CHAPTER 4

Humanistic Geosciences and the Planetary Human Niche

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Abstract The societal relevance and purpose of geoscience are discussed from a conceptual perspective in this chapter. It explores how people should live ethically in times of anthropogenic global change and describes the history and current state of 'human niche-building' (or 'engineering', in its broadest sense) at the planetary scale. It outlines how the Earth can be conceived as a single system, 'people included', by considering the geosphere, biosphere and 'noosphere'—a term repurposed here to denote the human agent and its socio-technological means, consisting of physical and mental artefacts. It posits Kohlberg's

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hierarchy of moral adequacy as a reference scale for assessing the maturity of human–Earth interactions, and argues for the social value of geoethical thinking in shaping public narratives about these interactions.

Keywords Geoethics · Earth system · Socio-ecological systems · Planetary human niche · Kohlberg's hierarchy of moral adequacy

The preceding chapter explored the societal context of geosciences from the perspective of daily practices. In turn, this chapter explores the societal context of geosciences from a conceptual perspective. Two fundamental questions are addressed: How should we live ethically in times of anthropogenic global change? How would geoethical thinking function as a public good?

Curious about the embedding of their professions into contemporary societies, geoscientists are inquiring into the societal contexts and ethical obligations of their activities. Curious to understand the natural dynamics of Earth, geoscientists are participating in research into local, regional and planetary socio-ecological systems that encompass perplexing features like human behaviour. Curious to understand the philosophical implications of their professions, geoscientists are questioning their education, professional experiences and responsibilities as citizens. These self-directed quests for humanistic geoscience, which were exemplified in the preceding chapters, provide preliminary insights into how humans may face 'the planetary' (Connolly 2017), that is, extending the human niche to the planetary scale (Rosol et al. 2018).

4.1 Happiness in Current Times

Inspired by Bunge (1989), it is considered that humans, driven by their quest for eudaimonia (Greek *εὐδαιμονία - eudaimonìa*: 'happiness', 'welfare', or 'human flourishing or prosperity'), have evolved as an engineering species—one that should enjoy an ethical life when building the planetary human niche in which it dwells. What contributes to a niche-builder's ethical life?

Anthropogenic global change is a consequence of the human niche-building endeavour, which combines natural and societal processes (Fressoz 2012; Bonneuil and Fressoz 2013; Ellis 2015; Fuentes 2017). Within the latter, the human agent operates in conditions of bounded or constrained rationality guided by affective and rational sense-making (Kowarsch 2016; Salvatore et al. 2018a). Constraints are, for example, the agent's psychological need to keep their worldview coherent within the cultural environment in which they operate. Rational sense-making and affective sense-making both have the function that the agent can internalise the systemic features of social life. These internalisations shape the perceptions of an individual or a group. Regarding building a human niche, intrinsic parts of social life are the concepts, explanations, justifications or institutions that frame the design of production systems or consumption patterns to support people's preferred lifestyles (Hulme 2009; Bohle 2017, 2018). The values that are juxtaposed with these concepts, explanations, justifications or institutions give the late Holocene an increasingly anthropogenic shape (Hamilton 2017).

Since prehistoric times, the biological evolution of humankind and its tool-making capacity developed alongside one another. The prehistoric and historical evolution of humankind resulted in the modification of environments to appropriate natural resources (Braje and Erlandson 2013). Overall, it appeared the right thing to do, although the justifications provided for the 'what and how' varied significantly both over time and between cultures (Purdy 2015). Abstracting across local specificities and changes over time, people use informal (traditional) and formal (conventional) norms and codes to govern the appropriation of natural resources and the related interventions into natural processes. To that end, physical objects (tools, techniques, technology, constructions, infrastructures, etc.), typical behaviour of individuals and groups, and worldviews (shared mental artefacts) are matched with each other to prescribe, in a coordinated manner, systems of production and consumption. Physical technological objects and mental artefacts are separate but interlinked entities (Jonas 1984). Throughout human history, trial and error or the copying of experiences that were perceived as better, led to consolidated practices (Henrich 2015), so that settlements and environmental conditions could be paired with norms and cultures more resilient than others to navigate challenges. When such co-evolution fails, instability of settlements, environmental change or unfitting norms and cultures may lead to the disruption of production and consumption, and ultimately endanger biological reproduction (Diamond 2005). Nowadays, having engineered industrial societies and global supply chains, favourable conditions have emerged for supporting the massive growth of the human population and its affluence (Hartwick 1998; Steffen et al. 2011a). In conjunction with these changes, the relatively steady natural environment of the Holocene seems to be coming to an end; even the cycle of glaciation may be altered (Ruddiman 2005).

As noted in the Chapter 3, to give meaning to phrasing like 'engineering industrial societies and global supply chains', the notion 'engineering' shall carry a wider sense as is found in the notions '*génie civil*' (French) or '*Ingenieurskunst*' (German). Their meaning is about developing a technological endeavour including its socio-political framing. Thus the notion 'engineering' prompts stating a general purpose, that is, for example, a system engineered to enable the production, distribution and consumption of goods and services according to agreed, even codified, practices and norms. The notion of 'engineered systems' contains what some may call the 'technosphere of physical artefacts' (Haff 2014a, b) and related thinking regarding the purpose and appropriate use of physical technological objects. Hence, wording like 'to engineer a human niche' shall denote how people configure the intersections between the (bio)geosphere and the human sphere of the arts, social interactions and the economy.

Throughout their cultural evolution, humans have innovated their knowledge of engineering and hence how to build the human niche. Within a pattern of specific societal conditions, over the past several hundred years the rate of cultural and technological innovations have increased massively (Mokyr 2016a, b). Nowadays, after roughly 200 years of industrial innovation, it is evident that people are profoundly altering the Earth system, which is currently required to sustain a population of 7 billion. Within less than one century, the number of people on Earth, the patterns of their consumption of resources and the engineering of their environments have together rapidly accelerated the human niche-building process, to the extent that it is massively altering natural planetary dynamics (Rockström et al. 2009; Palsson et al. 2013; Waters et al. 2016; Steffen et al. 2018). This process has been noticed over time, starting from early concerns in the nineteenth century (Fressoz 2012) through multiple warnings issued in recent decades, such as calls to limit growth (the 'Club of Rome' in 1972) or the Elsevier conference 'Planet under Pressure' of the International Geosphere–Biosphere Programme (Steffen et al. 2011b). These concerns gather scientists from many disciplines, including geoscience communities. In 1992, 1700 independent scientists, including most of the living Nobel laureates in the sciences, released the first 'World Scientists' Warning to Humanity'.[1] They called for restraint of environmental destruction and warned that 'a great change in our stewardship of the Earth and the life on it is required if vast human misery is to be avoided'. They signalled that 'human beings and the natural world are on a collision course' and that 'fundamental changes are urgent if we are to avoid the collision our present course will bring about'. In the recent, second Scientists' Warning (Ripple et al. 2017), the signatories highlight that 'since 1992, with the exception of stabilizing the stratospheric ozone layer, humanity has failed to make sufficient progress in generally solving these foreseen environmental challenges, and alarmingly, most of them are getting far worse'.

It is thus evident that human niche-building inscribes a history of intersecting societal and natural processes. People alter the rate of transformation (e.g., erosion) or fluxes of matter between reservoirs (e.g., carbon and nutrients) through their technological capabilities. The societal processes that relate to the development of these technological means form a composite of social, economic, cultural and political matters, which also determine how people intersect with the natural features of the planetary geosphere. By the ensemble of their shared insights, actions and interactions, people conceive both what type of economic activities shall be undertaken and how the related engineering endeavours shall be undertaken. Consequently, engineering is the activity that connects people to the geosphere. Engineering implies both constructing physical technological objects and intellectual artefacts (insights) about the 'whats, whys and hows' regarding the use of physical artefacts. Engineering these objects and artefacts requires geoscience knowledge. It has been mentioned previously that the history of stratospheric ozone–destroying substances (Wu et al. 2013; Solomon et al. 2016), their development, identification and the abatement of their emission, provides an example of such engineering of physical and intellectual artefacts, for which geoscience knowledge is paramount.

As already specified, 'geosciences' refers to a range of applied and fundamental research fields, mainly within natural sciences, as well as engineering disciplines and related commercial undertakings. Geosciences that involve technological development and applications are heavily

[1] http://www-formal.stanford.edu/jmc/progress/ucs-statement.txt. Retrieved 2018-08-06. (Archived by WebCite® at https://www.webcitation.org/61DcmWeQM).

ethically loaded, which in turn impinges on the fundamental research that underpins them (Potthast 2015; Stewart and Lewis 2017; Meller et al. 2018). Some may consider fundamental geoscience research to be ethically neutral; a view that Douglas (2009) challenges for any scientific discipline, and that seems obsolete in times of a functionally altered Holocene (Waters et al. 2016).

To differentiate ethical implications within geosciences we should remember that only in fundamental research fields is knowledge the primary goal, which in turn is expressed in laws, principles and hypotheses, possibly leading to general scientific truths. Engineering research does not pursue truth but control of engineered processes, grounded in the research and design of devices. The applied professions use known methodologies and proven technologies that are deployed to change the physical world. The geoscientist pursuing fundamental research does not have the same ethical dilemmas as the person doing engineering research, and neither of them is confronted with the dilemmas an applied professional will be faced with when using geosciences and geotechnologies to change the real world at local, regional and global scales (Srbulov 2014). However, the ethical requirements that are instilled in professionals in applied geosciences cascade through the chain of applied and engineering disciplines and ultimately are also felt in fundamental geoscience research. Going further, while fundamental research was often traditionally considered ontologically neutral, Bunge (2017) and other philosophers of science (Bernal 1939; Douglas 2009) argue that fundamental research is shaped and influenced by cultural values and norms and cannot be assumed to be politically indifferent and neutral. Matching Hamilton's (2013) arguments about researching climate engineering, Bunge (2017) argues that the facts of sciences, including physical sciences, have political relevance because they bear on the moral, social and political decisions of rational people. Consequently, geoscience knowledge is ethically loaded, including through its use cases and its mediation by geotechnologies. In summary, engineering the planetary human niche renders all geosciences ethically laden and requiring a consciously acting human agent.

4.1.1 *Perceiving Earth as One System, People Included*

What the idea of 'engineering a human niche' means for geoethical thinking can be explored further by explicitly embedding the human agent in our description of the Earth system. The following description, which uses a material-semiotic approach (Wong and Lockie 2018) and extends reflections developed in the preceding chapter, shows that ethical thinking can be modelled as an essential system feature.

In an idealised description, the natural biotic and abiotic parts of the Earth system are the biosphere and the geosphere, respectively. To account also for the human agent's socio-technological means and human sense-making, the notion 'noosphere' can be used (as it was framed in Chapter 3). As noted there, this modern interpretation of the term strips it of its traditional metaphysical meaning (Oldfield and Shaw 2006; Hamilton and Grinevald 2015) which denoted '[a] stage of evolutionary development dominated by consciousness, the mind, and interpersonal relationships'.[2]

The construct of the notions 'biosphere' and 'geosphere' uses two categories of meaning. On the one hand, these notions refer to the category of physical features of the Earth system, namely biotic and abiotic physical objects that may change in time and space. On the other hand, the same notions refer to the category of 'time/space-dependent processes' that describe the interactions of these physical objects. Albeit that they have a physical realisation, these processes also have the form of an intellectual construct (in the human mind) and symbolic representation (such as a mathematical formula). The former metaphysical definition of the noosphere does not use features like processes, physical objects and time/space-dependency. Such features will be used to redefine it. Hence, the notion 'noosphere' shall refer, first, to the ensemble of physical objects (tools, engineered systems for production and consumption, etc.) that people make. Thus the noosphere consists of an ensemble of physical technological objects, called by some the technosphere (Haff 2014a, b). Second, the notion 'noosphere' shall refer to the ensemble of intellectual artefacts (insights, etc.) of people about how to use physical objects, that is, for example, how to deploy and operate a given technology. An essential point is that these intellectual artefacts are not static, but that they evolve in time and space through the social, economic and cultural interaction of people. For example, such interactions happen when people apply their intellectual artefacts to conceive how to use a given physical object. Hence, the

[2] https://en.oxforddictionaries.com/definition/noosphere.

intellectual artefacts evolve by means of spatial and temporal processes. Thus putting the features together, the noosphere consists of both physical, technological features (objects, engineered systems, etc.) and time/space-dependent mental artefacts (ideas, insights, values, etc.) regarding how to use the technological artefacts. To word it differently, the noosphere includes both the physical objects of the technosphere and the intellectual insights of people to use them. The latter also includes social, cultural and political means and institutions. Hence, the redesigned notion 'noosphere' describes the human agent with tools and intentions, that is, the human agent with its socio-technological means. To illustrate the above, the livestock of industrial agriculture, including regulations, practices and values regarding how to treat animals, would be part of the noosphere.

Taking the geosphere, biosphere and noosphere together in this way, the Earth system can be conceived as consisting entirely of physical objects and time/space-dependent processes to describe their interactions. As a reminder—this idealised description uses three kinds of physical objects, biotic, abiotic and technological. Furthermore, the time- and space-dependent processes that describe their interactions have both a physical realisation outside the human body/brain and are an intellectual artefact inside the human brain/mind. Part of these intellectual artefacts is the ethics that the human agent applies to guide its actions. Thus, ethics are modelled as an essential system feature, and geoethical thinking concerns those intellectual artefacts that describe how to use (physical) technological objects to intersect with (physical) biotic and abiotic objects. Additionally, with reference to intellectual artefacts, geoscience has a paramount role regarding knowledge about the intersection of technological, abiotic and biotic objects. This feature of geosciences obliges geoscientists, and others who use geoscience knowledge, to act ethically, and hence to apply geoethics.

Describing the Earth system as the combined geosphere, biosphere and noosphere offers a new narrative of Earth, namely, as noted in Chapter 3, that of 'a kind of hybrid Earth, of nature injected with human will, however responsibly or irresponsibly that will may have been exercised' (Hamilton and Grinevald 2015, p. 68). Within this narrative, 'to engineer a human niche' means to use the physical objects of the technosphere to shape Earth in a manner that is guided by the ensemble of artefacts, that is, the social, cultural and political insights of people, including geoscience knowledge. Finally, how people do this is an ethical dilemma:

> *… [humans] must be judged not according to where they fall on the scale of good and evil but where they fall on the scale of care and neglect … The threat we present to the conditions of life is an expression of our agency, and any salvation can only be rooted in a radical change in how we understand and express our agency.* (Hamilton 2017, p. 150 [emphasis in the original])

4.1.2 Ethically Conditioned Stewardship

The contemporary dynamics of the Earth system exhibit a functional change compared with its past (Waters et al. 2016). This has resulted from niche-building, as humans have put in place production systems, arranged consumption patterns, shared practices and exhibited behaviours according to their understanding, values, worldviews, predispositions and preferences. As outlined in the preceding chapter, for example, this has included the building of large-scale infrastructure, such as transport and energy systems. To engineer such systems requires a double framework. The first framework accounts for the scientific and socio-technological means and socio-economic resources, while the second framework expresses what the specially engineered systems shall deliver; that is, a sort of 'engineering narrative' that provides purpose and shapes people's views of what their niche should be.

Hence, people's engineering endeavours depend on natural and technical conditions, on socio-economic means and on choices. The design, engineering and operation of a production system (or consumption pattern) is a value-driven allocation of opportunities. The engineering works that intersect people's activities and the geosphere depend as much on value systems, cultural choices and lifestyles as they do on scientific and technological choices in geosciences and engineering sciences (Kaufmann and Lee 2013).

The ongoing anthropogenic climate change is the most prominent example of the outcomes of applied geosciences and engineering, for exploration, extraction, transport, refinement and use of fuels, for example. Many other examples are available, such as the damming of rivers for hydroelectric power generation, flood management or irrigation. Hydropower plants are an example of engineering works that have huge impacts and benefits (Egré and Milewski 2002; Donia 2013; Abd-El Monsef et al. 2015). Experts, politicians and citizens vigorously appraise and contest impacts and benefits during planning, construction and operation. People use theories and facts, discuss uncertainties and hazards, and consider responsibilities and benefits for themselves, other people and future generations. These appraisals and debates (that happen within the noosphere) draw on vocational training, shared experiences, common sense, general education, affective preferences and worldviews. Although expert knowledge in geoscience and engineering is an inherent part of these processes, scientific assessments are embedded in a broader set of discourses (Aceves-Bueno et al. 2015; Cairney 2016). Furthermore, the use of resources other than scientific assessments make these appraisals even more complicated, by creating and spreading 'substitute narratives' that seem more plausible to some individuals (Salvatore et al. 2018a) and match the ethical standard adopted by those individuals (e.g., conformity with the group).

Implicit or explicit ethical considerations, using different foundations, enter the appraisals of benefits, impacts or purpose. Within them, an actor-centric virtue ethics, like the geoethics discussed in this book, has the distinguishing feature that the individual experiences, common sense, education, predispositions, preferences, worldviews, etc., of agents prevail and may lack reference to a common altruistic standard. Subsequently, to apply geosciences properly within the Earth system, it is necessary to construct reference standards to which people, organisations or institutions may adhere when they respond to ethical dilemmas.

As an example of such a construct, Kohlberg (1981), as inspired by Piaget (Murray and Hufnagel 1979), proposes a hierarchy of ethical

Table 4.1 Kohlberg's levels and stages of moral adequacy (Adapted from Kohlberg 1981)

Level	*Stage*	*Social driver*
Pre-conventional (morality is externally controlled—to avoid punishment or receive reward)	Lower	Obedience and punishment Blind egoism
	Upper	Self-interest orientation Individualism, instrumental egoism
Conventional (conformity to morality defined by society—to win the approval of others or to maintain social order)	Lower	Interpersonal accord and conformity Approval of others, social relationships
	Upper	Law and order Blind compliance, social systems
Post-conventional (morality is based on individual rights and justice—to act based on as universal as possible principles, by conviction)	Lower	Social contract orientation Agrees on common regulations
	Upper	Universal ethical principles Principled self-conscience and mutual respect

standards around a central category that he named 'societal conventions' (Table 4.1). At the 'pre-conventional levels', the primary social drivers are the silent acceptance of the rules imposed by the dominant powers. At the 'lower conventional level', the primary social drivers conform with the governing status quo, maintaining some relationships convenient to both those holding power and those conforming to this power. At the 'upper conventional level', people act mostly in compliance with law and order. At the 'lower post-conventional level', social contracts establish the rules on how to take a position. At the 'upper post-conventional level', the agent acts in line with ethical principles; they do not act to avoid punishment or to comply with conventions.

In a world operating beyond Kohlberg's 'conventional level', individuals, organisations or institutions seek to achieve a high standard of behaviour by conscious adherence to universal ethical principles. In many normal circumstances, individuals, organisations or institutions seek to follow committedly a given social contract. Such contracts may be a professional code of ethics/conduct (Marone and Marone 2014) or an international agreement (Marone and Marone 2018), to be situated at Kohlberg's 'lower post-conventional level'. Other agents may choose the 'upper conventional level', namely compliance with law and order. Hence, they are following the rules just because these are the rules that are imposed. Any formal adherence to professional rules, including formal adherence to geoethical values, falls in this category.

Currently, geoethics is conceptualised to be an actor-centric virtue ethics with various specifications as to the Kohlberg level at which an agent may operate. This positionality offers operational flexibility in a diverse world and can account for diversity of contexts, but some may argue that it runs the risk of relativism. However, this need not be the case if it is recognised that overarching values can be established and then contextualised to specific localities. The experience that was explored in Chapter 3 refers to the 'Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication',[3] agreed by FAO Member States. They set an international social contract matching Kohlberg's 'lower post-conventional level'. The guidelines support a local actor-centric virtue ethics but derive their justification of ethical claims from a more

[3] http://www.fao.org/3/a-i4356e.pdf.

general foundation as found in a human rights–based approach. Such a construct, namely aligning the foundations of the guidelines to universal principles, matches Kohlberg's 'upper post-conventional level' and may provide answers to the challenge of relativism.

A similar alignment, namely to enshrine ethical principles, self-consciousness and respect in educational foundations, is pursued by the Geoethical Promise of geoscientists (Matteucci et al. 2014; Riede et al. 2016a; Di Capua et al. 2017; Peppoloni and Di Capua 2017; Bohle and Ellis 2017). As it is constructed, the Geoethical Promise aligns as an ethical standard to Kohlberg's 'upper post-conventional level'. Hence, it should facilitate development of the capacity for a happy professional life. This happiness (eudaimonia) stems from making an essential contribution to geoscience knowledge, capabilities and skills that contemporary societies need. To achieve a happy professional life, ethical standards are needed that make geosciences operational in various societal contexts. Such standards can be found regarding utility or justice (Jax et al. 2013; Ott 2014; Hourdequin 2015). Geoethical thinking also offers geoscientists the perspective of exercising stewardship (for building the human niche) that is based on 'practical wisdom' (phronesis), rooted in the conceptual, methodological and practical spheres of geosciences. Consequently, this 'practical wisdom' may help the individual geoscientist to feel happiness (eudaimonia) (Han 2015; Lynn 2000; Rozzi et al. 2015).

4.2 Geoethical Thinking as a Public Good

It is the emerging paradigm of our present time that modern production and consumption patterns are modifying the dynamics of the Earth system. To summarise a view developed already; in this context, the term 'Anthropocene' may serve as a shorthand for the current times of anthropogenic global change, although it conceals, for example, the historical contexts. From the perspective that the ongoing massive environmental and societal changes captured by this term are conditioning the life of a global population of billions of citizens, one may argue that 'geoethical thinking' should be subsumed into more general reflections about social change, historical justice, people's sense-making and responsible citizenry. However, if it can offer a useful contribution to how people should act in times of anthropogenic global change, geoethical thinking may find its place among competing schools of thought.

4.2.1 Perceptions and Sense-Making

Following an extended period of admiration of engineering prowess and human interventions into the biosphere and geosphere from the last decades of the nineteenth century onward, today anthropogenic global change is part of a widespread perception of 'an endangered state of the globe'. That change of opinion began during the twentieth century with concerns about the state of the biosphere at regional scales (Lear 1993). Similar concerns about the biosphere had already been voiced in the eighteenth and nineteenth centuries when industrialisation started at the local scale (Fressoz 2012). The ecologist G. Hardin (1968) summarised some of these voices to raise awareness about the use of shared resources. He was inspired by the work of W. F. Lloyd (1833), who had mentioned a hypothetical dilemma about the over-use of a shared resource. Hardin's thesis has been, and continues to be, questioned (Scheiber 2018); for example, when he questions people's conscience as a means of governing the commons because it favours selfish individuals (egoistic utilitarianism) over those who are more altruistic and cooperate. If coercion, for example by socially enforced norms, fails, then even a minority of non-cooperating (free-riding) individuals may extract more than what is sustainable (Hauser et al. 2014). The actual exploitation of living and non-living marine resources from the high seas provides an excellent example of these risks (Silver et al. 2015; Campbell et al. 2016). Nevertheless, it can be shown that knowledge-based governance of shared resources is not doomed when it involves sound ethical foundations and active participation of citizens (Johnson 2003; Berkes 2006).

The cumulative choices for design and operation of contemporary production systems and consumption patterns reflect lifestyle choices, mainly of affluent people in developed countries, and their preferences and worldviews. Thus when people apply engineering sciences and geosciences to shape an economy, their actions and intentions intentionally intersect with the geosphere, which is a specific common heritage of humankind. When seen from this angle, creeping anthropogenic global change is an engineering endeavour of unprecedented complexity. At best, it is designed at a moderate Kohlberg level ('lower/upper conventional') and leaves ample space for free riding and related risks (Wilderer et al. 2013; Morton 2015; Stilgoe 2016; Boettcher and Schäfer 2017). Beyond intentional free riding, simply the diversity of values, worldviews, predispositions and preferences of people are a challenge to sound governance. Recalling discussions in the preceding chapter, scientific–technological means and socio-economic resources, values, worldviews, predispositions and preferences are essential drivers that guide decision-making processes regarding choices about what to consume and how to produce it. Within this framing, the attitudes of people towards risk, uncertainties and the perception of facts and theories differ and evolve in time and space. People's choices also vary with their social situation, for example, whether a person, their kin or their group is concerned, or whether an action is immediate, has happened, or will happen in the future. When people (or organisations/institutions) are debating opportunities, change or risks, much of the debate is about what course of action is worthwhile. Hence, it is about value-laden considerations. People (or organisations/institutions) tend to opt for what they consider as right or worthwhile in the context of their affective and rational sense-making and do not limit their considerations to concerns such as whether an action will be effective, what is important or what appropriate knowledge is required. This description is simplified, but it points not only to diversity in people's views (or those of organisations/institutions) representing a risk of disagreement but also to the risk of moral relativism. In turn, relativism opens space for moral absolutism, including fatalistic views (e.g., doomsday scenarios) or cognitive dissonance (e.g., denial), as debates about the reduction of emissions of greenhouse gases show.

These considerations indicate that, expressed in terms of Kohlberg's hierarchy of moral adequacy, the level of ethical frameworks for the design and operation of contemporary production systems and consumption patterns are habitually at an 'upper pre-conventional level' or 'lower conventional level' only. The Montreal Protocol may be the encouraging exception (Godin-Beekman 2013; Wu et al. 2013; Solomon et al. 2016), which likely was possible to achieve because of a relatively simple configuration of geoscience knowledge (atmospheric chemistry) and technological remedy (replacement of gases used in some industrial processes). The Montreal Protocol and the follow-up treaties are effectively regulating emissions of ozone-depleting substances. Regarding moral adequacy, these treaties match Kohlberg's 'lower post-conventional level' (using a social contract and agreed-upon regulations), which is a higher level of moral adequacy than is commonly found.

When facing such challenges, one may argue that geoethical thinking as part of people's ethical standards may help to identify sustainable intersections of production systems, consumption patterns and the geosphere. Likewise, geoethical thinking should facilitate development of sustainable intersections (e.g., the Montreal Protocol as an existing example and the treaties on the reduction of emissions of greenhouse gases as a challenge) that achieve an elevated level of moral adequacy.

4.2.2 Narratives and Sense-Making

People, as well as governments and regulators, share motivations for their decision-making pathways through their narratives, for example, about the purpose of actions and views about 'what is right'. Addressing their concerns depends on engaging with their narratives in relation to a given 'Earth issue' and associated behaviour that they regard as being justified. These narratives will not necessarily connect to geoscientific knowledge (Roberts 2012; Stewart and Nield 2013; Bohle et al. 2017). Regarding the frequent failure to convince people with the available scientific facts, Begon (2017) and Stewart and Lewis (2017) suggest appealing more directly to 'feelings' and hence to 'affective sense-making' (Salvatore et al. 2018b). As Bunge (1989, p. 361) says:

> Far from preaching the joyless life, we repeat the slogan 'Enjoy life and help live', and add the following unavoidable platitudes: (a) at present most people do not have the means to enjoy life, and many of those who do have them mistake the good life for the ability to buy whatever they fancy; (b) unless we alter some of our values and learn to administer wisely our resources, we shall rob our offspring of their inheritance.

To be effective, and hence to be a public good, narratives must encapsulate geoscience knowledge in a society-related context (Bohle 2015; Bohle et al. 2017).

Only recently have accounts of human–geosphere intersections been told as a historical process (Braje and Erlandson 2013; Foley et al. 2013; Smith and Zeder 2013; Chakrabarty 2015; Hamilton et al. 2015; Purdy 2015; Kunnas 2017); yet, there is a substantial corpus of climate research regarding this variant of the human–geosphere intersection. Some scholars have studied engineering history using a perspective that illustrates human–geosphere intersections, although without describing it as such (Viollet 2000). The history of engineering provides narratives relating to the different paradigms that have framed intersections of the activities of humans with abiotic, biotic and cultural environments. European examples are the initial spread of agriculture, through medieval deforestation to contemporary urbanised societies (Ellis et al. 2013; Ramirez and Seco 2012). Over recent centuries, the record of scholarly study shows both the appraisal of engineering works and concerns at the state of flora and fauna impacted by these works (Wilderer et al. 2013; Halbe et al. 2015; Murphy et al. 2015; Purdy 2015). By comparison, telling the history of the intersections of human activities with the geosphere is quite a recent subject (Chakrabarty 2009, 2015; Steffen et al. 2011a; Braje 2015; Uhrqvist and Linnér 2015), apart from stories about weather and climate change (Sirocko 2012; Elandson and Braje 2013; Riede et al. 2016a, b). Beyond the question of what corpus of studies or practical examples should be used, narratives about how to 'engineer a human niche' (at a global scale) must tackle several difficult issues (Wilderer et al. 2013; Fox and Chapman 2011).

The Earth system's dynamics are non-linear, with multiple and interlocking feedback loops that lead to counter-intuitive system behaviour. Consequently, the value-driven and perception-laden conception, planning and operation of engineered systems are complex adaptive problems. Problem handling must therefore be iterative, path-dependent, participatory and open-ended (Termeer et al. 2016; Preiser et al. 2018). An elaborate set of interacting features shape the decision-making process in an Earth system that consists of a volatile global economy coupled to the biogeosphere and a vast diversity of worldviews, socio-cultural features and affective preferences. Therefore publicly acceptable messages will be needed regarding how to handle ethical dilemmas, such as how to cope with conflicting values or an uneven distribution of hazards, how to manage inclusion, participation, benefits, or challenges to individual lifestyles and basic needs, or how to assist people or states, for example, in the case of relocating people from flooded coastal zones.

Considering the issues sketched above, geoethical thinking may contribute to shaping public narratives about matters such as managing knowledge, shaping intentions, justifying choices, and handling complexity.

Managing knowledge For people to understand anthropogenic global change processes, decision-makers and scientists should package knowledge in such a way that it fosters public understanding of how human–geosphere intersections function (Wright et al. 2018). Insights are formed (processed) in the noosphere by means of interactions between people, hence, participatory processes and governance schemes should be used. Understanding how human–geosphere intersections function combines scientific, engineering, social and economic studies with studies of the dynamics of the noosphere.

Shaping intentions Over the past century, anthropogenic global change has developed as the collateral outcome of humankind's accumulated actions (Sklair 2017). The number of people, the patterns of their consumption of resources, mainly by those who are affluent, and the alterations of natural environments have caused it. Nowadays, anthropogenic global change is either intentional negligence or a conscious act of any person with some Earth science literacy.

Justifying choices Humanity has alternatives as to how to consciously alter the Earth system at the planetary scale (Bohle 2017). One choice is whether to alter the geosphere (e.g., geoengineering) or to adjust system features of the noosphere (e.g., modify lifestyles). Whatever option is chosen, it will depend on people's worldviews, cultures and preferences. Thus beyond issues of whether science and technology are sound, there are overarching societal issues to tackle, such as how to govern appropriation and distribution of (material and immaterial) georesources; at what cost (or benefits) and for whom; what are the intended collateral effects; or what is the risk of the unintended collateral effects?

Handling complexity Consciously altering Earth at the planetary scale is ambitious, although it fits well into the historical development of industrialised societies and their paradigms of how to handle change (Preiser et al. 2017). Still, action at the planetary scale goes beyond any existing use case that may serve as a point of reference. Furthermore, the available technological means, scientific understanding and resources impose limits. In addition, the related noosphere is complex, given the variety of interacting worldviews, cultures and preferences, and the necessary participation of citizenries in decision-making.

If geoethical thinking can address issues like those listed above, then geoethics may evolve into a kind of 'crisis discipline' (Begon 2017).

4.3 Beyond Geoethical Thinking

As shown in the preceding sections, driven by curiosity, motivated by the multiple interfaces of geosciences and society, and incentivised by a diversity of inquiries into the intersections of the noosphere and the geosphere, the scope of matters that could be addressed meaningfully through 'geoethical thinking' is broad. Evidently, 'geoethical thinking' has border zones with thinking that are influenced by 'environmental ethics' or 'sustainability ethics'. As acknowledged, these border zones are permeable and not well-defined, and, at first sight, their demarcation may seem of little practical concern. Nevertheless, so that they can be identified and distinguished, the matters that belong to these border zones would benefit from having a dedicated name.

Conceivably, to nurture the interface between geosciences and humanities, a notion such as 'humanistic geosciences' (Mouchang 2011) or 'geo-humanities' could be used; although the latter notion is already used by geographers (including as the name of a journal). Within such an extended scope for geoethical thinking, geoethics may be characterised specifically as an actor-centric virtue ethic, which has the abiotic (inanimate) world as the object of its concern. It remains to be debated whether geoethics defined in such a way should apply only to geo-professions, to any professions contributing to niche-building (including citizen science) or to all citizens living in the human niche—a debate which is returned to in Chapter 5. However, the current definition of geoethics (see Chapter 1) states it 'consists of research and reflection on the values that underpin appropriate behaviours and practices, wherever human activities interact with the Earth system'. Hence, geoethics is relevant to any citizen, although as previously noted, the focus hitherto has been on geo-professionals.

Seeking a notion complementary to geoethics may be premature, because it remains to be debated how geoethical thinking founded on another ethical basis than an actor-centric virtue ethic would shape the border zones with environmental ethics or sustainability ethics. Irrespective of the outcome of such a debate, however, it may be helpful to seek a term to label the study of human–geosphere intersections other than in respect of ethical considerations.

A candidate notion could be geosophy. The 'candidature' would revive ideas discussed by Wright (1947) that were reassessed by Keighren (2005, 2017). The notion of ecosophical geography, which Shaw (2017, p. 140) proposed as a 'reconceptualisation of the human–earth relationship by paying the same attention to the "earth-body" as we have to humanity', is an inspiration to use the term geosophy. Hence, geosophy would address societal and natural processes within a shared frame of reference, to understand how attributes of the biogeosphere and technological objects of the noosphere are aggregated to shape anthropogenic global change. Slightly adjusting the wording (e.g., substituting 'geoscience' for 'geography') of J. K. Wright (1947, p. 10) in his presidential address to the 43rd annual meeting of the American Association of Geographers, the meaning of geosophy is outlined:

> My term is Geosophy, compounded from geo meaning "earth" and sophia meaning [wisdom]… Geosophy, to repeat, is the study of [geoscience] knowledge from any or all points of view … Thus, it extends far beyond the core area of scientific [geoscience] knowledge or of [geoscience] knowledge as otherwise systematised by [geoscientists]. Taking into account the whole peripheral realm, it covers the [geoscience] ideas, both true and false, of all manner of people – not only [geoscientists], but farmers and fishermen, business executives and poets, novelists and painters, Bedouins and Hottentots – and for this reason it necessarily has to do in large degree with subjective conceptions. Indeed, even those parts of it that deal with [geoscience] must reckon with human desires, motives, and prejudices, for unless I am mistaken, nowhere are [geoscientists] more likely to be influenced by the subjective than in their discussions of what [geoscience] is and ought to be.

In the face of a 'defiant Earth' (Hamilton 2017), the meaning of geosophy could evolve by encompassing various threads of inquiry to gather insights from any crisis discipline (Begon 2017). Keeping the original spirit (Wright 1947) and borrowing meaning derived from Shaw (2017), geosophy might bundle threads of inquiry from the three cultures, natural sciences, social sciences and the humanities (Kagan 2009). To this end, geosophy would inquire into the engineering of the human niche. These inquiries would consider jointly the natural features of the Earth system, the physical objects of the techno-sociosphere, the related ensemble of social, cultural and political insights of people (artefacts), as well as people's shared subjective mental artefacts about the Earth system. Hence, geosophy would gather the cognitive bases, so that citizenries may ethically enjoy the bio-/geo-/noospheres of Earth and be empowered to conserve, unravel or change them consciously and responsibly; and hence, to behave ethically.

References

Abd-El Monsef, H., Smith, S. E., & Darwish, K. (2015). Impacts of the Aswan High Dam After 50 Years. *Water Resources Management, 29*(6), 1873–1885. https://doi.org/10.1007/s11269-015-0916-z.

Aceves-Bueno, E., Adeleye, A. S., Bradley, D., Tyler Brandt, W., Callery, P., Feraud, M., et al. (2015). Citizen Science as an Approach for Overcoming Insufficient Monitoring and Inadequate Stakeholder Buy-in in Adaptive Management: Criteria and Evidence. *Ecosystems, 18*(3), 493–506. https://doi.org/10.1007/s10021-015-9842-4.

Begon, M. (2017). Mike Begon: Winning Public Arguments as Ecologists: Time for a New Doctrine? *Trends in Ecology & Evolution, 32*(6), 394–396. https://doi.org/10.1016/j.tree.2017.03.009.

Berkes, F. (2006). From Community-Based Resource Management to Complex Systems: The Scale Issue and Marine Commons. *Ecology and Society, 11*(1), 45. https://doi.org/10.5751/ES-01431-110145.

Bernal, J. D. (1939). *The Social Function of Science* (482pp.). London: George Routledge & Sons. https://archive.org/details/in.ernet.dli.2015.188098.

Boettcher, M., & Schäfer, S. (2017). Reflecting upon 10 Years of Geoengineering. Research: Introduction to the Crutzen + 10 Special Issue. *Earth's Future*, *5*, 266–277. https://doi.org/10.1002/2016EF000521.

Bohle, M. (2015). Simple Geoethics: An Essay on Daily Earth Science. In *Geoethics: The Role and Responsibility of Geoscientists* (pp. 5–12). Geological Society of London, Special Publications 419. https://doi.org/10.1144/SP419.3.

Bohle, M. (2017). Ideal-Type Narratives for Engineering a Human Niche. *Geosciences, 7*(1), 18. https://doi.org/10.3390/geosciences7010018.

Bohle, M. (2018). One Realm: Thinking Geoethically and Guiding Small-Scale Fisheries? *The European Journal of Development Research*, 1–39. https://doi.org/10.1057/s41287-018-0146-3.

Bohle, M., & Ellis, E. C. (2017). Furthering Ethical Requirements for Applied Earth Science. In *Geoethics at the Heart of All Geoscience. Annals of Geophysics, 60*(7). https://doi.org/10.4401/ag-7401.

Bohle, M., Sibilla, A., & Casals I Graels, R. (2017). A Concept of Society-Earth-Centric Narratives. In *Geoethics at the Heart of All Geoscience. Annals of Geophysics, 60*(7). https://doi.org/10.4401/ag-7358.

Bonneuil, C., & Fressoz, J.-B. (2013). *L'événement Anthropocène - La terre, l'histoire et nous* (320pp.). Le Seuil. ISBN 978-2021135008.

Braje, T. J. (2015). Earth Systems, Human Agency, and the Anthropocene: Planet Earth in the Human Age. *Journal of Archaeological Research, 23*(4), 369–396. https://doi.org/10.1007/s10814-015-9087-y.

Braje, T. J., & Erlandson, J. M. (2013). Looking Forward, Looking Back: Humans, Anthropogenic Change, and the Anthropocene. *Anthropocene, 4,* 116–121. https://doi.org/10.1016/j.ancene.2014.05.002.

Bunge, M. A. (1989). *Treaties on Basic Philosophy—Ethics: The Good and the Right* (Vol. 8, XVI, 428pp.). Dordrecht, The Netherlands: Springer. ISBN 978-94-009-2601-1.

Bunge, M. A. (2017). *Doing Science: In the Light of Philosophy* (244pp.). Singapore: World Scientific. ISBN 978-9813202764. https://doi.org/10.1142/10333.

Cairney, P. (2016). *The Politics of Evidence-Based Policy Making*. London: Palgrave Pivot. ISBN 978-1-137-51780-7. https://doi.org/10.1057/978-1-137-51781-4.

Campbell, L. M., Gray, N. J., Fairbanks, L., Silver, J. J., Gruby, R. L., Dubik, B. A., et al. (2016). Global Oceans Governance: New and Emerging Issues. *Annual Review of Environment and Resources, 41*(1), 517–543. https://doi.org/10.1146/annurev-environ-102014-021121.

Chakrabarty, D. (2009). The Climate of History: Four Theses. *Critical Inquiry, 35*(2), 197–222. https://doi.org/10.1086/596640.

Chakrabarty, D. (2015). The Anthropocene and the Convergence of Histories. In *The Anthropocene and the Global Environmental Crisis: Rethinking Modernity in a New Epoch* (pp. 32–43). London: Routledge.

Connolly, W. E. (2017). *Facing the Planetary: Entangled Humanism and the Politics of Swarming* (240pp.). Durham: Duke University Press Books. ISBN 978-0822363415.

Di Capua, G., Peppoloni, S., & Bobrowsky, P. T. (2017). The Cape Town Statement on Geoethics. In *Geoethics at the Heart of All Geoscience. Annals of Geophysics, 60*(7). https://doi.org/10.4401/ag-7553.

Diamond, J. (2005). *Collapse: How Societies Choose to Fail or Succeed [Survive]* (608pp.). New York: Viking Penguin. ISBN 978-0241958681 (Reprint Edition in 2011).

Donia, N. (2013). Aswan High Dam Reservoir Management System. *Journal of Hydroinformatics, 15*(4), 1491–1510. https://doi.org/10.2166/hydro.2013.003.

Douglas, H. (2009). *Science, Policy, and the Value-Free Ideal* (256pp.). Pittsburgh, PA: University of Pittsburgh Press. ISBN 978-0822960263.

Egré, D., & Milewski, J. C. (2002). The Diversity of Hydropower Projects. *Energy Policy, 30*(14), 1225–1230. https://doi.org/10.1016/S0301-4215(02)00083-6.

Ellis, E. C. (2015). Ecology in an Anthropogenic Biosphere. *Ecological Monographs, 85*(3), 287–331. https://doi.org/10.1890/14-2274.1.

Ellis, E. C., Kaplan, J. O., Fuller, D. Q., Vavrus, S., Klein Goldewijk, K., & Verburg, P. H. (2013). Used Planet: A Global History. *Proceedings of the National Academy of Sciences, 110*(20), 7978–7985. https://doi.org/10.1073/pnas.1217241110.

Erlandson, J. M., & Braje, T. J. (2013). Archeology and the Anthropocene. *Anthropocene, 4*, 1–7. https://doi.org/10.1016/j.ancene.2014.05.003.

Foley, S. F., Gronenborn, D., Andreae, M. O., Kadereit, J. W., Esper, J., Scholz, D., et al. (2013). The Palaeoanthropocene—The Beginnings of Anthropogenic Environmental Change. *Anthropocene*, *3*, 83–88. https://doi.org/10.1016/j.ancene.2013.11.002.

Fox, T. A., & Chapman, L. (2011). Engineering Geo-Engineering. *Meteorological Applications, 18*(1), 1–8. https://doi.org/10.1002/met.245.

Fressoz, J.-B. (2012). *L'Apocalypse joyeuse - Une histoire du risque technologique* (320pp.). L'univers historique/Le Seuil. ISBN 978-2021056983.

Fuentes, A. (2017). Human Niche, Human Behaviour, Human Nature. *Interface Focus, 7*(5), 20160136. https://doi.org/10.1098/rsfs.2016.0136.

Godin-Beekmann, S. (2013). Évolution de la couche d'ozone sous l'effet du protocole de Montréal et du changement climatique. *La Météorologie, 80,* 59–66. https://doi.org/10.4267/2042/48795.

Haff, P. K. (2014a). Humans and Technology in the Anthropocene: Six Rules. *The Anthropocene Review*, *1*(2), 126–136. https://doi.org/10.1177/2053019614530575.

Haff, P. K. (2014b). Technology as a Geological Phenomenon: Implications for Human Well-Being. In *A Stratigraphical Basis for the Anthropocene* (pp. 301–309). Geological Society of London, Special Publications 395. https://doi.org/10.1144/SP395.4.

Halbe, J., Adamowski, J., & Pahl-Wostl, C. (2015). The Role of Paradigms in Engineering Practice and Education for Sustainable Development. *Journal of Cleaner Production, 106*, 272–282. https://doi.org/10.1016/j.jclepro.2015.01.093.

Hamilton, C. (2013). No, We Should Not Just 'At Least Do the Research'. *Nature*, *496*(7444), 139. https://doi.org/10.1038/496139a.

Hamilton, C. (2017). *Defiant Earth—The Fate of Humans in the Anthropocene* (200pp.). Cambridge: Wiley, Polity Press. ISBN 978-1509519750.

Hamilton, C., & Grinevald, J. (2015). Was the Anthropocene Anticipated? *The Anthropocene Review, 2*(1), 59–72. https://doi.org/10.1177/2053019614567155.

Hamilton, C., Bonneuil, C., & Gemenne, F. (2015). Thinking the Anthropocene. In *The Anthropocene and the Global Environmental Crisis: Rethinking Modernity in a New Epoch* (pp. 1–13). London: Routledge. ISBN 978-1138821231.

Han, H. (2015). Virtue Ethics, Positive Psychology, and a New Model of Science and Engineering Ethics Education. *Science and Engineering Ethics, 21*(2), 441–460. https://doi.org/10.1007/s11948-014-9539-7.

Hardin, G. (1968). The Tragedy of the Commons. *Science, 162*(3859), 1243–1248. https://doi.org/10.1126/science.162.3859.1243.

Hartwick, E. (1998). Geographies of Consumption: A Commodity-Chain Approach. *Environment and Planning D: Society and Space, 16*(4), 423–437. https://doi.org/10.1068/d160423.

Hauser, O. P., Rand, D. G., Peysakhovich, A., & Nowak, M. A. (2014). Cooperating with the Future. *Nature, 511*, 220–223. https://doi.org/10.1038/nature13530.

Henrich, J. (2015). *The Secret of Our Success: How Culture Is Driving Human Evolution, Domesticating Our Species, and Making Us Smarter* (445pp.). Princeton: Princeton University Press. ISBN 978-0691166858.

Hourdequin, M. (2015). *Environmental Ethics—From Theory to Practice* (pp. 256). London: Bloomsbury Academic. ISBN 9781472510983.

Hulme, M. (2009). *Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity* (428pp.). Cambridge: Cambridge University Press. ISBN 978-0521727327.

Jax, K., Barton, D. N., Chan, K. M. A., de Groot, R., Doyle, U., Eser, U., et al. (2013). Ecosystem Services and Ethics. *Ecological Economics, 93*, 260–268. https://doi.org/10.1016/j.ecolecon.2013.06.008.

Johnson, B. L. (2003). Ethical Obligations in a Tragedy of the Commons. *Environmental Values, 12*(3), 271–287. https://www.jstor.org/stable/30301928.

Jonas, H. (1984). The Imperative of Responsibility (263pp.). Chicago: University of Chicago Press. ISBN 0-226-40597-4.

Kagan, J. (2009). *The Three Cultures—Natural Sciences, Social Sciences and the Humanities in the 21st Century*. Cambridge: Cambridge University Press.

Kauffman, J., & Lee, K.-M. (Eds.). (2013). *Handbook of Sustainable Engineering* (1298pp.). Dordrecht, The Netherlands: Springer. ISBN 978-1-4020-8938-1.

Keighren, I. M. (2005). Geosophy, Imagination, and Terrae Incognitae: Exploring the Intellectual History of John Kirtland Wright. *Journal of Historical Geography, 31*(3), 546–562. https://doi.org/10.1016/j.jhg.2004.04.004.

Keighren, I. M. (2017). History and Philosophy of Geography I. *Progress in Human Geography, 41*(5), 638–647. https://doi.org/10.1177/0309132516653285.

Kohlberg, L. (1981). *The Philosophy of Moral Development: Moral Stages and the Idea of Justice* (441pp.). San Francisco: Harper & Row. ISBN 978-0060647605.

Kowarsch, M. (2016). *A Pragmatist Orientation for the Social Sciences in Climate Policy* (Vol. 323). Cham: Springer. ISBN 978-3-319-43279-3. https://doi.org/10.1007/978-3-319-43281-6.

Kunnas, J. (2017). Storytelling: From the Early Anthropocene to the Good or the Bad Anthropocene. *The Anthropocene Review, 4*(2), 136–150. https://doi.org/10.1177/2053019617725538.

Lear, L. J. (1993). Rachel Carson's Silent Spring. *Environmental History Review, 17*(2), 23–48. https://doi.org/10.2307/3984849.
Lloyd, W. F. (1833). *Two Lectures on the Checks of Population*. Oxford: Oxford University Press. http://philosophy.lander.edu/intro/articles/lloyd_commons.pdf.
Lynn, W. S. (2000). *Geoethics: Ethics, Geography and Moral Understanding* (Dissertation). University of Minnesota, Minnesota. http://philpapers.org/rec/LYNGEG.
Marone, E., & Marone, L. (2014). A Road Map for a Deontological Code for Geoscientists Dealing with Natural Hazards. In *Engineering Geology for Society and Territory—Volume 7, Education, Professional Ethics and Public Recognition of Engineering Geology* (pp. 45–48). Cham: Springer. https://doi.org/10.1007/978-3-319-09303-1_8.
Marone, E., & Marone, L. (2018). UNCLOS Framework of Ocean Governance: Ethical Dimensions. In *The Future of Ocean Governance and Capacity Development Essays in Honor of Elisabeth Mann Borgese (1918-2002)* (pp. 34–39). Halifax: International Ocean Institute-Canada. https://doi.org/10.1163/9789004380271_008.
Matteucci, R., Gosso, G., Peppoloni, S., Piacente, S., & Wasowski, J. (2014). The "Geoethical Promise": A Proposal. *Episodes*, *37*(3), 190–191.
Meller, C., Schill, E., Bremer, J., Kolditz, O., Bleicher, A., Benighaus, C., et al. (2018). Acceptability of Geothermal Installations: A Geoethical Concept for GeoLaB. *Geothermics, 73,* 133–145. https://doi.org/10.1016/j.geothermics.2017.07.008.
Mokyr, J. (2016a). Institutions and the Origins of the Great Enrichment. *Atlantic Economic Journal, 44*(2), 243–259. https://doi.org/10.1007/s11293-016-9496-4.
Mokyr, J. (2016b). *A Culture of Growth: The Origins of the Modern Economy* (400pp.). Princeton: Princeton University Press. ISBN 978-0691168883.
Morton, O. (2015). *The Planet Remade—How Geoengineering Could Change the World* (440pp.). Princeton: Princeton University Press. ISBN 978-0691148250.
Mouchang, Y. U. (2011). Geoscience Ethics: Turn of Geoscience Towards Humanism. *Journal of Shanghai Normal University (Philosophy & Social Sciences), 2011*(3), 5–16.
Murphy, C., Gardoni, P., Bashir, H., Harris, C. E., & Masad, E. (2015). *Engineering Ethics for a Globalized World*. Part of the Philosophy of Engineering and Technology Book Series (POET, Vol. 22). Cham: Springer International Publishing. ISBN 978-3-319-18259-9. https://doi.org/10.1007/978-3-319-18260-5.
Murray, F. B., & Hufnagel, P. (1979). Review: Gruber, H. E., & Vonèche, J. (1977). The Essential Piaget. *Educational Researcher*, *8*(11), 20–21. https://doi.org/10.2307/1174291.

Oldfield, J. D., & Shaw, D. J. B. (2006). V.I. Vernadsky and the Noosphere Concept: Russian Understandings of Society-Nature Interaction. *Geoforum, 37*(1), 145–154. https://doi.org/10.1016/j.geoforum.2005.01.004.

Ott, K. (2014). Institutionalizing Strong Sustainability: A Rawlsian Perspective. *Sustainability, 6*(2), 894–912. https://doi.org/10.3390/su6020894.

Palsson, G., Szerszynski, B., Sörlin, S., Marks, J., Avril, B., Crumley, C., et al. (2013). Reconceptualizing the 'Anthropos' in the Anthropocene: Integrating the Social Sciences and Humanities in Global Environmental Change Research. *Environmental Science & Policy, 28,* 3–13. https://doi.org/10.1016/j.envsci.2012.11.004.

Peppoloni, S., & Di Capua, G. (2017). Geoethics: Ethical, Social and Cultural Implications in Geosciences. In *Geoethics at the Heart of All Geoscience. Annals of Geophysics, 60*(7). https://doi.org/10.4401/ag-7473.

Potthast, T. (2015). Toward an Inclusive Geoethics—Commonalities of Ethics in Technology, Science, Business, and Environment. In *Geoethics: Ethical Challenges and Case Studies in Earth Sciences* (pp. 49–56), Amsterdam: Elsevier. https://doi.org/10.1016/B978-0-12-799935-7.00005-8.

Preiser, R., Biggs, R., De Vos, A., & Folke, C. (2018). Social-Ecological Systems as Complex Adaptive Systems: Organizing Principles for Advancing Research Methods and Approaches. *Ecology and Society, 23*(4), 46. https://doi.org/10.5751/ES-10558-230446.

Preiser, R., Pereira, L. M., Biggs, R., & (Oonise). (2017). Navigating Alternative Framings of Human-Environment Interactions: Variations on the Theme of 'Finding Nemo'. *Anthropocene, 20,* 83–87. https://doi.org/10.1016/j.ancene.2017.10.003.

Purdy, J. (2015). *After Nature: A Politics for the Anthropocene* (326pp.). Cambridge, MA: Harvard University Press. ISBN 978-0674368224.

Ramírez, F., & Seco, A. (2012). Civil Engineering at the Crossroads in the Twenty-First Century. *Science and Engineering Ethics, 18*(4), 681–687. https://doi.org/10.1007/s11948-011-9258-2.

Riede, F., Andersen, P., & Price, N. (2016a). Does Environmental Archaeology Need an Ethical Promise? *World Archaeology, 48*(4), 466–481. https://doi.org/10.1080/00438243.2016.1192483.

Riede, F., Vestergaard, C., & Fredensborg, K. H. (2016b). A Field Archaeological Perspective on the Anthropocene. *Antiquity, 90*(354), e7. https://doi.org/10.15184/aqy.2016.183.

Ripple, W. J., Wolf, C., Newsome, T. M., Galetti, M., Alamgir, M., Crist, E., et al. & 15,364 Scientists Signatories from 184 Countries. (2017). World Scientists' Warning to Humanity: A Second Notice. *BioScience, 67*(12), 1026–1028. https://doi.org/10.1093/biosci/bix125.

Roberts, R. (2012). Narrative Ethics. *Philosophy Compass, 7*(3), 174–182. https://doi.org/10.1111/j.1747-9991.2011.00472.x.

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin III, F. S., Lambin, E. F., et al. (2009). A Safe Operating Space for Humanity. *Nature, 461*, 472–475. https://doi.org/10.1038/461472a.

Rosol, C., Steininger, B., Renn, J., & Schlögl, R. (2018). On the Age of Computation in the Epoch of Humankind. *Nature Outlook,* 1–5. https://www.nature.com/articles/d42473-018-00286-8.

Rozzi, R., Chapin III, F. S., Callicott, J. B., Pickett, S. T. A., Power, M. E., Armesto, J. J., et al. (Eds.). (2015). *Earth Stewardship: Linking Ecology and Ethics in Theory and Practice* (Vol. 2). Cham: Springer. ISBN 978-3-319-12132-1. https://doi.org/10.1007/978-3-319-12133-8.

Ruddiman, W. F. (2005). How Did Humans First Alter Global Climate? *Scientific American, 292*(3), 46–53. https://doi.org/10.1038/scientificamerican0305-46.

Salvatore, S., Fini, V., Mannarini, T., Veltri, G. A., Avdi, E., Battaglia, F., et al. (2018a). Symbolic Universes Between Present and Future of Europe. First Results of the Map of European Societies' Cultural Milieu. *PLoS One, 13*(1), e0189885. https://doi.org/10.1371/journal.pone.0189885.

Salvatore, S., Mannarini, T., Avdi, E., Battaglia, F., Cremaschi, M., Fini, et al. (2018b). Globalization, Demand of Sense and Enemization of the Other: A Psychocultural Analysis of European Societies' Sociopolitical Crisis. *Culture and Psychology*. https://doi.org/10.1177/1354067X18779056.

Scheiber, H. N. (2018). The "Commons" Discourse on Marine Fisheries Resources: Another Antecedent to Hardin's "Tragedy". *Theoretical Inquiries in Law, 19*(2), 489–505. https://doi.org/10.1515/til-2018-0025.

Shaw, R. (2017). Knowing Homes and Writing Worlds? Ethics of the 'Eco-', Ethics of the 'Geo-' and How to Light a Planet. *Geografiska Annaler: Series B, Human Geography, 99*(2), 128–142. https://doi.org/10.1080/04353684.2017.1311469.

Silver, J. J., Gray, N. J., Campbell, L. M., Fairbanks, L. W., & Gruby, R. L. (2015). Blue Economy and Competing Discourses in International Oceans Governance. *The Journal of Environment & Development, 24*(2), 135–160. https://doi.org/10.1177/1070496515580797.

Sirocko, F. (2012). *Wetter, Klima, Menschheitsentwicklung: Von der Eiszeit bis ins 21. Jahrhundert* (pp. 208). (Buchgesellschaft thesis). Wiss, Darmstadt. ISBN 978-3534255207.

Sklair, L. (2017). Sleepwalking Through the Anthropocene. *The British Journal of Sociology, 68*(4), 775–784. https://doi.org/10.1111/1468-4446.12304.

Smith, B. D., & Zeder, M. A. (2013). The Onset of the Anthropocene. *Anthropocene, 4,* 8–13. https://doi.org/10.1016/j.ancene.2013.05.001.

Solomon, S., Ivy, D. J., Kinnison, D., Mills, M. J., Neely, R. R., & Schmidt, A. (2016). Emergence of Healing in the Antarctic Ozone Layer. *Science, 353*(6296), 269–274. https://doi.org/10.1126/science.aae0061.

Srbulov, M. (2014). *Practical Guide to Geo-Engineering: With Equations, Tables, Graphs and Check Lists* (370pp.). Part of the Geotechnical, Geological and Earthquake Engineering Book Series (GGEE, Vol. 29). Dordrecht, Netherlands: Springer. ISBN 978-94-017-8637-9.

Steffen, W., Grinevald, J., Crutzen, P., & McNeill, J. (2011a). The Anthropocene: Conceptual and Historical Perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 369*(1938), 842–867. https://doi.org/10.1098/rsta.2010.0327.

Steffen, W., Persson, Å., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., et al. (2011b). The Anthropocene: From Global Change to Planetary Stewardship. *Ambio, 40,* 739–761. https://doi.org/10.1007/s13280-011-0185-x.

Steffen, W., Rockström, J., Richardson, K., Lenton, T. M., Folke, C., Liverman, D., et al. (2018). Trajectories of the Earth System in the Anthropocene. *Proceedings of the National Academy of Sciences, 115*(33), 8252–8259. https://doi.org/10.1073/pnas.1810141115.

Stewart, I. S., & Nield, T. (2013). Earth Stories: Context and Narrative in the Communication of Popular Geoscience. *Proceedings of the Geologists' Association, 124*(4), 699–712. https://doi.org/10.1016/j.pgeola.2012.08.008.

Stewart, I. S., & Lewis, D. (2017). Communicating Contested Geoscience to the Public: Moving from 'Matters of Fact' to 'Matters of Concern'. *Earth-Science Reviews, 174,* 122–133. https://doi.org/10.1016/j.earscirev.2017.09.003.

Stilgoe, J. (2016). Geoengineering as Collective Experimentation. *Science and Engineering Ethics, 22*(3), 851–869. https://doi.org/10.1007/s11948-015-9646-0.

Termeer, C. J. A. M., Dewulf, A., Karlsson-Vinkhuyzen, S. I., Vink, M., & van Vliet, M. (2016). Coping with the Wicked Problem of Climate Adaptation Across Scales: The Five R Governance Capabilities. *Landscape and Urban Planning, 154,* 11–19. https://doi.org/10.1016/j.landurbplan.2016.01.007.

Uhrqvist, O., & Linnér, B.-O. (2015). Narratives of the Past for Future Earth: The Historiography of Global Environmental Change Research. *The Anthropocene Review, 2*(2), 159–173. https://doi.org/10.1177/2053019614567543.

Viollet, P.-L. (2000). *L'hydraulique dans les civilisations anciennes: 5000 ans d'histoire* (374pp.). Paria: Presses Ponts et Chaussées. ISBN 2-85978-335-0.

Waters, C. N., Zalasiewicz, J., Summerhayes, C., Barnosky, A. D., Poirier, C., Galuszka, A., et al. (2016). The Anthropocene Is Functionally and Stratigraphically Distinct from the Holocene. *Science*, *351*(6269), aad2622. https://doi.org/10.1126/science.aad2622.

Wilderer, P. A., Grambow, M., Meng, W. (2013). Sustainable Earth System Engineering: Incentives and Perspectives. In *Handbook of Sustainable Engineering* (pp. 195–209). Dordrecht, The Netherlands: Springer. https://doi.org/10.1007/978-1-4020-8939-8_47.

Wong, C. M. L., & Lockie, S. (2018). Sociology, Risk and the Environment: A Material-Semiotic Approach. *Journal of Risk Research, 21*(9), 1077–1092. https://doi.org/10.1080/13669877.2017.1422783.

Wright, J. K. (1947). Terrae Incognitae: The Place of the Imagination in Geography. *Annals of the Association of American Geographers, 37*(1), 1–15.

Wright, C., Nyberg, D., Rickards, L., & Freund, J. (2018). Organizing in the Anthropocene. *Organization, 25*(4), 455–471. https://doi.org/10.1177/1350508418779649.

Wu, Y., Polvani, L. M., & Seager, R. (2013). The Importance of the Montreal Protocol in Protecting Earth's Hydroclimate. *Journal of Climate, 26*(12), 4049–4068. https://doi.org/10.1175/JCLI-D-12-00675.1.