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The Anthropocene -The Earth in Our Hands

Reinhold Leinfelder, Freie Universität Berlin*

1 Introduction

An outstanding characteristic of the human species is its ability to think ahead into the future. However, such foresight is a major challenge if it is to go beyond one's own personal environment. The future is therefore difficult to grasp – also depending on which temporal and spatial scales are adopted. Geologists predict probable Earth plate constellations even up to 250 million years in advance.[1] Paleontologists may agree to "what if" future scenarios based on plausibility conditions, such as in the BBC fiction "The Future is Wild", produced with the participation of paleontologists, in which, in 20-200 million years, fish could actually have conquered the air and octopuses the land[2]. In general, science fiction films often shape our ideas for the future - in fact, they have anticipated technical developments, such as tablet computers, 3D visualizations or 'intelligent assistants'. However, many think of the future in terms of socio-political and environmental challenges on a local, regional and global scale or of many euphemistic promises of the industry. Hence, it is no surprise that very often fears of the future prevail or the topic future is simply ignored. We do not want that robots take over our work, nor do we want to be made personally responsible for all these problems. The complexity of the closely interlinked challenges seems too much for us: The future seems cloudy, pixelated, not an integral picture. The usual, especially western dualistic, dialectical approach of discursive categorization into close vs. strange, good vs. evil, beautiful vs. ugly, right vs. wrong, nature vs. culture, human vs. technology etc. is counterproductive and does not help (Schwägerl & Leinfelder 2014, Leinfelder 2017a). Cheap, psychologically quite comprehensible self-excuses promote populist attempts for splitting societies, which are currently experiencing an alarming boom (Leinfelder 2013a, 2018, Levandowsky et al. 2018). Can a new scientific concept derived from the Earth system and geosciences, the Anthropocene, help here? Does it have the right name? Doesn't it promote an apocalyptic, fatalistic attitude or, quite contrary isn't it a gateway for positivistic, technocratic delusions? And how is a concept that has grown out of the "deep past", i.e. the history of the Earth, supposed to have any relevance for the future? Once again we seem to be trapped in our simplifying, dualistic "either-or" ideas, into which we want to categorize new concepts as fast as possible.

The purpose of this article is to present the concept of the Anthropocene also with regard to its potential for a systemic sustainability analysis and the resulting responsibilities, commitments and design options. Perhaps the most exciting thing about the Anthropocene concept is the challenge of abandoning dualisms in favor of a diverse spectrum of graduations, new approaches and new solution pathways. However, the different levels of the Anthropocene approach should be distinguished, so that it is always clear what we are exactly talking and debating about.

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Author's address: Prof. Dr. Reinhold Leinfelder, Freie Universität Berlin, Institute of Geological Sciences, Malteserstr. 74-100, Haus D, D-12249 Berlin, Germany. Email: reinhold.leinfelder@fu-berlin.de

[1] See Scotese C.R. (1998ff.), Pangea Ultima: http://www.scotese.com/future2.htm (as of Feb 2020).
[2] See Dixon / Adams (2016) and http://www.thefutureiswild.com (as of Feb 2020).

2. Paul Crutzen - the Father of the Anthropocene

Atmospheric chemist and Nobel laureate Paul Crutzen first used the term “Anthropocene” at a large conference of the Earth system sciences in Mexico in 2000. Earth system scientists are trying to understand the processes of the Earth system and thus the interplay of the lithosphere, pedosphere, hydrosphere, biosphere, and atmosphere. Recently the influence of humans (sociosphere or anthroposphere, sensu WBGU 1993) on these natural spheres and thus on the stability of the Earth system has also been evaluated. Crutzen was horrified by the extent of human intervention in the Earth system and - emotionally moved - claimed in an interim remark that we would no longer live in the Holocene, but in the “Anthropocene”. Since then, the new term has entered the scientific and public discussion.[3]

Following the conference in 2000, it was Crutzen who, together with the ecologist Eugene Stoermer (who had been using the term Anthropocene in his lectures for some time), published a short concept of the Anthropocene in the newsletter of the International Geosphere Biosphere Program (IGBP) that hosted Mexico Conference (Crutzen & Stoermer 2000). This was followed by his highly regarded article “Geology of Mankind” in the renowned journal “Nature” (Crutzen 2002). Crutzen thus implicitly put forward three theses: First, that today's Earth system does not correspond to the Holocene Earth system anymore, so humankind has become a crucial factor of the Earth system. Second, by using the term in linguistic analogy to the more recent geological epochs (Paleocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene and Holocene) he hypothesized that these interventions were also geologically detectable, permanently manifested in new sedimentary characteristics, and thus required the formal definition of a new geological epoch. Third, he did not stop at this analytical approach, but also formulated that its outcome must have consequences for future human action, and that not politics alone, but also science and technology must make a significant contribution to this. The Anthropocene concept can therefore best be described by these three levels, a) the Earth system level, b) the geological stratigraphic level, and c) the consequential meta-level (Leinfelder 2016a, 2017a, b).

3. The Multi-Level Approach

3.1 The Earth System Level of the Anthropocene Concept

Human intervention in the environment has reached dimensions that are difficult to imagine - quantitative estimates of this can illustrate this: so far, humanity has reshaped more than three quarters of the ice-free solid Earth - a "pristine nature" no longer exists here[4]. Today's natural landscapes are therefore mostly cultural landscapes. The situation is similar in the oceans, where overfishing has reached enormous proportions and where temperature increase, acidification, over-fertilization and other pollutants endanger coral reefs, plankton and other marine life[5]. Overall, the situation of biological diversity is critical. Although only about 0.5-2% of vertebrate species have become extinct since the beginning of the 18th century (Waters et al. 2016), this is still 100-1000 times faster than before the beginning of human influences happens (Barnosky et al. 2012, Ceballos et al. 2015).

[3] The history of ideas from the Anthropocene dates back to the 19th century when the Italian geologist Antonio Stoppani spoke of an "anthropozoic era". The Russian geologist V.I. Vernadsky took a similar view in 1926 by referring to the “Noosphere”, introduced by Teilhard de Chardin as a world of thought, in order to emphasize the role of human thinking in shaping one's own future and one's own environment. The biologist Hubert Markl spoke of a “change into the Anthropozoic era” in the early 1990s and described “nature as a cultural task”. Science journalist Andrew Revkin used the term “anthrocene” in one of his books (Leinfelder 2012, Trischler 2016).

[4] See Ellis / Ramankutty (2008), Ellis et al. (2010), Ellis (2011).

[5] WGBU (2013), Leinfelder / Haum (2016a, b), Leinfelder (2019a).

When monitoring 16,704 populations of 4005 vertebrate species, their population size has declined by 60% since 1970 (Grooten & Almond 2018). The change is even more dramatic when considering the ratios of biomass proportions. For example, despite the large number of individuals (almost 7.5 billion), humans only represent 0.01% of global, carbon-based biomass - most of it, namely 82%, is contained in plants and, in turn, in tree trunks. However, humans and their mammalian livestock, in particular cattle, sheep and pigs, represent 96% of the biomass of all living mammals (humans 36%, livestock 60%). All wild animal species together therefore represent only 4% of the carbon biomass of all mammals. In birds, even 70% of the biomass is accounted for by breeding poultry (Bar-On et al. 2018).

The extent to which non-renewable resources are used also plays a very special role. Humans use fossil fuels, which have accumulated over hundreds of millions of years from biomass. Their combustion causes today's anthropogenic climate change within a very short time. In addition, we also use vast quantities of other raw, non-renewable materials such as sand, limestones, clays, iron ore, other metals or rare earths to produce buildings, infrastructure, machinery and appliances, the construction and operation of which in turn requires enormous amounts of energy. Our scientific estimate of the magnitude says that humankind has so far produced the unimaginable amount of 30 trillion tons of technosphere. 40% of this technosphere is located in and under the cities of the world (Zalasiewicz et al. 2017a). Other technical products, such as plastics in particular, are spread all over the Earth. Humans have produced a total of about 8.3 billion tons of plastics (Geyer et al. 2017). While pre-war production was minimal and only about 1.5 million tons were produced in 1950, annual production has now risen to around 400 million tons, which is more than the biomass of all living humans (cf. Zalasiewicz et al. 2016, Leinfelder & Ivar do Sul 2019, Fuhr et al. 2019). 2.5 billion tons of the total plastic produced are currently still in use, but only a very small part is recycled or incinerated worldwide, while about 4.9 billion tons, i.e. about 60% of all plastic produced up to now, has been released into the environment, either still dumped in geologically non-permanent landfills or directly distributed on land and in the sea (Geyer et al. 2017).

The construction and operation of technical machines from such non-renewable resources then in turn enabled other resources, such as phosphates, to be extracted. The majority of the mined phosphates are added to agricultural land in the form of artificial fertilizers in order to generate renewable biological resources. Between 1910 and 2005 the human-made share of the net primary plant production (NPP) doubled from 13 to 25% of global vegetation, which led to a doubling of the input of reactive nitrogen and phosphorus into the environment and which also required huge amounts of fossil energy for agricultural production. In 2014, 225 million tons of fossil phosphates were mined and 258 million tons are projected for 2018. The scenarios for the human share of total primary crop production by year 2050 amount to 27-44% NPP.[6]

Humans are thus removing whole mountains, cutting new valleys, allowing lakes to flow in or out, determining where and what is sedimented, which organisms live where and where they do not, raising sea levels and changing the climate.[7] Humankind has not only changed the Earth system qualitatively and quantitatively, but also made these changes at an enormous and increasing speed. The sciences refer to this as the coupled “Great Acceleration” of geoecological and socioeconomic processes (Steffen et al.2007, 2015). The danger of tipping over into a completely new Earth system status is great, especially if it is not possible to limit anthropogenic global warming to a maximum of 2° C globally, although even a warming of "only" 1.5-2° C is already well outside the range of the Holocene (Leinfelder & Haum 2016a, Steffen et al. 2016).

In summary, the Earth system hypothesis of the Anthropocene concept states that humanity has already changed the Earth system in a way that is not only comprehensive, but that also makes these changes largely irreversible. Unfortunately, all of the available data now seem to confirm this.

[6] Williams et al. (2016), Leinfelder (2017b), reference also for additional literature.

[7] Waters et al. (2016), Leinfelder (2017a, b, 2018), reference also for additional literature.

However, it depends upon our future actions, how far the new Earth system actually will differ from that of the Holocene. Can it still be designed in such a way that it can support human societies and that these societies can develop as freely and democratically as possible? Or do we fall into a "hothouse" phase, with in detail unpredictable tipping point cascades, in which humanity will only be able to survive in the reaction mode (Steffen et al. 2016, 2018)?[8]

3.2 The Geological-Stratigraphic Level of the Anthropocene Concept

The enormous anthropogenic changes in the Earth system are also permanently documented in the present and future sediments as geologically detectable signatures. Caused by water regulation, agriculture, infrastructure, construction and mining, sedimentary processes today differ largely from natural processes. Adding to this, characteristics of the sediments have also changed, now showing completely new geosignatures and components. The Working Group set up by the International Stratigraphic Commission on the 'Anthropocene' (AWG)[9] includes geologists together with other Earth system scientists, as well as representatives from many other disciplines. This group has been investigating for several years to what extent the changes in the Earth system are also manifested in altered sedimentary signatures that are characteristic of the Anthropocene.

This is the basis for the further assessment of whether the Anthropocene should be formally defined as a new geological epoch, and if so, where the lower limit of this epoch should then be positioned. The fact that the Anthropocene should be considered as a new epoch is meanwhile largely undisputed within the AWG. Various proposals are discussed within and outside the AWG, such as the anthropogenic changes in the Neolithic, the "upsurge" of the Industrial Revolution after the perfection of the steam engine around 1800, or the enormous increase in sedimentary geosignals due to the "Great Acceleration" (sensu Steffen et al. 2007, 2015a) since the mid-20th century. The AWG now favors the latter by a large majority, since both synchronicity and worldwide detectability are given for the first time. This lower limit would be characterized in particular by 1) the radioactive fallout of the atomic bomb tests in the 50/60s, 2) the strongly accelerated increase of "technofossils" such as plastics, elementary aluminium, industrial ash particles, concrete fragments since 1950, and 3) relics and geosignatures of our “grow-use-dispose” societies, with are constantly embedded in the sediments.[10]

3.3 What’s Next? The Consequential Meta-Level of the Anthropocene Concept

From a physician treating us we not only expect that his examination methodology is adequate and that his diagnosis is correct, but also that he presents this diagnosis in an understandable way, suggests further action, monitors the treatment and, if needed, urgently advises us to change our life style (if necessary with emphasis on the risks if we do not follow). In the same way, the social relevance of the Anthropocene analysis requires further attention and care, including scientific support, as well as recommendations for urgent behavioral change. This needs translation, dialogue and discourse skills, communicative interaction, ethical discourse, transdisciplinary cooperation with all social groups as well as scientific monitoring of all implementation processes. This is referred to here as the consequential metalevel of the Anthropocene concept.

[8] Further in-depth resources on Chap. 3.1. see e.g. Barnosky et al. (2012), Brown et al. (2013), Ellis et al. (2013), Leinfelder (2017a), Steffen et al. (2015a, b), Waters et al. (2016), Williams et al. (2016).

[9] http://quaternary.stratigraphy.org/working-groups/anthropocene/

[10] See e.g. Waters et al. (2016, 2018), Zalasiewicz et al. (2017b, 2019a, b) for detailed recent statements, also for the further process. Current results of the voting in the AWG on May 21, 2019 see http://quaternary. stratigraphy.org/ working-groups / anthropocene / (as of Feb 18, 2020).

In fact, not only researchers from the Earth sciences, but also from ecology, archaeology, sociology, philosophy, education, environmental, historical, literary, political, design, technical, architectural and other cultural studies and the arts are increasingly using the term "Anthropocene" and are thus discussing all aspects of the immense environmental change caused by humans ("Anthropos") as well as their effects and potential consequential reactions to it[11]. This consequential metalevel of the Anthropocene can be formulated as a further hypothesis: Humans, which have become an immense geological force - albeit to a very different extent and responsibility (cf. Allen et al. 2018) - has brought the Earth system to the brink of a possible tipping. For ethical reasons and on the basis of its now very comprehensive knowledge, humanity should also be in a position to help shape the Earth in a "knowledge-gardening", sustainable manner and in compliance with the precautionary principle in such a way that we humans become an integrative part of a permanently functional, anthropocene Earth system that is habitable for humanity and all other diverse life. In the best case, this would create the basis for fair and just development opportunities for present and future generations worldwide. In the following, five conceptual approaches to solving this problem are briefly outlined.

Interdisciplinarity approach: A complex science challenge such as the full analysis and monitoring of the Anthropocene and its resulting transformative relevance can hardly be achieved with the prevailing scientific method of confining scientific studies to small, manageable problems, which are then studied in great detail and depth. Multidisciplinarity, which only means that certain research objects are examined by different disciplines in their respective disciplinary context, also cannot create the necessary cross-linkages. Only full interdisciplinarity, in which different disciplines analyze problems together under a common objective and develop joint proposals for solutions, can achieve the necessary systemic analysis and enable transformative research and transformative education (sensu WBGU 2011).
On the one hand, the Anthropocene concept is thus a science-based analytic and monitoring instrument which, first and foremost, underlines the need to expand systemic and interdisciplinary research. The necessity of interdisciplinarity begins with the analytical inventory of human-made changes. This integrated approach makes it possible, for example, to correlate historical data from archaeology and historical research closely with the sedimentary archives. Since not all historical facts have been recorded by humans, there is a great added value here: An Anthropocene sedimentology and stratigraphy makes the spread of crops, the introduction of invasive species, the distribution of hazardous substances, the warming of the climate, or the omnipresence of plastics traceable regardless of historical records and thus allows to complements them.
On the other hand, the concept is also a docking point and an ethical imperative for a major social transformation in which science and education systems jointly research and teach in an inter-disciplinary and transformative manner and in which dedicated groups from civil society, science, authorities, business and politics work on sustainable solutions in a transdisciplinary manner, from the municipal to the national, multi-national and UN level (WGBU 2011). In order to ensure that this social contract not only remains virtual, but also has the prospect of political implementation, the legal systems, again at all levels, i.e. from private law to municipal regulations to international law, must be reconsidered from this perspective and, if necessary, adapted or supplemented (Leinfelder 2017a).

Systemic sustainability approach: The integrative view of the Anthropocene also requires a complete rethinking of the concept of sustainability. The concept used in politics and business up to now is based on the three-pillar model of the Brundtland Report (UN 1987) and defines sustainability as the intersection between economic, social and ecological sustainability. Unfortunately, in most cases, both the ecological and the social aspects are subordinated to the economic aspects, often with the argument that otherwise there would be social hardships. Very often, the social factor is largely atrophied, resembling the "mitochondrion of the economy", while the ecology is only considered as

[11] For example, articles in Möllers et al. (2015) and in Renn / Scherer (2015), see also Hamann et al. (2014), Leinfelder et al. (2016); for discussions and criticisms - including terminology - see the author's Anthropocene blog at http://anthropocene.de

an "environment" surrounding (ie environing) us at a certain distance (in the sense of a world just "around us", also ref. to the German expression “Umwelt” for environment). Though being valued by many, for most it only functions as a "nice to have" or "perhaps worth protecting" addition (cf. Leinfelder 2018). Fortunately, the theme-based Sustainable Development Goals – as adopted by the UN in 2015 – now interlink areas of life and environmental issues, which is a step in the right direction (UNSDGs 2015). However, it does not yet adequately show how all our activities, productivity, nourishment, security and well-being is strongly dependent upon a functioning Earth system. The approach known as "Wedding Cake", linking Sustainable Development Goals (SDGs) with a concentric model of sustainability (cf. Griggs et al. 2013, Rockström & Sukhdev 2016) is a further step forward, but it embeds economic and social issues only in the biosphere and leaves the rest of the Earth system largely unconsidered. Also, the term "environment" (“Umwelt”) itself assigns to ecology just this excluding, distanced area, and does not show how much our livelihoods depend on it. Possibly the metaphor of an "Usworld" (in German: “Unswelt”) could be an eye-opener here, pointing to the need to rethink that the economy must serve the social/cultural system, and both, economy and social/cultural spheres have to be seen as an integrated, embedded part of the Earth system (Leinfelder 2011, 2013b, 2018).

Ethics Approach: Rethinking our embedding in the Earth system and our strong dependence on the history of the Earth not only requires to redesign the concept of sustainability, but also increases the "responsibility imperative" for action even further: If there is hardly any untouched nature left and if we have become a dominant Earth system factor as well as a geological force by our cumulative actions, then there is no real difference between nature and culture. Humankind should therefore see itself as being an integral part of the Earth system (see above: "Usworld"). Living a human life only *from* the Earth system, not *with* the Earth system is impossible, at least in a permanent, sustainable way. The main challenge of the Anthropocene concept is actually the insight into a completely new ethical relationship with the Earth: Everything I and others do has an effect on the Earth system, often in a completely unexpected and unforeseeable way. Each individual and all communities are therefore responsible. Politics or even the economy cannot be discharged from their responsibility, but alone they also cannot guarantee our Earth system integration. The use of the Earth by everyone also obliges everyone to a compatible, sustainable, and possibly even in a resource-augmenting behavior. The contrast between human necessities and the intrinsic value of nature (i.e. anthropocentric versus bio-/physicocentric) would then also resolved in an interdependent, integrative way. If the well-being of humanity depends on the well-being of nature, and vice versa the well-being of nature depends on Earth-system-compatible behavior of humans, then anthropocentric "parasitism" would transform into a genuine “mutual symbiosis" of humans and nature - this could then be described as an "anthropocenic" view (Leinfelder 2013b, 2016).

Design approach: Our knowledge society is complex, it is based not only on scientific knowledge, but also on experiences and convictions. Thus, a multimodal approach should be chosen for sustainability communication, in which facts are not only described but are also interwoven with metaphors, narratives and real images. Through narratives and visualizations, emotional access and insights can be enabled, and motivation can be generated (see following section). Facts should also be provided simultaneously in order to prevent any manipulative character (cf. Leinfelder et al. 2015, Leinfelder 2014, 2016b). Personal participation, which could start with individual trial and error approaches might further extend to active participation in environmental Citizen Science monitoring, school laboratories, maker faires, future workshops, or artistic environmental and design projects. All this supports the necessary "permanence" of approaches and strengthens fundamental and goal-forming mental resources (cf. Hunecke 2013). In the context of the Anthropocene, a combination of narrative, participatory and creative approaches should hence help giving meaning to individual and societal future life histories that can still be shaped in a spirit of solidarity and sustainability, and should also strengthen personal experiences of self-efficacy and corresponding cooperative behavior and action through active participation (cf. Leinfelder 2018).
In this context, it is extremely gratifying that the responsibility of science and higher education is

increasingly being expressed through public dialogue forums. The University of Coburg is exemplary in this respect, where 16 experts/lecturers from all six faculties plus experts from the science and culture centre have initiated an interdisciplinary, problem-oriented discourse on the Anthropocene. In this way the university consciously and exemplarily assumes responsibility for the "Future of the Earth" both internally within the circle of scientists and for students in higher education. In doing so, it also visibly demonstrates - and hopefully encourages followers - that the education of university graduates is seen as the key to shaping the future.

Narrative approach: How could such a reflection of the human being on the necessity for repositioning as an integrative part of the Earth system be achieved? An interesting approach for a new connection with nature is to use images, metaphors and narratives that - far from any false eco-romanticism - make us aware that not only renewable resources, but also fossil fuels and other raw materials such as limestone, sand, iron, manganese, copper, rare earths, phosphates etc. are finite. Such resource limitation is real for quite some substances owing to nearly complete exploitation of reserves in the foreseeable nearer future. However, most resources are not scarce *per se* at present, but owing to immense mining costs and negative externalities their availability is, or should be, extremely limited, particularly for environmental reasons.
Apocalyptic narratives are certainly no solution, they promote powerlessness rather than motivate for action. Culture, education, science and entrepreneurs should therefore use new optimistic narratives, locations, interventions, experiments and prototypes to help politicians and society as a whole to develop new and diverse solution approaches[12].

Excursus

One example is the Anthropocene narrative "Machines must also be fed": Of the 30 trillion tons of technosphere generated since about 1950 (see Section 3.1), each living human being accounts for about 4000 tons, consisting of buildings, infrastructures, vehicles, machines, appliances, gadgets, human-made soils, etc. If these materials were evenly distributed on the Earth's surface, there would be 50 kg of these substances per square meter, both on land or at sea. For comparison: Although we are currently almost 7.7 billion people, each of us, statistically speaking, has an average of about 7 soccer fields (again, related equally to land and sea). We often forget that it is not only the raw materials necessary for our technical products that we explore, mine, transport and assemble into products with a high energy requirement, but that the buildings, machines and equipment created by this process also require other resources, in particular energy, in order to become comfortable (houses) or to do work for us: They drive, fly, swim, transport, calculate, illuminate, rinse, sew, wash, store, heat or cool for us. This narrative could help to underline the need for renewable energies and the importance of improved efficiency and, above all, the permanent recycling of resources.

4. Future? Futures!

How could the obstacles to dealing with the future described at the beginning of this article be overcome conceptually? Our culture of discussion about future solutions often suffers from the fact that possible future scenarios and possible pathways to get there are usually hard to imagine and are therefore immediately discarded - here, too, it usually feels better to remain caught in the familiar than to get involved in something that is difficult to imagine (Leinfelder 2015). Desire research shows that we wish above all for what others already have, i.e. what is therefore conceivable (cf. Helbig 2013, Fischer 2016). Since it is easy to outline and easier to update, the sciences - and then also media, film and pop culture - tend to use business-as-usual scenarios, i.e. explorative, probable, thus imaginable

[12] For more on narratives, including other examples, see Leinfelder (2017a, b, c, 2018), Leinfelder et al. (2015, 2017).

futures. Far too little attention is paid to possible alternative futures and even less to normative, desirable futures. In the Anthropocene context, desirable futures should be compatible both with the planetary boundaries and with SDGs. Nevertheless, the window of opportunity is wide enough to design different possible future pathways and thus to increase their imaginability, to strengthen the capacity for discourse, to then distill desirable futures and, based on that, to develop mixed solution portfolios to reach there.

For such purposes the author proposed a set of possible ideal-type future scenarios, and distinguishes – besides the usually undesired 1) Business-as-usual path (BAU) - between 2) a reactive path, 3) a less-is-more path, 4) a bio-adaptive consistency path and 5) a path characterized by innovative high-tech elements (Leinfelder 2014, 2016b). These pathways or "futures" can then be used to illustrate possible future everyday life settings such as energy supply, living, mobility, work, health and nutrition. In the field of nutrition, for example, the *BAU scenario* would correspond to a further increase in the consumption of meat and further extension of resource-intensive agriculture. A *reactive scenario* could include the optimization of sewage treatment plants, further end-of-pipe solutions and possibly an increase in productivity through new breeding and biotechnologies. A *sufficiency scenario* is based on local and seasonal, preferably vegetarian or even purely vegan diets, and avoids packaging and artificial fertilizers. A *bioadaptive scenario* tries to take nature as a model and redesign it. Food could be produced worldwide where this is best possible in a very resource-saving way. Energy for processing and transport would come from renewable energies, packaging would be completely compostable or even edible. Alternatively or additionally, nature's closed water and nutrient cycles could be mirrored and automated locally, e.g. by combining vegetable and fish farming (Kuhlemann 2017). In animal breeding, a switch could be made to insects, which are already consumed by two billion people and can be bred in a very resource-saving manner (Huis 2017). If this is not desirable for our culture, at least the aquaculture of carnivorous fish could be switched to insect feed. A nutritional *high-tech scenario* could include meat from the laboratory, "functional food" made of synthetic components and the 3D printer, or food production in farm scrapers in the middle of the cities, where most of the people will live anyway in the future.[13] Further examples on the subject of nutritional futures as well as other living world futures can be found in Leinfelder (2014, 2016b, 2017b) and Liebender et al. (2017).

5. Conclusions

The Anthropocene concept is a comprehensive conceptual "toolbox" for systemic analysis, interdisciplinary monitoring and a new understanding of the gigantic current impact of human activities on the Earth system. At the same time, it neither implies a fatalistic acceptance of an apocalypse, nor does it promote a simplistic "everything will be fine" positivism, but rather allows differentiated observations from different perspectives. Precisely because of its systemic and interdisciplinary approach, the concept does not narrow possible pathways for the development, propagation and application of future options. On the contrary, the Earth system sciences, social sciences, cultural studies and the humanities together and very clearly express that in order to achieve global development goals such as justice, food security, health, peace and other goals for sustainable development (SDGs) (UNSDGs 2015), we keep on needing "assessable" and predictable conditions of an Anthropocene Earth system (Steffen et al. 2016). In order not to completely switch from the relative stability of the Holocene to incalculable risks, but rather to transform the Anthropocene Earth System into a different, but permanently habitable Anthropocene, it is necessary not to exceed planetary boundaries (sensu Rockström et al. 2009, Steffen et al. 2015b) and to see the SDGs as a compass. For this purpose, continuous monitoring of the state of the Anthropocene Earth system is indispensable.

[13] From Leinfelder (2017a). For information on the future of nutrition, see also Leinfelder et al. (2016, 204f.), Krausse et al. (2017).

Only then both safe shelter spaces and a creative leeway for shaping the Anthropocene remain guaranteed. Within this framework, and depending on the region, the culture, the social requirements and the sociopolitical goals, it should be possible to negotiate very freely where the future journey should go. Necessary for that is a generally more holistic, systemic view of the integration of humankind into planetary processes, which means an integration of all societal groups, i.e. politics, science, business, administration, civil society groups and individuals. Another prerequisite is the improvement of future literacy via education in schools, universities, companies etc., with the goal to develop skills for better imagining alternate futures, depicting desirable futures, and designing solution portfolios for them.

Dichotomous "right or wrong" solutions, or even simple “silver bullet” solutions do not exist. Thus, even for "ideal-type" solution scenarios sensu Leinfelder (2014, 2016) there are not only various transitions and mixed forms, but these scenarios are even explicitly intended to generate such mixed solution portfolios. None of these ideal-type solution approaches has a fundamental advantage over the others, as they can also be implemented differently in terms of their temporality. Reactive solutions can be implemented directly in some cases, while complete recycling management and other innovative high-tech systems will only be available in the future, not only because of technical, but also of social, legal and cultural challenges. On the other hand, reactive solutions that can be quickly implemented today must not prevent the further development of complex recycling management or other high-tech systems. Mixed portfolios can also include an experimental trial character and should be open for continuous recomposing whenever new solutions become available. This will make it possible to shape the future Anthropocene in a more open, but also much more creative and innovative way.

The proclamation of the Anthropocene alone will definitely not solve any environmental and social problem of the Earth. But it would result in a strong impulse for rethinking our role as part of a single and unique Earth system, which for this very reason should not be seen as an exploitable resource, but rather as a functioning overall system, similar to a foundation. In an ideal world all nations would take on the role of trustees for the functioning of the entire Earth system (cf. WBGU 2013, Leinfelder 2017a). But even in an imperfect world it holds true that if every part of our society - from politics, business, administration, science, designers, the education system, civil society groups to the individual – would participate in the necessary “anthropocenic” transformation, we would be on the way to a future-proof Anthropocene epoch that could permanently carry, support and protect humanity. It is high time not to shy away any longer from this, but to start now with this transformative design in a creative, inclusive and future-oriented way.

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Short author CV (from original book page 233)

Prof. Dr. Reinhold Leinfelder is Professor of "Invertebrate Paleontology and Geobiology" at the Freie Universität Berlin. His teaching and research include coral reefs, geological history, the Anthropocene, future transformation and new methods of knowledge communication. After studying at the LMU Munich, he did his doctorate and habilitation at the University of Mainz. He held professorships at universities in Stuttgart, Munich and Berlin, as well as directorships for various museums and natural history collections, including the Museum für Naturkunde Berlin. From 2008-2013 he was a member of the Scientific Advisory Board of the Federal Government on Global Change (WBGU). He has been a member of the international Anthropocene Working Group since 2013. From 2012-2014 he was founding director of the Future House / Futurium, Berlin. Since 2018 he has also been a lecturer at the Institut Futur of Freie Universität. In addition to scientific publications, Leinfelder's portfolio also includes exhibitions, participatory projects and knowledge comics.
Further information: http://www.reinhold-leinfelder.de