asteroid with Earth like the one that extinguished the dinosaurs could happen, also the everyday heating of Earth because of human-caused climate change in our 'Anthropocene' could force us one day to leave the Earth. This should not serve as an excuse, of course, not to care about our planet. In less than six billion years, however, expansion of the Sun will make life on Earth impossible. Whatever the developments will be, 'without our expansion of our instruments and people into space, humanity could conceivably perish' (Pass *et al.* 2006: 5). To some extent, a truly sustainable concept of sustainability therefore has to be an *inter*-planetary one, which makes a continuous technological development a necessity.

This does not diminish the previously invoked dimensions of sustainability. They are even the more important to enable a long-term technological change. On other planets that could be affected by our expansion, balancing the human needs with the protection of the respective environment needs to be discussed. Meanwhile, we truly have to be cautious about the ideal of 'progress', as it 'could easily lead us in directions that make us lose touch with human values' (UNESCO, 2003:3). Ethical questions within the context of a planetary sustainability therefore have not only to include *all dimensions of sustainability*, but also an additional *technological imperative*, balanced with questions of *responsibility* regarding the *acquisition of and intervention in* extraterrestrial resources, especially if they are potential habitats.

The importance of planetary and environmental protection – does it have to include asteroids as well?

Earth is isolated from other space objects by vacuum, but space missions can pass through this vacuum, and hence it is in humankind's hand to protect planets from contamination. 'From the time that humans first began sending spacecraft out from Earth, the possibility has existed of forever changing the extraterrestrial environments that we visit. If we irrevocably alter the nature of other celestial bodies, we compromise all future scientific experiments on these bodies and may also damage any extant life here. By inadvertently carrying exotic organisms back to Earth on our spaceships, we risk the release of biohazardous materials into our own ecology' (Meltzer 2010:1). *Planetary Protection* is therefore necessary and is defined as a process 'of preventing contamination of planetary environments by living organisms from other planets, in accordance with Article IX of the 1967 *Outer Space Treaty* and policies maintained by the *Committee on Space Research* (*COSPAR*). Nations sending missions to other planets must ensure that Earth life does not contaminate them (forward contamination), and that any samples brought to Earth do not release harmful organisms into our environment (backward contamination)' (Conley 2011).

Although the highest priority is to protect Earth, it is also valid that the protection of other planets against Earthly life has a value, because it safeguards our efforts for scientific research and the search for extraterrestrial life (Conley 2011). When we look for simple extraterrestrial life on Mars, how can we avoid finding only those microbes that we brought there from Earth? The 'total sterilization of humans and machines is impossible' (Persson 2017). With humans, this is obvious, because a total sterilization would cause our death. With machines, we can be more thoroughgoing, but in general, the same problem applies to them. 'The electronics in a rover is usually more sensitive than at least some Earth microbes. This means that we need to find a balance between our efforts to find life and our efforts to protect it' (Persson 2017).

So much for 'planetary protection' as we know it, which is a legally defined term and therefore expression of restricted use which implies distinct policies (the COSPAR guidelines) to be applied to a particular category of space missions (NASA, 2011). If we one day will really find extraterrestrial life, be it on Mars or elsewhere in our Solar System, additional issues will be raised, that I want to consider under the heading of 'environmental protection'. Are we allowed to bring probes back to Earth? Or would we risk contaminating Earth with a hazard for which we have no resistance on Earth? Let us repeat, what is at stake; there are even more questions involved:

- 'Do we have an ethical obligation to preserve a planetary environment to the same degree that we seek to protect our Earth's environment?
- Does this obligation hold, even if there is no life on a planet?
- Or, since environmental ethics seek to benefit and enhance life, do we have an *obligation* to see that terrestrial life expands onto lifeless planets?
- Does the type of extraterrestrial life we discover determine the appropriate level of protection? In other words, are exotic microbes deserving of the same level of protection as intelligent life?' (Meltzer 2010: 111–112; cf. Rummel *et al.* 2012)

One should think that regarding asteroids, at least, this matter should be unproblematic. When Luxembourg's press release states the aim would be 'to open access to a wealth of previously unexplored mineral resources on lifeless rocks hurling through space, without damaging natural habitats', one can ask the question how do we know that all these rocks do not carry any traces of life. This may be probable indeed, 'because of ionizing radiation that is pervasive in space, Clark *et al.* expected the top meter or so of asteroid surface to be sterile. For this reason as well as because of the effects of high vacuum and thermal disruption

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(which, among other impacts, cause outgassing of water vapour from regoliths), Clark *et al.* suggested that sample return missions excavating asteroidal material only to shallow depths should not require back contamination protection such as quarantining' (Meltzer 2010: 334) with reference to (Clark *et al.* 1999).

Now, mining certainly goes beyond 'shallow depths'. Hence, a scientific control of space mining missions is of the essence. We also know too little how life originates to exclude the possibility of traces of life on asteroids even though it might be in the shape of remaining micro fossils (cf. Losch, 2017). There could also be many more scientific reasons why a space object could be interesting for science to study and why it should be protected from exploitation. A *regulation of space mining* would indeed be of high significance, and Luxembourg would do very well to establish it quickly, and, as intended, in an internationally agreed-on manner. Only this way, the concept of sustainability could be applied on these questions as well, while the respective meaning of each of the dimensions of sustainability in these regards certainly still would have to be thought through.

One day Mars will be in reach for space mining. A follow-up question would be, if we are also responsible for protecting Mars' 'biosphere' (Peters 2014:454). Not long ago, human expansion and exploration was combined with an imperialistic attitude in relation to local life and local culture. In this context, it would maybe help studying the history of human colonialism and what we can learn from it. The economic advantage to be the first to act in space, does summon the dangers of imperialism regarding the ownership of resources (Capova 2016). 'Examining the history of spaceflight advocacy reveals an ideology of spaceflight that draws deeply on a durable American narrative – a national mythology – of frontier pioneering, continual progress, manifest destiny, free enterprise, ragged individualism, and a right to life without limits'(Billings 2007: 483). Already one commercial mission with contaminating effect could suffice to undermine decades of work on planetary protection, for instance.

What is going on? A constructive-critical realist interpretation

We therefore have the responsibility to shape our exploration of celestial bodies with as much wisdom as possible and to consider future generations' needs as much as possible.(Meltzer 2010: 2) This might simply mean being committed to our children's and their children's generations, not willing to sacrifice their future on the altar of our short-term well-being. Religious traditions can maybe help balancing the economic interests with other, more moral values[17]. From a distinctively Christian theological perspective, accepting something superior to one's own interests – as I would understand the 'fear of God' – is 'the beginning of wisdom' (Psalm 111, 10). This also means in my view that we humans must be aware that we are never grasping the whole story of what is going on, cannot employ a God's-eye view and hence the fragmentary character of our perception needs to be clear and conscious, while we are responsible to the whole of reality (Niebuhr 1963), acknowledging that 'we are men, not God; we are responsible for making choices between greater and lesser evils' (Niebuhr 1968: 56)[18]. In theological interpretation, sustainable development means to take responsibility for the 'preservation' of creation. With 'creation', a fundamentally positive evaluation of nature is meant that is nevertheless aware of a serious discrepancy in the relationship between humans and their world environment.

Realism is the philosophical stance that is particularly suitable to illustrate these interconnections, because it mirrors the entanglement of humankind with the given reality of their surrounding environment (Losch 2011: 252). A *critical* realism can additionally grasp the fragmentary aspect of this relation, and also qualify the moral realism associated here with the epistemological concept. The further attribution of this realism as a *constructive-critical* one attributes due credit to the facilitating powers of humans. I will hence describe these relations here with the term *CCR* and try to apply the concept on the issue of sustainability. This version of realism emphasizes the *constructive-critical* role of the subject, which mirrors two essential capacities of the human mind, the abilities to believe and to doubt. CCR is originally an epistemology that orientates its form at the respective research field. It is nevertheless open for an ethical or theological interpretation of the matter described. Epistemologically, CCR agrees with a critical view of the subject's role in the natural sciences; here, the subject's influence on research needs to be eliminated as much as possible, even if this is never totally the case. A realism best expresses the experience of discovery and persistence of reality that scientists have. In *cultural sciences and humanities*, the contribution of the subject, however, is crucial to the research field, which approximates a constructivism. CCR therefore is a form of realism that allows for some constructivism, especially regarding cultural research objects (Losch 2011: 252).

The combination of the two attributes has an additional evaluating meaning and hence hints at the relation of research and ethics; in scientific research processes, cultural construction involving ethical decisions takes place, and therefore no attempt to know is innocent. When we have to admit that the knower is part of the process of knowledge, his or her values do matter in research. In theological interpretation of this setting, we are on the one hand responsible stewards of the creation and have to be careful regarding our actions. We do not own the Earth. On the other hand, we are maybe more than just stewards. All 'beings of the universe' (Francis 2014) that are created in God's image[19], are in some sense co-creative. One can even speak of humans as 'created co-creators'. This nominalization, however, appears too strong to me, because of biblical reservations to safeguard the word for 'creation' to God alone, and hence I want to translate the respective deliberations by Philipp Hefner (Hefner 1995) here in that way, that it is humankind's purpose to shape nature in creative and responsible participation in God's creation and with the means of culture towards increasing realization of freedom in relationship (Losch 2005: 285). We human images of God, however, do not only participate co-creatively in shaping our habitat, but we also destroy it[20], which is illustrated theologically by the concept of sin – this is why Christian theology has contributed to the ideas of environmental protection and of sustainability

[17]What is undertaken here for Christian belief needs to be pursued for other traditions as well, I am convinced. The results, however, could be divergent, and could make an intercultural dialogue necessary. Even within the Christian theological tradition, the situation regarding the awareness of sustainability quite varies. While Vogt (2009) presents an encompassing catholic approach on the 'principle of sustainability', from a protestant perspective the topic of sustainability still needs to be dealt with more deeply, cf. Meireis (2016).

[18]Cf. Lovin (2009). The common traits in both Niebuhr brother's ethics sketches Ottati (2009).

[19]Cf. the discussion in Losch and Krebs (2015).

[20]Cf. Sigurd Martin Daecke's description of humans as 'co-destroyers', Daecke (1993).

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(see, for instance, Moltmann, 1985; Barbour, 1994). The dark side of the cultural narrative behind spaceflight and space mining may be greed and egocentrism thriving, or at least self-righteousness.

To avoid lasting damage to our planet's eco systems, we have to take care for the sustainability of our actions. Therefore, the idea of a *CCR* shall now be employed on the concept of sustainability, under consideration of not only *ecological* (that is to say nature-orientated) sustainability, but also of *economic*, *social* and *cultural* dimensions. In this context, the cultural aspect will therefore not only be regarded as an additional pillar of sustainability, but to some extent also as the *means* through which the topic is approached and framed. '[E]nvironmental problems, like other problems, are socially constructed, building on expert language and concepts, research practices, and available technology' (Soini & Birkeland 2014: 215). According to this social constructivist approach, to see a natural disposition as a 'problem' already implies a cultural aspect, an ethical evaluation of it. The idea of CCR allows for such a degree of constructivism and is able to keep this cultural dimension present, without losing the natural-realistic conditions of the one reality by which we are bound and of which we are part of out of sight. It therefore seems particularly able to broach the issue of the multiple dimensions of sustainability in this context.

What does this all mean for human interplanetary research? Let us take the example of Mars: What do we want to achieve with our voyages to Mars? Is it sheer curiosity or is it intended to 'show, what is possible', when the human habitat is expanded into the 'final frontier' space? Is it indeed a necessary step to safeguard humankind's survival? Which sort of environmental ethics one would have to apply on a lifeless Mars? And if there would be microbial life on Mars, would it be allowed to 'sacrifice' it when 'terraforming' Mars one distant day (cf. McKay, 2009; Smith, 2009)? Which agenda and which research aims are behind the diverse Mars programmes? Is Martian life to be protected for its own sake or only as means for our research goals? Would extraterrestrial life in general have a dignity of its own, or only if it would somehow prove intelligent? And what if extraterrestrial life would be malevolent or simply damaging to humankind? So far, the ethical considerations mentioned had all been more or less anthropocentric. Within a truly intercultural and universal framework, one would maybe need to reconsider this approach.

Conclusion and outlook

These questions call for their own ethical treatment, hence the argument of this article. Even in the very long run, later generations should be able to meet their own needs without perishing due to events in our Solar System. To enable us to last that long, all the developed dimensions of sustainability need to be upheld. Additionally, as noted, the *technological imperative* and the necessary *acquisition of and intervention in* extraterrestrial resources and therefore potential habitats[21] need to be discussed, conscious of humankind's achievements and failures. Not all changes that are and that will be technically possible are good. The technological imperative therefore needs to be balanced by *the imperative of responsibility* (Jonas 1985). '[T]he planet's future sustainability will go wherever education and ethical thought can lead' (UNESCO, 2003: 6); and this will not only be true for planet Earth.

[21]In both senses of 'potential', as discussed above.

Reality is not only there to be discovered, but it is also our task how to shape it. Each discovery bears the potential for change. NASA's courageous initiative, for instance, could even change a whole world, Mars. What would it mean in this context, to care for sustainability? CCR acknowledges the reality changing power of the acting human mind and hence calls for a necessarily *transparent research agenda*. It also reminds us to choose sustainable developmental goals, considering the interplay of the different aspects of sustainability. Such a cultivation of Earth and its surrounding space shall be envisioned that allows for long-term use of existing resources, but also a technological development that makes us one day hopefully independent from Earth. In ethical perspective, such a presentation takes on anew the contemporary challenge of a sustainable development of humankind and reconsiders it in the extended framework of the Solar System. Philosophically and theologically, it involves reflections on the moral status of life in the universe, be it earthbound or extraterrestrial.

Because Asian countries are now pushing into space as well, the space race is accelerating. A settlement on the Moon is a very concrete vision. Mars is the next step. Even more, after a multiplicity of inhabited worlds has been for centuries fiction and imagination only (Crowe 1999), in our days thousands of planets outside of our Solar System are to be categorized. We may expect that at least every tenth star has its own planet; even the closest Solar System *Proxima Centauri* has a planet in the habitable zone. Facing at least 300 billion stars in our Galaxy alone, and hundreds of billions of galaxies in the universe, the existence of extraterrestrial life seems at least to be possible. What if we discover a 'second Earth' one day which proves to be inhabited? We should be prepared for the potential discovery or one day even contact with extraterrestrial life. At least Christian theology should consider it[22], as it does believe in one creator God of everything, who may have allowed life to sprout multiple times (Losch & Krebs 2015). Or does all life in the universe stem from one source, as 'panspermia' propagators are convinced? One day, we will hopefully know.

These considerations exceed what is possible to be sketched within an article, which presents arguments for the *need* of an ethics of planetary sustainability, and is scarcely already a development of that ethics itself.

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[22]On the readiness of academic theology and the general public for such a discovery, see Bertka (2013); Peters (2013).

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