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Exploring Geoethics

Ethical Implications, Societal Contexts, and Professional Obligations of the Geosciences

Edited by

Martin Bohle

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Preface

This pivotal book presents the field of geoethics and analyses its potential and limitations. The six co-authors, who offer more than an assemblage of their individual views, are practitioners and researchers in geoscience and related disciplines, with diverse educational backgrounds and professional experiences.

This work is aimed at a readership that comprises scholars, researchers, practitioners and students within and beyond geosciences who are interested in how ethical subjects relate to professional duties, scholarly interests, activities in professional geoscience associations or responsible citizenship in times of anthropogenic global change. Furthermore, the authors hope that by offering this pivotal work, they can reach out to scholarly communities and practitioners in social sciences, political sciences and humanities. Such collaboration will be of substantial value to geosciences, including geoethics, as well as to society by addressing some of the fundamental challenges now facing humankind.

This book makes a contribution to debates about the responsible conduct of science with particular reference to geosciences. Within the last decade, some geoscientists have shaped the notion of geoethics to consolidate inquiries into two subjects, namely (1) the responsible behaviour of professionals in geosciences and (2) the societal relevance of geosciences. These inquiries have led them to explore more fully the societal, cultural and philosophical implications of geoscience knowledge, research, practice, education and communication. Anchored initially in the geological disciplines, these inquiries have since extended into some other geosciences and have also started to engage with social sciences and humanities. Thinking about the applications of geoethics serves as a prompt to consider broader concerns, like how to better communicate across the science–society interface.

This book makes an effort to consolidate an emerging field. In less than a decade, numerous contributions have been made to the field of geoethics, through peer-reviewed journal articles, conference proceedings, collections of papers in special issues of geoscience journals and in online media. Many of these resources are used in the chapters that follow and provide the reader with a rich selection of readings for further exploration. The main themes discussed in these contributions are brought together in the first and second chapters to contextualise the specific framing of geoethics that informs the discussion as presented in this book and to describe the current state of the core of geoethics and its implications for the professional activities of geoscientists. Some geoethical subjects have emerged that are expanding the initial development path of geoethics. Analysing some of these topics in a shared context in the third and fourth chapters arguably points to the need to widen the conceptual frameworks that are used. In the concluding chapter of the book, some perspectives are explored as to how geoethical thinking may evolve further.

Brussels, Belgium Martin Bohle

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CHAPTER 1

Setting the Scene

Martin Bohle and Giuseppe Di Capua

Abstract The recent development of the concept 'geoethics' is a response by geoscientists to shape deeper engagement with their professional responsibilities and the wider societal relevance of geosciences. This introductory chapter outlines the development of geoethics to date, as a 'virtue ethics' focusing primarily on the role of the geoscientist, describes its meaning and function in relation to neighbouring fields and explores how to situate geoethics in relation to a wider range of issues that require ethical consideration. The emerging field of geoethics has already touched on many topics. This chapter reflects on the significance of geoethics as an effective operational toolkit for geoscientists, asking whether this functional purpose may be weakened if the range of matters considered under the term 'geoethics' becomes too wide.

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This book takes stock of the field of geoethics. This chapter highlights the purpose of the book, the context for writing it and the limits to its scope. It sets the scene by introducing the relevance of geoethics, how it relates to professional matters pertaining to the geosciences and its broader application to other fields of study and interest.

Contemporary geosciences refer to a range of applied and fundamental research fields within and beyond natural sciences, as well as engineering disciplines and related commercial undertakings. Traditionally, the term 'Earth system' refers to the Earth's physical, chemical and biological constituents and the processes that determine the interactions that transform or transfer matter, energy and information. Over recent centuries, 'geosciences' (or 'Earth sciences') have evolved into a set of basic and applied, scientific and engineering disciplines to study natural systems and human-built systems that intersect with one another.

Within the last decade, geoscientists have shaped the notion of 'geoethics' to frame inquiries into two subjects, namely: (1) the responsible behaviour of professionals in geosciences and (2) the societal relevance of geosciences. These inquiries (see Peppoloni and Di Capua 2017) have led to the exploration of the societal, cultural and philosophical contexts and implications of geoscience knowledge, research, practice, education and communication. Thinking about the implications and applications of geoethics, or 'geoethical thinking', can be located within broader societal concerns about the responsible conduct of science and the science–society interface. How individuals such as geoscientists act when exercising their profession, for example, is relevant to the functioning of modern societies (Press 2008).

When arranging the matters that belong to the realm of geoethical thinking, a geoscientist may be inclined to employ as a metaphor a sphere consisting of a core with concentric layers around it. The core would consist of amalgamated general and professional ethics that applies to geosciences, to their particularities and to individual geoscientists. The first layer around the core would comprise ethical issues that challenge the professional activities of geoscientists. Around this layer, a geo-professional mind may perceive an outer shell of various societal considerations which, like tectonic plates, spread, collide and subduct one another. Evidently, this metaphor has a professional bias, and a philosopher of science may find it annoying. Nevertheless, such a metaphor may assist the reader to follow the lines of thought as they are presented in this book.

Within such a metaphor, the core and the adjacent layer represent the status quo of geoethics (Chapter 2), which might be called ‘enriched geo-professional ethics’. Studying these matters triggers thoughts about the wider relevance of geoethical thinking. Therefore the two subsequent chapters gather several essays that explore the societal relevance of geosciences, first taking a view which is anchored in daily experiences (Chapter 3) and second, offering a more conceptual overview of some geoethical concepts and applications (Chapter 4). Among the matters addressed are the day-to-day functioning of modern societies that intensively apply geoscience knowledge; governance issues and the quest for normative frameworks within Earth system sciences; the need to embrace participatory practices in geoscience; and how to apply geoscience knowledge to give meaning to human behaviour. Drawing on such reflections opens inquiries about the purpose of geoethics when building what has been termed the ‘human niche’ (Fuentes 2016), that is, the natural space shaped and occupied by humans. These reflections and inquiries enlarge the perimeter of matters that geoethical thinking may include beyond its traditional scope. Consequently, the question arises (Chapter 5) whether this perimeter is getting too comprehensive, so that the notion of geoethics risks no longer being a meaningful concept, either for geoscientists or for citizens. Other concepts, such as ‘environmental ethics’ (Hourdequin 2015) or ‘sustainability ethics’ (Becker 2012; Rozzi et al. 2015), may be considered better suited than geoethics to frame some of these matters. Given this concern, the authors have looked for concepts that would be complementary to geoethics or that could describe reflections and inquiries at or beyond the boundaries of geoethical thinking. When studying the interfaces between geosciences, social sciences and humanities (Kagan 2009), for example, a concept such as ‘geo-humanities’ may be deemed suitable. It seems to be one option (of several) to reflect on insights that, for example, emerge from climate change research or subjects such as anthropogenic global change, geoengineering or the Gaia hypothesis. In closing, the book keeps this question at least partially open, seeking suggestions from constituencies other than geosciences.

1.1 Context and Purpose of Geoethical Inquiries

As sketched above, geosciences address the functioning of the Earth system as well as the use of non-living resources. Likewise, geosciences are instrumental in understanding and handling anthropogenic global change. Moreover, within this perspective, each geoscientist must reflect on whether their professional conduct in each instance is scientifically and technically sound, compliant with norms and justified vis-à-vis citizens. Geoethical thinking attempts to tackle such questions.

1.1.1 Looking Inward

Over recent years, the applied geoscience professions have steadily strengthened their professional ethical frameworks, for example, by means of accreditation processes for an individual qualifying as a chartered geologist, who adheres to a professional standard characterised by an elevated level of knowledge, skill and experience and is bound by a code of professional conduct (Peppoloni et al. 2015; Wyss and Peppoloni 2015; Abbott 2017a, b; Gundersen 2017a; Mogk 2017). These efforts cut across various fields of geoscience research and practice, such as engineering geology, geohazards and geo-resources (Bobrowsky et al. 2017; Di Capua and Peppoloni 2014; Neuberg 2015; Nickless 2017; Nurmi 2017; Peppoloni and Di Capua 2018), although they do not yet cover the full breadth and complexity of the Earth sciences (Bohle and Ellis 2017). Discussions about ethics and responsible scientific practice in other parts of the Earth sciences in, for example, global change research or sustainability ethics, have informed the development of geoethics, although specific deliberations are only in their initial stages. Hence, geoethical inquiry has touched on a limited number of subjects so far.

The word geoethics (often spelled differently) has emerged spontaneously in various geoscience contexts with variable meanings, such as to provide guidelines for mapping geographical data (Harley 1990; DiBiase et al. 2012) or as a political notion that is used to describe geo-citizenry (Stoddard and Cornwell 2003). Against this background, the notion of geoethics has been established recently in some applied geoscience communities (Bobrowsky et al. 2017). It has evolved with specific relevance to the scholarly and practical domains of these communities.

The L'Aquila trials,[1] held after the earthquakes that caused 300 deaths in Central Italy in 2009 (Cocco et al. 2015), intensified discussions (Mucciarelli 2015). In addition, because geoscientists are exposed to the wide range of social circumstances under which they execute their professions, the emergence of geoethics has advanced (Wyss and Peppoloni 2015; Bobrowsky et al. 2017; Gill and Bullough 2017; Stewart and Gill 2017).

Demonstrably, the international Earth sciences community has felt a need to strengthen professional ethical frameworks (Peppoloni and Di Capua 2015a, 2016; Gundersen 2017a; Mogk 2017). Following the initial debates concerning ethics in geosciences, a distinctive meaning of geoethics has emerged since the 34th International Geological Congress (Brisbane, Australia, 2012). The 'Cape Town Statement on Geoethics' (Di Capua et al. 2017) was published in 2016 by the International Association for Promoting Geoethics.[2] It frames geoethics as a kind of 'enriched geo-professional virtue ethics' that aims to contribute towards a cultural shift in society that advocates for more responsible interaction with the Earth system. This setting marks a departure from earlier approaches to geoethical thinking (e.g., Martínez-Frías et al. 2011) which by their structure, approach and content qualify as belonging to the corpus of environmental ethics and related schools of thought (Hourdequin 2015). There is a tension as to whether geoethics should be anchored within the field of environmental ethics or whether to pursue it as something distinctly different that builds on the foundation of the professional ethics of applied geosciences. The question also arises as to how to interact with other ethical domains as, for example, the field of research ethics that defines the guidelines for conducting responsible science (United Nations 2013). Recently, when considering the peculiar societal and cultural settings in which geoscientists exercise their professions, some scholars have begun to enrich and diversify the notion of geoethics. Their thinking has evolved beyond specific professional ethics. In the last decade it has resulted in a substantial corpus of contributions as demonstrated by Bobrowsky et al. (2017) and Peppoloni and Di Capua (2017).

[1] http://www.sciencemag.org/news/2015/11/italy-s-supreme-court-clears-l-aquila-earthquake-scientists-good.

[2] http://www.geoethics.org/ctsg.

1.1.2 Looking Outward

Against the background of past efforts, a more systematic trans-/multi-disciplinary interaction should be undertaken to define specific considerations that can strengthen and further the aims and relevance of geoethics. Hence, current geoethical thinking should seek exposure to a broader academic, professional and societal audience, in and beyond social and natural sciences. Such exposure should trigger trans-/multi-disciplinary dialogues to reflect on geosciences (including self-reflection within geosciences), to unearth philosophical and social roots in the history of geosciences or to evaluate the societal relevance of geosciences and their responsible conduct. Interactions with disciplines based in the social sciences and humanities should be fostered to draw on their conceptual depth and methods of inquiry into ethical and societal issues. Interdisciplinary dialogue can also expose the challenges that geoscientists face in contemporary societies as they reflect on how to respond to anthropogenic global change.

Hence, this book offers some insights into geoethics to communities beyond its traditional audiences, as well as seeking to further discussions about geoethical thinking within geoscience professions. It is hoped the book will broaden the understanding of geoethics within the scholarly community, offering deeper insights into geoethical thinking. It should also facilitate the development of research agendas for the coming years, which are likely to go beyond those matters that geoethics initially encompassed.

In presenting the state-of-debates about developing geoethics, this book can be read with three areas of inquiry in mind:

1. Taking a professional focus: what are the ethical issues that are relevant to an individual geoscientist?[3]
2. Taking a societal focus: what are the wider considerations that evolve from considering professional ethics, especially when contemplating the place of geosciences and geoscientists in

[3]The notion geoscientist refers to any category of expert in geosciences (researchers, chartered and other applied professionals, teachers); for example, in the sense that 'geoscientists are stewards or caretakers of Earth's resources and environment. They work to understand natural processes on Earth …' (see https://www.bucknell.edu/academics/arts-and-sciences-college-of/academic-departments-and-programs/geology-and-environmental-geosciences/what-is-a-geoscientist).

contemporary societies which operate (i) under the conditions of anthropogenic global change, (ii) in the context of the quest for sustainable and responsible development, and (iii) with the aim of improving societal resilience?

3. What, under these two operational perspectives (professional and societal focus), is the core of geoethics and 'geoethical thinking' in geosciences; and what aspects can be stimulated to engage more general considerations?

As indicated above, tackling these research questions triggers reflections as to whether to utilise notions such as geo-humanities (Sörlin 2012; Castree et al. 2014; Hawkins et al. 2015; Holm et al. 2015) or geosophy. The latter notion may be used as initially coined by Wright (1947) or may be derived from reflections presented by Shaw (2017). Whatever notion may complement that of geoethics, it should encapsulate concepts and matters that go beyond geo-professional ethical issues to avoid using geoethics as a catch-all term. Several concerns drive such a reflection. First, geoscientists must acknowledge that their work shapes the intersections of human activities and the Earth system. Second, the insights of professional ethicists about the ethics, for example, of climate change (Hulme 2009, 2011, 2014; Victor 2008, 2015) and the environment (Hourdequin 2015) raise concerns in frameworks other than professional ethics. Third, the humanities and social sciences offer insights as to how to situate geoscientists and their professions in different societal contexts (Douglas 2009, 2017; Castree 2017). Active dialogue and exchange between the geosciences, humanities and social sciences could result in new conceptual frameworks and guidelines for practical engagement (Barry et al. 2008; Paul 2018).

1.2 Locating Contemporary Geoethical Thinking

This section presents the current state of inquiry into geoethical thinking from four viewpoints. The first point of view situates geoethics within adjacent fields of ethical inquiries (e.g., environmental ethics). The second view traces the history of the term geoethics with precursors (e.g., Lynn 2000), albeit without attempting an exegesis. The third view regards the subjects of the current debates, namely professional behaviour and 'geoethical thinking', in a broader sense. The fourth view lists some debates in which geoethics engages only marginally so far.

1.2.1 Neighbouring Fields

Over the last decade, the experiences of geoscientists and practitioners who have explored the meanings of geoethics have determined the choice of topics and themes that were included to shape debates around the development of geoethics. Hence, debates happened 'by constituency' by means of a bottom-up approach and have been driven on a case-by-case basis by the practical matters that needed to be tackled. Examples are debates on the design and application of professional codes (Gundersen and Townsend 2015; Abbott 2017b), the conception of training events (Druguet et al. 2013; Mogk et al. 2017) and the need to reach out to the public (Peppoloni and Di Capua 2012; Stewart and Nield 2013). So far, these bottom-up processes have attracted only a few contributions by scholars who focus on philosophical aspects of geoethics (Pievani 2012, 2015; Potthast 2015; Pölzler 2017). Also, the scholarly debates of theoretical ethicists and philosophers of science have had little influence on shaping geoethical thinking. Notwithstanding this limitation, geoscientists engaged with these topics have benefited from some discussions with ethicists, philosophers of science and sociologists. One example is the wording of a formal definition of 'geoethics' (Peppoloni and Di Capua 2015a) that will be introduced towards the end of this chapter.

The status that the emerging field of geoethics may gain is dependent on the extent to which there is professional cooperation among disciplines and constituencies. Within that context, some might worry that applying a rigorous philosophical methodology might render the development of geoethics devoid of practical meaning, hindering fellow geoscientists' acceptance of it, whereas viewed from an operational geoscience perspective attracting them is important. Others might consider that although substantial progress could be made by shaping geoethics from a bottom-up mode, regular interaction with neighbouring fields of scholarly inquiry is now much needed.

Neighbouring relations with geoethics come in different shades and hues. Geoethics has not yet addressed the big ticket matters like climate change or geoengineering, exceptions apart in the grey literature. Inquiries into ethics have a well-developed place within these subjects (Rayner et al. 2013, for the 'Oxford Principles', or Lawrence et al. 2018, Box 1), which could be taken up from a geoethics perspective. Similarly, observations that pertain to metaphysical subjects in geosciences, like the Gaia hypothesis, have not been studied. Also, inquiries into ethical matters that are already being undertaken, for example, in hydrology or marine research (Linton and Budds 2014; Campbell et al. 2016; Barbier et al. 2018), could easily be taken up as part of geoethics. In summary, geoscientists who are interested in geoethics will find within geosciences several disciplines that offer opportunities for further inquiry.

Beyond matters pertaining to geosciences, fields of ethical inquiry that neighbour geoethics come in three configurations. The first configuration is by subject matter, for example, environmental ethics. The second configuration is by cognitive content, for example, research integrity or responsible science; both notions refer to the complicated matter of science–society interactions and have a strong focus on internal interactions within the sciences. The third configuration is by methodology, prompting consideration of general inquiries into ethics or the application of scientific methods.

Until now, geoscientists inquiring into geoethics have explored only some parts of the above. Understandably, most have considered their primary task to anchor geoethics in their research communities and daily practices. Notwithstanding this primary focus, a thorough awareness of essential efforts in neighbouring fields of inquiry is paramount for the methodological development of geoethics.

Possibly the best-explored relationship between geoethics and adjacent fields of ethical inquiries concerns issues relating to research integrity (Mayer 2015) and public outreach and communication about natural and technological hazards and risks (Stewart and Nield 2013; Bohle 2015; Marone and Peppoloni 2017; Meller et al. 2018). Related to these are reflections about the 'Geoethical Promise' (Matteucci et al. 2014; Riede et al. 2016) and the need for training (Peppoloni and Di Capua 2017). Exceptions apart (Stewart and Lewis 2017), inquiries about hazards and risks often seem to fall short in exploring insights into science–society interactions from a geoscience perspective (Allenby and Sarewitz 2011; Cairney 2016), as has been done more systematically for climate research (Hulme 2009; Kowarsch 2016).

The most promising interface of geoethics with adjacent fields is probably its relation to the field of environmental ethics. Some fundamental principles of environmental ethics (Hourdequin 2015) are profoundly relevant for geoethical research, such as the application of the precautionary principle, considering a utilitarian approach versus issues relating to environmental justice, reflecting on generic values of beings and features or studying how to make value judgements in circumstances of uncertainty. Seen from such perspectives, some scholars may even argue that geoethics is (or should be) a part of environmental ethics. Nevertheless, a possible distinction has recently become evident for justifying and developing geoethical thinking (Bobrowsky et al. 2017; Peppoloni and Di Capua 2017). The core of environmental ethics is concern for the relationships between humans and other living beings, specifically beings that feel pain and exhibit traits of consciousness. Geoethics, on the other hand, does not explicitly include a focus on the relationships between humans and other living beings, although one of the precursor authors (Lynn 1998a, b, 2000) who used the notion 'geoethics' did not apply this distinction. Geoethics, as discussed in this book, would qualify within environmental ethics as a virtue ethics (Bohle 2018). Virtue ethics is one of several ethical framings used in environmental ethics. Within geoethics, it refers to the 'virtue ethics of an individual agent' (e.g., geoscientist), as distinct from (but not necessarily in contradiction with), for example, approaches that apply utilitarian ethics as a societal norm.

Beyond observations of the relationship between geoethics and environmental ethics, it can be considered that the application of professional geoscience expertise in modern societies is closely linked with that of engineering professions. This linkage brings into the scope of geoethics a set of concerns that some scholars would wish to treat as sustainability ethics, with an emphasis on the functioning of societies.

To summarise, any debate regarding the delineation of geoethics from environmental ethics or sustainability ethics can be seen as a question of degree and professional affinity. The delineation partly seems a matter of convenience. For the following discussions, the core of geoethics refers to the 'virtue ethics of an individual agent' applied with the purpose to guide the behaviour and practices of the individual agent. The following chapters will delineate an operational perimeter for the kinds of agents and actions that comprise the sphere of geoethics.

Compared to the question of how to relate geoethics and environmental or sustainability ethics, the question of how to assimilate into geoethics those inquiries into ethics taking place within any field of geosciences, should not be an issue of professional affinity. Such assimilation has happened only to a limited degree, either due to lack of opportunity, resources and time or due to the thematic specialisation of interested scholars. It will be challenging to explore the interface of geoethics with climate research, mainly because of the volume of relevant contributions and its societal implications, not least when considering the subject of geoengineering (climate engineering). Nevertheless, it seems fruitful to exploit that interface at least to gain deeper insights into the processes that shape science–society interactions (Kowarsch 2016), which in turn would find application in exploring the context and concerns of geoethics in the perspective of anthropogenic global change.

1.2.2 Early Reflections About Geoethics

Discussions about the ethics of science and research intensified around the turn of the last century, as the example of physical sciences illustrates (Leys 1952; Kirby and Houle 2004; Whitbeck 2004). Hence, when exploring the societal context, implications and obligations of the geosciences, it is mainly the efforts undertaken during the last decade that are analysed in this book. Notwithstanding the emphasis that is given in this book to recent efforts to shape geoethics, the early geoethics-like thinking provides a further context for discussions. References may be found from the mid-nineteenth century (see Lucchesi 2017, about the work of Antonio Stoppani, 1824–1891) to the twenty-first century (Bobrowsky et al. 2017). The 'land ethic' of Aldo Leopold (1887–1948) should also be mentioned (Leopold 1949). At the turn of the last century, Lynn (2000 p. 1) wrote of the need to 'recover ethics as part of the geographic tradition and begin justifying a distinctly geographic account of how we ought to live; all through a distinct perspective on moral understanding I call geoethics'.

The semantic combination of the prefix 'geo' and the term 'ethics' has been used to refer to quite different concepts (Stoddard and Cornwell 2003), and hence the word 'geoethics' has found a variety of meanings. Lynn's (2000) generic approach to geoethics of 'how we ought to live' has led him to consider relationships between humans and animals, which contrasts with other approaches. Considering human activities in a geoscience context easily leads to a range of philosophical reflections, which might often be situated in environmental ethics (for instance, advocacy of the precautionary principle) or considered metaphysical concepts (such as the Gaia hypothesis) (Weston 1987; Kleinhans et al. 2010; Lucchesi and Giardino 2012; Peppoloni and Di Capua 2012; Bobrowsky 2013; Almeida and Vasconcelos 2015).

Geographers have discussed the ethics of geography since the 1990s (Cutchin 2002) using the term geoethics when referring to ethical issues that are related to mapping (Harley 1990, 1991; Crampton 1995; Brennetot 2010, 2011; Sánchez Guitián 2013). Otherwise, presidents of the Geological Society of America have discussed ethical issues at the society–geosciences interface without using the notion 'geoethics' (Zen 1993; Moores 1997). In addition, some scholars have used the notion 'geoethics' (see references in Martínez-Frías et al. 2011; Peppoloni and Di Capua 2015a, b) when other scholars would prefer the term sustainability ethics or environmental ethics for such matters (Shearman 1990; Miller and Kirk 1992; Proctor 1998; Sparrow 1999; Becker 2012).

1.2.3 Core and Peripheral Matters

The notion of 'enriched professional ethics' may denote the core of geoethics to put the behaviour of the agent at the centre of our thinking. In the first instance, this agent is the geoscientist. The philosophy of ethics describes such an approach as virtue ethics. Other approaches to ethics are possible: for example, a utilitarian approach (Auster et al. 2009); a model that seeks a generic value of the environment (Cherkashin and Sklyanova 2016); or the ethics of justice (Kunnas 2012; Ott 2014; Kopnina 2014). When the agent is made a central feature of the approach to ethical issues, then considering agency provides a conceptual means with which a distinction can be drawn between different approaches to ethics. A focus on the individual, that is, the human agent, belongs at the core of geoethics.

In seeking to clarify the specific content of geoethics, etymological analysis of the term has brought to the fore notions of 'home', 'dwelling place' and 'individual and social responsibility' (explored further in Chapter 2). Such considerations relate well to an actor-centric approach projected towards a world outside the self. Exploring the etymology of the word 'geoethics' and the concepts that underpin its roots thus foster a deeper understanding of its meaning.

Martínez-Frias (2008, p. 1) describes geoethics as:

> … a key discipline in the field of Earth and Planetary Sciences, which involves scientific, technological, methodological and social-cultural aspects (e.g. sustainability, development, museology), but also the necessity of considering appropriate protocols, scientific integrity issues and a

> code of good practice, regarding the study of the abiotic world. Studies on planetary geology (sensu lato) and astrobiology also require a geoethical approach.

Such a description aims to be all-embracing regarding the subjects of geoethics although, for example, it does not include reflection and guidance relating to objects and methodologies of inquiry into ethical issues. In addition, it locates geoethics firmly within environmental ethics.

In contrast to the above, Peppoloni and Di Capua proposed[4] in 2012 that:

> Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system. Geoethics deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and responsibility of geoscientists in conducting their activities. (Peppoloni and Di Capua 2015a, pp. 4–5; 2017, p. 2)

Such a delineation of the meaning of geoethics, for example, clearly specifies what objects and subjects are to be included in a definition of geoethics and provides orientation with regards to its spheres of application. The inherent significance of this definition is illustrated by subsequent scholarly enquiries into whether and how to develop a kind of 'Hippocratic Oath' for geosciences (Rotblat 1999; Riede et al. 2016; Bohle and Ellis 2017), such as the Geoethical Promise (Matteucci et al. 2014), again discussed further in Chapter 2. Likewise, the definition by Peppoloni and Di Capua (2015a, 2017) positions geoethics meaningfully to engage with broader issues at the society–science interface.

Currently, the bulk of peer-reviewed publications on geoethics has interpreted the expression 'appropriate behaviours and practices, wherever human activities interact with the Earth system' as focusing on geoscientists within their professional and societal sphere. Such focusing of the interpretation is possible, while the potential of the wording is broader and more powerful, namely, it includes other human agents who interact with the Earth system. Explicitly, when considering anthropogenic global change, limiting the application of geoethics to actions of geoscientists may be too restrictive. A broader interpretation

[4] http://www.geoethics.org.

reflects the reality that geoethical engagement concerns any human agent who shapes production systems and consumption patterns, which in turn interact with the Earth system.

However, if it is intended to consolidate 'enriched geo-professional ethics' into an operational tool within geosciences, then such a broader interpretation of geoethics may refer to matters that are too peripheral to geoscience professions. Consequently, to address them, a concept may be needed that is complementary to geoethics. Hence, the discussions that are presented in this book shall help to draw a perimeter around matters that are subsumed under the notion 'geoethics'.

1.2.4 Ethical Debates Beyond Geoethical Inquiries

Inquiries into ethical principles and guidelines form a growing activity within geoscience scholarship and practice, and geoethical thinking is part of it. To close this chapter, the following paragraphs characterise some matters that geoethical thinking should tackle soon.

Geoethics could bridge several ethical questions and dilemmas within geosciences which relate, for example, to climate change (Gardiner 2004), hydrology (Linton and Budds 2014), meteorology (Schwab and von Storch 2018), the marine environment (Duarte 2014) or geoengineering (Brown and Schmidt 2014). However, these inquiries currently do not coincide. Furthermore, ethical inquiry in geosciences often links to broader ethical subjects, such as research ethics, value judgements in circumstances of uncertainty or environmental justice. Consequently, scholars may overlook commonalities across geosciences that should enrich their inquiries. The example of 'geoengineering', for instance, poses a major ethical dilemma (Corner and Pidgeon 2010; Rayner et al. 2013; Lövbrand et al. 2015; Schmidt et al. 2016). While scholars inquiring into geoethics have contributed little to this debate, it would be an object par excellence to which the Geoethical Promise could be applied. Likewise, geoethical argumentation may focus more on governance issues and historical experiences (Banerjee 2011; Gordijn and ten Have 2012; Bodansky 2013; Biermann 2014; Rozzi et al. 2015). In a similar sense, discussions about applying geoscience knowledge relate to reflections about the ethics of engineering (El-Zein et al. 2008; Ramírez and Seco 2012; Diekmann and Peterson 2013), as metaphorically reflected by Langmuir and Broecker (2012) in the title of their book on the evolution of Earth, *How to Build a Habitable Planet?*

Finally, inquiry about the 'ethics of geosciences' happens in various geoscience communities, although normally it does not refer to the actor-centric perspective of 'geoethics'. Nevertheless, such a perspective seems attractive, at least for most domains of applied research. Consequently, it has been suggested that the scope of the Geoethical Promise be extended to include applied Earth system sciences (Bohle and Ellis 2017). Subsequently, the way in which geoethics can reach out to any other ethical debate in Earth sciences could be explored. Geoethics could progressively enter into any debate where human activities interact with the Earth system; at least within the professional sphere of Earth system sciences.

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CHAPTER 2

Contemporary Geoethics Within the Geosciences

Silvia Peppoloni, Nic Bilham and Giuseppe Di Capua

Abstract Responsible interaction of people with the Earth system calls for deep engagement with ethical considerations. Due to their professional knowledge and skills, geoscientists in particular should reflect on the ethical implications of their work that could guide responsible interactions. Geoethics offers geoscientists a framework for operationalising and exercising this responsibility whilst also orienting other professions and society towards responsible interactions with the Earth system. This chapter explores the meaning of geoethics in detail and describes the current state of geoethical thinking and its application to geoscience

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research and practice. It argues that reference values and general principles should be reconciled with context-dependent perspectives in complex decision-making settings, and reflects on the potential of geoethics to inform a more 'responsible anthropocentrism'.

Keywords Geoethics · Geosciences · Earth system · Professional responsibilities · Geoscience research and practice

In recent years geoscientists have felt an increasing need to reflect on the ethical values that underlie geoscience practice and research. Understanding the Earth, discovering and using its resources, characterising natural processes and finding ways to live with their impacts, and intervening in such natural systems and processes are activities that present significant responsibilities for all citizens, and in particular for professional geoscientists. Human actions impact on complex socio-ecological systems that consist of strongly interconnected elements and that exhibit system behaviour that can be difficult to assess. If they are to contribute to finding solutions to current global challenges that are both effective and socially acceptable, scientific advances should be complemented by consideration of their ethical and social aspects.

But what ethical criteria can guide human interaction with the Earth? How can we find a sustainable balance between conservation of the planet and economic development to find a 'safe operating space' for humanity (Rockström et al. 2009; Steffen et al. 2015)? What is the social role of geoscientists in this context, as professionals and as citizens?

Geoethics has been conceived to answer these and related questions.

The ideas that underpin the conceptual foundations of geoethics can be traced back to the eighteenth and nineteenth centuries when anthropogenic impacts on nature began to be recognised and documented (Fressoz 2012; Peppoloni and Di Capua 2012; Bonneuil and Fressoz 2013; Lucchesi 2017; Häusler 2018). Since then, major technological, industrial and social developments, subsequent and ongoing rapid growth of the population and urban expansion have greatly increased the effects of human interference on the Earth system. This shift confronts us with the need to consider, from an ethical perspective, challenges such as the sustainable use of geo-resources and energy, protection against natural and man-made hazards, the reduction of pollution, the mitigation of global environmental change and adaptation to such change.

Geoethics arises from the awareness that, in a more or less conscious manner, humankind is modifying the natural realms and territories in which it operates and lives, and their physical and biological characteristics. It is also a response to the social and cultural features of humankind's appropriation of these realms and territories. Here the notion 'territory' encompasses the land and the sea, as human impacts extend well beyond the former. The impacts of human interventions on natural realms produce profound changes in the Earth system, which in turn influence economic development and the societal prospects of people on a global scale.

The purpose of this chapter is to describe geoethics as it has evolved so far and to outline a framework for its current conceptual structure, essential characteristics and practical applications.

The roots of geoethics are to be found in the geosciences. However, its development, albeit centred on the role and responsibility of geoscientists (Peppoloni and Di Capua 2012), should extend beyond a specific scientific and professional community. Rather than searching for and developing prescriptive norms that are to be applied to geosciences, geoethics promotes a critical attitude that is rooted in science. Geoethics seeks to transfer such attitudes for societal benefit, to foster responsible and well-informed economic, technological and social development. Geoethics has a vital role to play in shaping cultural categories and behavioural reference values founded in scientific experience and knowledge (Peppoloni and Di Capua 2016; Tuana 2017). In doing so, its social value will be demonstrated, furthering its intellectual and practical credibility.

2.1 The Origins of Geoethics

Geoethics is increasingly recognised as an emerging subject within the geosciences (Bobrowsky et al. 2017). Over the past few years, a growing community of geoscientists and other practitioners and professional institutions have engaged in a shared, bottom-up process to establish the main topics of geoethics as it currently stands and to develop a robust conceptual structure by progressively defining its content, definitions, methods, tools and a shared vision. Through this participatory process, geoethics today has well-established conceptual foundations and a developing framework for its practical application across a growing range of geoscience disciplines and sectors (Peppoloni and Di Capua 2017a).

Contemporary and past environmentalism has provided geoscientists with fresh perspectives, which have inspired (and continue to inspire) the development of geoethics. It has also contributed to furthering the sensibility of society towards the environment. Governmental regulations and international treaties reflecting conceptual formulations of environmental thinking can be seen as representing a gradual shift in economic and technological paradigms. However, this trend has not been uniform and its continuation should not be taken for granted. It has been accompanied by value- and faith-driven discussions, controversies, social tensions and instances of political prejudice and manipulation. Complex settings in which geoscience knowledge is applied, such as mining or large-scale infrastructure development, are fraught with such tensions.

As noted in Chapter 1, a distinguishing feature of geoethics is that it is actor-centric and in particular oriented towards informing the conceptual frameworks and practical interventions of the individual scientist. Moreover, geoethics is based on geoscience knowledge. The individual (the geoscientist), who possesses a specific corpus of knowledge, is equipped to promote attitudes and ways of thinking founded on that knowledge base, including through cooperation with those who are not experts in the field, to find the most acceptable ways in which to interact with the Earth system.

Geoethics is a virtue ethics, placing at the forefront individual, responsible action based on the adoption of societal and professional reference values. Its development and its application are led by scientists for the benefit of society, within a pragmatic, open and continuous revision process. It focuses on the comprehension (in the original meaning of the Latin word '*comprehendĕre*', composed of the preposition '*cum*' and the verb '*prehendere*', that is 'to contain, to take in, to include') of physical and social realities. Geoethics is shaped and informed by a strong awareness of the technical, environmental, economic, cultural and political limits existing in different socio-ecological contexts. In other words, geoethics is context-dependent in space and time and ethically sound choices may differ for similar ethical dilemmas. Such choices must also be guided by geoscience knowledge, which is imperfect, applied in a given space–time context. Geoscientists acting from a geoethical perspective should be encouraged to ask: What is it right to do, here and now? How? And why? Such apparent relativism may be perceived by some as an inherent risk within geoethics, but conversely a search for prescriptive norms that ignores the importance of context is likely to be fruitless.

The essential characteristics outlined above prefigure geoethics' innovative potential.

2.1.1 From Ethics to Geoethics

The conceptual structure, content and values of geoethics have their origins in the definition and application of the more general discipline of the philosophy of ethics.

Considering a Western cultural context, the Greek philosopher Aristotle (384–322 BC) characterised ethics as reflecting on the conduct of humans and identifying legitimate criteria by which to evaluate behaviour and choices to identify 'true good', as well as the means to achieve this goal. His concept of ethics also addresses the moral obligations of human beings towards themselves and others and provides the principles to guide appropriate action when facing a decision. Other cultural roots may be drawn upon to trace the relation between ethics and geoethics; however, considering the predominant role of European culture in shaping and framing modern science, this reference may serve its purpose.

In a global society that renounces slavery, genocide and other societal atrocities, ethics must concern all humans without distinction and have equity as a central tenet. Since the middle of the last century, there has been increased recognition of universal values as the basis for individual and social good. Codifications, such as the Universal Declaration of Human Rights of the United Nations,[1] set out essential ethical features for guiding human behaviour, including dignity, justice and respect for life. The principle of intergenerational equity is also fundamental to modern ethics. To make choices rationally and responsibly requires us to apply moral principles in pursuit of the greater good (Weber 1919), not just in respect of present-day society but also considering the impact of our choices on future generations (Jonas 1984). However, experience shows that the ways in which universal values, such as honesty, responsibility, respect for the environment and consideration for future

[1] United Nations, 1948, The Universal Declaration of Human Rights: http://www.un.org/en/universal-declaration-human-rights/.

generations, are applied vary across time and space, depending on the specific social, political and cultural context. Likewise, the attitudes of those who have significant scientific, social or political roles and responsibilities vary, as do claims regarding constraints on these roles and responsibilities resulting from ethical obligations.

Ethics has a clear purpose and means. Simplifying, it aims to clarify, for a given circumstance, how principles and values should inform appropriate action, giving consideration to the consequences of such action. Its function is to offer guiding principles to people when they need to make a choice by providing a framework of reference values, shared by the social group to which they belong, that can lead to what is good for, or what is most useful or acceptable to, the individual or society (Peppoloni and Di Capua 2018). Nevertheless, experience confirms that choices that are taken in a specific social and cultural setting, that respect the ethical norms of this setting, may appear unethical elsewhere. Thus the apparent relativism of geoethics, referred to above, has its roots in a fundamental feature of virtue ethics. How to handle such 'relativism' is an ethical dilemma of geoethics.

Regarding the practice of a profession, ethics is expressed through the identification of duties and rights that regulate professional activity (deontology) by members of a social group, who are characterised by the possession of specific technical–scientific knowledge, methods and tools for its application (Peppoloni and Di Capua 2018).

In the field of geosciences, the term 'geoethics' is used to frame the ethical problems related to geoscience research and practice. As mentioned in Chapter 1, 'Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system' (Peppoloni and Di Capua 2015a, pp. 4–5; Bobrowsky et al. 2017, p. 5). This definition provides a basis for analysis and practice and highlights the need to identify values on which to base the growing interaction between humans and the Earth system. Moreover, 'Geoethics deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and responsibility of geoscientists in conducting their activities' (Di Capua et al. 2017; Peppoloni and Di Capua 2017a). This phrasing reflects the centrality of the geosciences as a significant body of technical–scientific knowledge and practice to inform human interaction with Earth. Geoscientists are asked to assume the responsibility of using their knowledge for the benefit of society. Their actions and choices are submitted to the judgment of their colleagues (scientifically and technically) and society (in terms of their wider impacts and implications). Taking responsibility therefore means being answerable for their actions, because of their competence to address problems at hand.

2.1.2 Exploring the Meaning of the Term 'Geoethics'

Where does the word 'geoethics' originate? What are its connotations and what is the history of its components? Hence, what possible meanings are encapsulated in its etymological roots?

As outlined in Chapter 1, the word 'geoethics' is associated with different meanings, some of which have little in common. In this context, an etymological analysis can make a valuable contribution to the conceptual framework on which to base geoethics, to illuminate relevant concepts and to provide a deeper understanding of its philosophical base (Peppoloni and Di Capua 2015a).

Considering its rather simple semantic construction, 'geoethics' is the union of the prefix 'geo' and the word 'ethics'.

The prefix 'geo' carries an ancient meaning. It refers to '*gaia*', which means 'Earth' in Greek, but its much older Sumerian base '*ga*' refers more specifically to 'home, the dwelling place'. So the Earth is the place where humans dwell, where their ancestors dwelt and where their children will dwell. The notion of dwelling relates directly to the more recent concept of 'niche-building' (Ellis et al. 2016).

Etymological analysis of the word 'ethics' reveals a more complex conceptual development. First, the word 'ethics' is derived from the Greek '*ἔθος*' (*ĕthos*), which means 'habit, custom'. This noun has the same origin as '*εἴωθα*' (*eiotha*), a Greek perfect form meaning 'I am accustomed to, I have the habit of, I am familiar with' (Liddell and Scott 1996). Words such as 'accustomed' and 'familiar' imply a sense of belonging to a community, be it a family or a larger social group. But what determines familiarity and therefore a habit of behaviour? This can be traced back to the Semitic root '*edum*' meaning 'experience, to be experienced in'. In other words, I experience something (an event, a circumstance), I acquire knowledge and I familiarise myself with this event. From now on, my acquired expertise helps me to choose the behaviour or custom most suitable to a given circumstance or event. Second, the word 'ethics' has additional meanings. It can be traced also to the

Greek '*ἦθος*' (*ēthos*), which refers more specifically to the characteristics or habits of the individual, one's personal characteristics (Liddell and Scott 1996). Both nouns (ĕthos and ēthos) derive from the same root '*sweth-*' (compare to the Latin '*suesco*', 'I use', Ernout and Meillet 1994). However, the second term gives evidence of the double nature of human beings as both individuals and members of a community. So the word 'ethics' can be rooted in a dual meaning: one related to the social sphere and one to the individual sphere.

The same double origin can be observed going back from Greek to the Accadian language. Starting from the Accadian base '*esdu*', ethics denotes 'social foundation, social discipline', and in a wider sense 'assurance of continuity'. Again, we meet the social dimension, the reference of the word 'ethics' to the community (Semerano 2007). However, from the Accadian base '*betu*' comes the meaning of 'home, dwelling, shelter'. As such it can refer to something more personal and intimate. Moreover, from the Accadian base '*ettu*', the word 'ethics' assumes the meaning of 'character, distinguishing marks of an individual, characteristic of a person'. Again, the individual sphere is referred to (Semerano 2007). Therefore 'ethics' relates in origin to what individuals have in common when perceiving themselves to be part of a community.

In summary, it seems that a double meaning can be associated with the word ethics. On the one hand it contains a sense of belonging to a social dimension. On the other hand, it expresses the personal, the individual. It follows from the etymological roots that the notion 'ethics' concerns both the common sphere, the interactions between individuals belonging to a social organisation and the personal sphere, what distinguishes an individual. Hence, ethics means 'to be part of', and at the same time 'to belong to oneself'. These two existential conditions (social and individual) coexist in the word ethics, unexpected though this may be for many.

By analogy, these considerations can be extended to geoethics, shaping its definition on the one hand as an investigation of, and reflection on, the behaviour of geoscientists towards society and the Earth system (their enlarged existential dimension, as it were) and on the other hand as the analysis of the relationship between the geoscientist and their actions, relative to the intimate individual dimension. In geoethics, geoscientists are called upon to shoulder not only individual responsibility, but also social and environmental responsibility. These are inextricably linked, as personal ethical attitudes are reflected in social behaviour and interaction.

2.2 Contemporary Geoethical Thinking

2.2.1 The Concept of Responsibility—Four Levels of Interaction

The concept of responsibility is a central pivot in geoethics (Hocke 2015; Peppoloni and Di Capua 2015a, 2017a). Obviously, it shares this feature with professional ethics in other disciplines (Leys 1952; Hourdequin 2015; Rozzi et al. 2015). However, the subject of geosciences introduces some peculiarities.

The word 'responsibility' derives from the Latin verb '*respòndere*', meaning 'to respond', and so it expresses the commitment to answer to someone for our actions and their consequences—the duty to satisfactorily perform a task, which has a consequent 'penalty for failure'. For the scientific community, the 'penalty for failure' must not be conceived only in legal terms. If, for example, calculations to stabilise a slope are wrong owing to negligence and a disaster occurs, scientists may be held legally liable for the consequences. But another penalty for failure is loss of credibility (both individually and collectively as a profession), the failure of the scientific and cultural role of geoscientists to facilitate society in facing geological problems, and hence loss of rationale for being geoscientists (Peppoloni and Di Capua 2017a, 2018).

The geoscientist sits at the centre of an ethical reference system in which individual, professional, social and environmental values coexist, underpinning their responsibilities at these four levels. Geoscientists should examine their choices with reference to these values, considering their actions and interactions in the corresponding consecutively wider, more complex and entangled domains of experience (Peppoloni and Di Capua 2017a; Mogk et al. 2017).

First, geoscientists have a responsibility to themselves—conducting their work to the best of their ability. This means pursuing excellence in science, applying appropriate methods and technologies in scientific research and application and following (and contributing to the development and promulgation of) best scientific and professional practice. Examples include maintaining high standards of intellectual honesty; verifying sources of information; reporting findings and interpretations fully and objectively; not altering or ignoring evidence to strengthen one's argument; making clear any limitations or gaps in evidence and information; being honest about the limits of one's own knowledge and competence, and acting within these limits; avoiding conflicts of interest wherever possible, and declaring any potential conflicts of interest; and engaging in ongoing professional training and the continuous improvement of geoscience knowledge throughout one's career (Mayer 2015; Peppoloni et al. 2015; Abbott 2017a; Mogk 2017).

Second, geoscientists should assess their actions with respect to their working environment, colleagues and wider profession. In common with other scientists, it is the individual's responsibility to cooperate and treat colleagues honestly and fairly; to respect others' ideas, welcome fair debate and embrace a diversity of perspectives, expertise and methods; to foster mutual understanding, share information and data, and support the intellectual and professional development of others; to respect and acknowledge the intellectual property of others; and not to compete unfairly—for instance, recognising if others are better qualified to carry out the work at hand.

The geoscientist produces knowledge and designs solutions for the benefit of society and its component parts. It is the individual's responsibility to serve society as effectively as possible, in order to support its development and assure its safety. To achieve such goals, as in other sciences, it is essential to take care of the 'data life cycle' (Gundersen 2017b), including making data and the results of one's studies public (Van Gessel et al. 2017). Research results and the implications of their application should be shared with relevant public and non-expert audiences in ways that address their knowledge, interests, needs and concerns, are easily accessible and user-friendly, and are contextualised with explanatory information. Geoscientists should take similar care when communicating their knowledge to policy-makers and public bodies at all levels, in which they should play an active part, and should seek to develop constructive and responsible interactions between academia and industry. They have a key role to play in the training and skills development of technicians and professionals and in participating in public engagement, raising public awareness and educational activities.

Finally, the role geoscientists play in helping to manage the natural realm, understood in a more general sense than just the terrestrial, brings with it a responsibility to the environment. Geoscientists have knowledge, expertise and professional and cultural sensibilities that are essential to protect natural environments, to manage the development of natural resources and places so as to minimise negative impacts on ecosystems, to enhance the scientific, educational, cultural and aesthetic value of biodiversity and geodiversity, and to entrust these to future generations.

Given the importance of the concept of responsibility, it is vital periodically to review the scope and nature of the action and involvement of geoscientists in each specific context and therefore understand their role in wider decision-making and implementation processes (Bobrowsky et al. 2017; Dolce and Di Bucci 2015). Notwithstanding the specificity of particular geoscience disciplines, further research is needed to clarify the distinctive features of how geoscience and decision-making (including policy-making) interact, vis-à-vis science–policy–society interaction more generally (Douglas 2009; Gluckman 2014; Kowarsch 2016; Kowarsch et al. 2016), as recognised in Chapter 1.

However, it is also important to realise that responsibility does not rest solely with the geoscientist since they usually help other actors to operate using their geoscience knowledge; similarly, responsibility should never rest on the shoulders of scientists alone. The need to assign responsibility fairly to individual actors is a feature of structured, engineering-like operational processes that characterise many geoscience professions. Where different actors share responsibility, a shared value system is helpful for fostering sound cooperation. A clear distinction of roles and a common foundation that allows for shared understanding are both fundamental when multiple professional actors cooperate to handle complex problems or when different stakeholders are involved. Geosciences are rich in such situations, for example, in risk management, where well-defined and shared operational protocols are required to avoid an overlapping of tasks and to assure clarity in the decision-making process.

2.2.2 Reference Values on Which to Base Geoethical Perspectives and Actions

In order to better understand the responsibilities of geoscientists and to inform their actions, it is essential to identify reference values capable of guiding choice and behaviour across a wide range of settings, on the basis of which better, more beneficial or more acceptable decisions can be discriminated from worse, less beneficial or less acceptable ones. Such values must be rooted in an awareness of the social and environmental implications associated with the activities of geoscientists and their responsibility to society, future generations and the Earth.

Three sets of values are proposed, grouped according to their functional aim, although these often intersect (Peppoloni and Di Capua 2016).

Ethical Values

The Singapore and Montreal Statements[2] established internationally a set of reference principles on which to base research integrity (Mayer 2015; Steneck et al. 2017). Similarly, professional or ethical codes[3] developed over many years by professional geoscience institutions have defined ethical norms for professional activities (Allington and Fernandez-Fuentes 2014; Abbott 2017a, b; Boland and Mogk 2017; McPhaden 2017). Typically these include many (though not all) of the values set out above in relation to the individual, professional, social and environmental spheres, and are associated with a 'penalty for failure' for the individual, policed at the professional level through the disciplinary procedures of various institutions. They can be considered 'deontological codes', in that they codify rules for ethical professional behaviour, although the motivations for their establishment and maintenance have their roots in virtue ethics (in that they seek to encapsulate what is morally right for the professional geoscientist to do) and utilitarianism (in that they deliver public benefit and promote and defend the legitimacy and credibility of the individual and the profession).

The common matrix of these reference documents can be traced back to fundamental values that apply across scientific/scholarly disciplines, such as honesty, accountability, professionalism, and stewardship. These values can be integrated with awareness, accuracy, cooperation, inclusiveness and fairness. They assure professional courtesy in working with others, good stewardship of activities, adherence to regulations and to scientific methods, repeatability of studies by colleagues and the sharing of results, respect of intellectual property and the rules on authorship and the peer review process, and due scrutiny of conflicts of interest (Mogk 2017).

In the era of globalisation, where issues of environment, climate, infrastructure, resources and energy have no borders and require international efforts for their management, it is important to promote a shared ethical set of values among geoscientists around the world. Beyond concern for the commonalities and tensions of a globalised world, many geoscientists exercise their professions in different parts of the world,

[2] "Singapore Statement on Research Integrity" (2010) and "Montreal Statement on Research Integrity in Cross-Boundary Research Collaborations" (2013): https://wcrif.org/guidance.

[3] Such as those listed at http://www.geoethics.org/codes.

from exploration for minerals in Africa to seafloor studies in the Pacific. Social, political, cultural, technological and economic differences among nations can cause tensions when facing issues such as research integrity and the ethical conduct of professional activity. It is important to assure some common ethical values and standards that extend beyond national boundaries. Such considerations have driven international efforts to promote common professional standards in geoscience, including mutual recognition agreements between professional bodies, the work of the European Federation of Geologists[4] and the establishment of a Task Group on Global Geoscience Professionalism[5] by the International Union of Geological Sciences, among others.

Ethical values in respect of international cooperation aim to involve geoscientists from all over the world in the discussion of global issues, and to debate and compare ideas, even if these are very different, in the search for common solutions. Moreover, a set of shared ethical values is essential if multidisciplinary work is to reach its full potential, allowing the effective integration of different specialist disciplines and professional skills in facing problems.

Often cross-boundary research and professional collaborations (whether across disciplinary or national boundaries) present special challenges for the responsible conduct of scientific and technical activities (Mayer 2015), because they may involve substantial differences in regulatory and legal systems, organisational and funding structures, research cultures and approaches to training. Therefore it is critically important that geoscientists are aware of and able to address such differences. Principles of utmost importance are trust, transparency, communication and compliance with laws, policies, regulations and publishing rules.

Cultural Values

Geoethical thinking highlights and enhances the social and cultural dimensions of the geosciences. Identifying and promoting the cultural values associated with geoscience research and practice can help guide society in its choice of responsible behaviour towards the Earth, in both its biotic (e.g., biodiversity) and abiotic (e.g., geodiversity) components (Peppoloni and Di Capua 2012), which are inextricably linked.

[4] https://eurogeologists.eu.

[5] https://tg-ggp.org.

Concepts such as geoheritage, geoconservation and geodiversity bring together not only scientific but also cultural elements, tangible or otherwise. These concepts have been informally addressed for many years by the geosciences, but a need for greater formality and definition of terms has arisen only relatively recently, particularly in seeking dialogue across disciplines and with policy-makers. Notwithstanding a plethora of alternative definitions, geodiversity is defined as 'the variety of natural elements, such as minerals, rocks, fossils, landforms and their landscapes, soils, and active geological/geomorphological processes' (ProGEO 2017, p. 1). Geoheritage comprises those 'elements of the Earth's geodiversity that are considered to have significant scientific, educational, cultural, aesthetic, ecological or ecosystem service values' (Woo 2017). Geoconservation comprises actions taken to preserve geodiversity and geoheritage in order to ensure that the 'face' of the planet (rocks, landscapes and waters) is adequately protected against human intervention for future generations (Bobrowsky et al. 2017; ProGEO 2017).

These concepts, their enhancement and their promulgation represent an important resource for strengthening the relationship and the sense of belonging of the population to the land it inhabits, contributing to a richer understanding of the identity of human communities, and focusing attention and care towards the socio-natural environment. Geoheritage, geodiversity and geoconservation are practical expressions of taking a geoethical view of the planet: recognising their importance as a means to restoring an inner connection between humans and the Earth system is a fundamental starting point to develop best practices in managing environments. At the same time, geoethics highlights their intrinsic social and economic value, since geoheritage and geodiversity form part of non-renewable societal and natural capital.

Initiatives like UNESCO Global Geoparks[6] and sectors like geotourism[7] (Allan 2015) are the material expressions of those values, and a means of celebrating and interpreting the geological landscape, resulting in a broader understanding of geosciences through appreciation and learning (Gordon 2018). In these terms, geosciences are capable of influencing the way people think about the planet. If properly managed, geoparks can

[6] http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/unesco-global-geoparks.

[7] International Congress Arouca, 2011, Arouca Declaration on Geoturism: http://www.europeangeoparks.org/?p=223.

provide countries with opportunities for sustainable development, where the geosciences and social sciences interact on common ground. The geopark movement is a global phenomenon that offers many benefits, such as effective multidisciplinary work and cross-border international collaboration; an increase in public awareness and education; an improved quality of life for local populations through economic stimulus; and a general move towards greater awareness of the importance and diversity of nature.

Social Values

Great challenges, such as the mitigation of climate change and adaptation to it, the search for new sources of energy, the need for a sustainable approach to the environment and defence against geo-hazards, can and must be pursued through diverse approaches and perspectives. Geoethics seeks to provide a common matrix to address such issues globally. As a consequence, one aim of geoethics research is to search for social values that are capable of bringing together diverse cultures and sensibilities.

General societal concepts that are widely applicable across such fundamental challenges, such as sustainability, prevention, adaptation and education, can be regarded as a set of shared social values, helping to frame a new common vision for our societies in the coming decades. These concepts are introduced below in general terms, and their application to geoscience is addressed later in this chapter.

First, the concept of sustainability presents us with a double challenge, but promises a corresponding double social value. It raises the need, for example, to minimise and optimise the production and use of energy and minerals, and to facilitate transition to the use of renewable energies; and informs development of strategies and technologies for doing so, maximising the positive and minimising the negative social and environmental impacts of such resource use. However, it also highlights the need to build new models of economic development, recognising that it is a fundamental human right not to live in poverty and that a global society that ignores this right cannot be truly sustainable. The concept of 'sustainable development' (explored in greater detail below) captures a tension between the need to facilitate the economic and social development of the world's poor and the need to reduce and, where possible, reverse damage to the Earth system—but it also raises the possibility of reconciling these challenges. Geoethics should help to define the boundaries of how to live sustainably on the planet.

Second, prevention refers to a set of activities and tools, either to prevent processes or events from happening, or to prevent resulting harm. The development of a culture centred on prevention is a way to improve the resilience of human communities, namely their ability to anticipate, avoid and/or respond to an event. This includes the capacity to restore the material, cultural and spiritual conditions that existed before an event and to prepare for and respond to future events in a more effective way. Considered in risk management terms, prevention strategies aim to break the pathway between the possible causes of a risk event and the risk event itself (proactive controls) or between the risk event and its possible consequences (reactive controls). Developing resilient prevention strategies requires access to accurate scientific information, communication and education, as well as effective governance. It also depends on improving communities' awareness of natural risks and their capacity to assess and establish reasonable, acceptable risk thresholds. This can help facilitate the adoption of strategies to reduce the likelihood of potentially damaging natural events or processes occurring, or the transformation of such events into disasters.

Third, human adaptation refers to the ability of a social group to modify its characteristics and the ways it interacts with its environment in response to change. The necessity to consider adaptation arises from the observation that natural systems are often altered in an irreversible manner, given their interconnectedness and complexity, often characterised by non-linear system dynamics that hinder restoration of earlier conditions. Beyond the need to handle environmental change and to ensure the survival of society, adaptation is also a way for communities to strengthen their internal social ties in pursuit of a common benefit.

Fourth, '(geo-)education' is an important social value in geoethics. Developing and disseminating a culture of Earth science literacy across society is essential to changing the way in which people perceive their relationship with the Earth system, equipping and empowering them to participate in debate and action to address global challenges, as well as providing the basis for the education and training of future generations of geoscientists whose skills will be essential to meeting these challenges. Geosciences must play a fundamental role in building a knowledgeable society, raising awareness about how the Earth system operates and evolves and how people interact with it and equipping us with the intellectual and practical tools to do so responsibly.

A primary task of geoethics is to make communities outside the geoscience profession aware of the immense value of such concepts and to emphasise the need to pursue such concepts to assure human safety and progress.

2.2.3 Intellectual Freedom: A Fundamental Prerequisite for Practicing Geoethics

Geoethics entails a conscious and rational way of acting. An ethical decision can only arise from exercising responsible choice. Intellectual freedom is a fundamental prerequisite for acting ethically. To be credible, geoscientists must adhere to scientific methodologies. They must use their geoscience knowledge impartially, without being influenced in their methods or conclusions by external pressures or conflicting interests. In particular, their professional endeavours should not be driven by opportunism, political pressures or economic interests (Gaur 2015; Gawthrop 2015; Wyss 2015).

Likewise, harassment, bullying, discrimination and exploitation of power dynamics threaten the integrity of geoscientists' working environments and inhibit their freedom of choice. A respectful working environment is fundamental to maintaining professional standards and assuring ethical conduct when practicing geosciences. Harassment (sexual, psychological or physical) and discrimination (whether on grounds of gender, race, disability, sexual orientation, religion or any other characteristic) offend the dignity of a person and seriously undermine not only the integrity and credibility of the geoscience community (Williams et al. 2017) but also in turn the quality of scientific work. These kinds of behaviour prevent individuals, driven by fear of punishment or retaliation, from making decisions in an ethical manner (Peppoloni and Di Capua 2017a). The need for the geoscience community to address harassment and discrimination, to ensure that working and educational environments are respectful and inclusive and that unacceptable behaviour is identified and effectively policed, is increasingly being recognised in the policies and ethical codes of professional geoscience organisations—an example of ethical codes evolving to meet current requirements.

Furthermore, principles such as adherence to truth, freedom from conflicting personal interests, and an openness to cooperation and open discussion with colleagues should be the basis on which to found scientific activity, in whatever field considered (applied, academic or educational). A geoscientist who is working in an environment that pursues these values is well-placed to scrutinise the integrity and honesty of their own, and other people's, scientific research and practice, and to ensure that access to research results is open. They should be aware that scientific validity cannot be negotiated, obscured or influenced by conventions or agreements between power groups, companies or states. Recognising and pursuing these principles should be the responsibility and mission of every geoscientist.

Nonetheless, it is evident that where strong partisan interests are at play, whether in commercial, academic or government settings, this freedom is not easily won or guaranteed. For example, geoscientists working for mining or oil and gas companies may find themselves under pressure to support choices that are not in line with their professional ethics, notwithstanding the fact that they are operating in publicly regulated legal frameworks. In such egregious instances of pressure being unfairly and explicitly exerted, the ethical course of action should not be hard to discern, however difficult it is to achieve—the individual should always act ethically and should always be allowed to do so. Aside from such clear-cut cases, ethical challenges may arise when legitimate commercial, political or economic factors come into conflict with individual or collective ethical principles. In these cases, identifying the best course of action may be less simple and clear-cut. What considerations should take precedence? Is it possible to find an acceptable balance in this dialectic relationship?

This problem, though far from being easy to resolve (Gaur 2015), may be addressed by means of the adoption of common values and rules to accommodate the diversity of relevant factors and perspectives. Aligning companies' needs (and society's demand for resources) more closely with inalienable requirements, such as respect for personal ethics, environments and communities, is an area of active development that is yielding concrete results. In the field of mining, a number of initiatives are underway, at various stages of development, to establish principles and implement mechanisms to address these challenges (Nurmi 2017), like those developed by the International Council on Mining and Metals.[8] Whatever approaches are adopted,

[8] http://www.icmm.com.

however, rigorous application of ethical criteria implies the risk that individuals face insoluble dilemmas. Such challenges, though far from being unique to the geosciences, should be studied from a geoethical perspective to assist geoscientists who are facing them in a professional capacity. It is also incumbent on geoscientists in leadership positions to promote supportive and inclusive professional environments in which such sensitive and complex matters can be addressed honestly and openly.

2.3 Ethical Issues and Ethical Dilemmas

A geoethical issue might be assumed to be a choice between at least two alternatives, one of which is the best option, taking into account the reference system of scientific, economic, social and cultural values in which a geoscientist is acting, and assuming there is complete and accurate knowledge of the problem and adequate competence for its resolution (Peppoloni and Di Capua 2018). If one option is patently better than another, then the decision to be taken may be relatively simple. But often geoscientists are faced with true ethical dilemmas (Bilham 2015). In such cases, an 'ideal' choice is not available. Instead, different options exist, all with different benefits and impacts on society or the environment (Marone and Peppoloni 2017). Under such circumstances, how can a choice be made from an ethical point of view? On what should geoscientists base their choices?

A real ethical dilemma has no perfect solution. Instead it has one that is deemed most acceptable in a specific economic, social, cultural and environmental context. Identifying the most acceptable solution requires consideration of both the positive and negative consequences of the options available, choosing the one that maximises benefits and minimises disbenefits. It follows that even the 'best' solution may have adverse consequences that must be accepted. Making technical–scientific choices under uncertainty (Albarello 2015; Tinti et al. 2015) inevitably implies accepting compromises, a feature that is common to applied sciences (Christensen et al. 2007; Hansson 2015; Murphy et al. 2015).

Deciding on the feasibility and desirability of a course of action (e.g., regarding a proposed infrastructure project, an energy initiative or a hazard prevention scheme) may depend not only on scientific and technical considerations but also on economic, political, social and cultural factors. Making an ethical choice depends on assessing these factors in the context not only of the geoscientist, and the perspectives and values they hold, but also the perspectives and values of other stakeholders and communities who may be affected (either positively or negatively)—values which may sometimes conflict (Peppoloni and Di Capua 2017a). For example, a dam may have significant adverse impacts on natural habitats, but at the same time can ensure protection from flooding and supply water to thousands of people. Similarly, a mine might be seen as a threat to the surrounding environment and the health of local communities but may also bring benefits in the form of jobs, facilities and infrastructure improvement, as well as providing the mineral resources needed for low-carbon technologies, for instance. Therefore it is vital to work with local communities and stakeholders to determine where there is a reasonable alignment of economic, social, cultural and ethical values and to work to reconcile these and seek out opportunities for collaborative action to maximise both social and environmental benefits (Owen and Kemp 2013; Hostettler 2015; Arvanitidis et al. 2017). Considering more generic reference values, such as sustainability and community resilience, is also important and may help to frame efforts to resolve conflicting interests.

In most applications, it is not the geoscientist who makes the final decision about a specific matter. In these cases, geoscientists have a professional responsibility to provide decision-makers with information and advice (based on professional judgment rather than personal views) on all aspects of a problem that they consider relevant to a decision being made in a given social or environmental context, as well as in light of more generic reference values.

However, policy-makers and other decision-makers often expect a geoscientist (or other professional expert) to recommend a solution, or at least to advise on the desirability of options, notwithstanding their dependence on matters outside the geoscientist's professional competence (Bobrowsky et al. 2017). When geoscientists are facing a geoethical dilemma, they should accept and make clear to others that they cannot offer a unique solution. Instead they should define and characterise options, scenarios and potential outcomes. Geoscientists have a duty (along with other relevant professionals) to explain such choices and their consequences. In doing so, they should avoid making the mistake of considering geoscience knowledge as a 'universal law', assuming that they might solve an ethical dilemma based on geoscientific considerations alone, or by using 'right' or 'wrong' categorisations (Marone and Peppoloni 2017). Geoscientists can help to ensure that geoethical decisions are reached by characterising problems and options adequately from a scientific and technical point of view and by clearly indicating the positive and negative impacts of the options available. In many cases, it may be appropriate to carry out a cost/benefit analysis (Potthast 2015; Stefanovic 2015), framed in societal and environmental as well as economic terms, looking at positive and negative impacts from multiple perspectives across the short and long term and at a variety of physical scales. Such analyses should also take into account uncertainties (quantified where possible), internal and external to the system under consideration, and recognise that such a cost/benefit analysis alone may not provide an optimal (or even acceptable) solution (Peppoloni and Di Capua 2018). There is extensive literature on science–policy interaction that explores these and related themes, albeit not focused on geoscience, which has been influential on practice in this area in recent years (e.g., Douglas 2009; Gluckman 2014).

2.4 Geoethics Applied to Geosciences

Geoethics covers the entire range of geoscience applications, from basic research to commercial undertakings. In recent years, its application in different realms has been analysed, including through paradigmatic case studies (Peppoloni and Di Capua 2015b; Wyss and Peppoloni 2015; Gundersen 2017a; Peppoloni et al. 2017).

The main issues and topics geoethics addresses include sustainable use of natural resources (including water, energy, mineral and biological resources); the reduction and management of natural and anthropogenic risks; the management of land, coastal areas, seas and open oceans; pollution and its impacts on health; global environmental change, including climate change; protection of natural environments; research integrity and the development of codes of scientific and professional conduct; literacy and education in geosciences; geodiversity, geoheritage, geoparks and geotourism; forensic geology; and medical geology.

Returning to the question 'On what should geoscientists base their choices?', some of the key principles which guide the practical application of geoethics to these issues and topics are: to encourage critical analysis and the responsible use of natural resources; to promote accurate and useful information on hazards and environmental risks; to foster the development of environmentally friendly technologies; to highlight the social role of the geosciences; and to promote geological heritage as a scientific, cultural and educational resource. These principles are all aimed at guiding society towards appropriate behaviour to tackle practical problems facing humanity in relation to the Earth system, and at helping society find solutions that are compatible with economic and social development and with conservation of nature and land.

Consequently, even though geoethics originates in the field of geosciences and refers in the first instance to the scientific and professional activity of geoscientists, it goes beyond this sphere of influence, turning towards other elements of society and contributing to economic, political and cultural debate. These matters are explored further in Chapter 3.

2.4.1 The Specific Knowledge and Skills of Geoscientists

Geoscientists are social actors as well as scientists and professionals. Geoscientists, engineers and others who have expertise relating to the Earth, possess scientific knowledge, skills and training essential for investigating, managing and intervening in various elements of the Earth system and can contribute to fostering better science–society relations (Gill 2016; Tubman and Escobar-Wolf 2016). This entails ethical obligations. Geoscientists work to understand how the Earth system functions, the nature and distribution of resources, environmental dynamics and the interaction of human and natural processes. This knowledge carries with it a responsibility to best serve the public good.

A geoethical approach can help to develop the knowledge, skills and capabilities of geoscientists. As discussed above, ethical criteria, such as honesty, openness and adherence to scientific methodology (while recognising its limits), are vital to the success of the research and practice of geoscientists, facilitating the connection of scientific validity, freedom and responsibility in their work. Furthermore, it allows geoscientists to reflect on their activities, improve their professional and personal practice and learn more about themselves, in terms of research, teaching or professional applications. Scientific research and its practical application must be carried out with intellectual honesty in order to be of real service to others. In this spirit, geoethics can serve geoscientists by confirming (and in many cases rediscovering) fundamental elements of their identity, upon which can be built professional motivation and a personal ethics of responsibility, thereby informing personal social function. In this manner, geoethics can provide ‘philosophical bonds’ within a cohesive geoscience community.

2.4.2 Why Should We Act Ethically? Geoethics as an Advantage

So how does a community promote the idea that its members should behave ethically? As suggested in Bobrowsky et al. (2017):

> … three steps seem to be necessary. First, ethical behaviour should be affirmed by the community as the expected norm. Second, ethical behaviour should be taught as well as modelled in both formal and informal educational settings. Third, unethical behaviour should be identified as unacceptable, and there should be undesirable consequences for such behaviour.

In order to encourage the spread of (geo)ethical behaviours and practices in the geoscience community, the advantages of acting ethically, following ethical values and best practice, should be highlighted and fostered and given a central place in geoscience education. Conducting geoscience activities in a responsible way means finding wiser and cheaper technical solutions, winning the trust of clients and communities and earning professional and scientific credibility and legitimacy. At the same time, it is important to create cultural, social and legal conditions such that there is no advantage for geoscientists, within companies or acting as individual professionals, to act unethically, because of the negative repercussions on their reputation or in terms of penalties. This is not to minimise the intrinsic value of ethical action, but its beneficial aspects should also be emphasised. To follow such an approach is to recognise the value of utilitarian and deontological perspectives on geoethics, notwithstanding its primary characterisation as a virtue ethics.

2.4.3 Towards Society: Addressing Global Issues

Society faces a nexus of global challenges and these must be the overriding priority for science as well as for political and public debate and decision-making in the coming decades. Securing sufficient food, energy, raw materials and water for all, ensuring human health, managing competing demands for land, maintaining soil quality and protecting natural environments and ecosystems, locally and globally, are closely interlinked challenges. These are exacerbated by a large and growing human population, major movements of people (including urbanisation), past and present over-exploitation of resources, rampant consumerism in post-industrial societies and massive inequalities in wealth, health and access to resources. The 17 Sustainable Development Goals of the United Nations,[9] for the period 2015–2030, summarise and emphasise the importance of solving these issues as a joint challenge.

Climate change, as one feature of wider global environmental change, constitutes an existential threat to society and natural systems, requiring (among other work) the study of past climates, the continuous monitoring of environmental parameters and the modelling of possible scenarios to inform shared global political and social action. The 2015 COP 21 Paris Agreement, to which 195 nations are signatories, establishes shared objectives for limiting carbon emissions and provides a framework for the action and investment required for a low-carbon, resilient and sustainable future.[10]

Disaster risk reduction is another fundamental objective, achievement of which will depend on continued multidisciplinary research, development of early warning systems and monitoring networks, and information and capability-building campaigns aimed at citizens. The Sendai Framework for Disaster Risk Reduction 2015–2030[11] is the first major agreement of the post-2015 development agenda, with four priorities for action. It is an agreement which recognises that the state has the primary role in preventing and reducing disaster risk but that responsibility should be shared with other stakeholders including local government and the private sector.

Geoscience has a vital role to play in addressing all of these challenges (Gill and Bullough 2017). At their heart are international efforts to build more effective global governance frameworks (Nickless 2017), and to increase the resilience and preparedness of communities, by developing and promoting appropriate tools, raising awareness and educational campaigns, and facilitating genuine multilateral communication and engagement. In this context, the competence of geoscientists, beyond the merely technical, becomes indispensable, and the ethical value of their expertise assumes global implications. We return here to the four generic social values in geoethics that were outlined earlier in the chapter—sustainability, prevention, adaptation and education—and provide illustrations of their relevance to these challenges.

[9] https://www.un.org/sustainabledevelopment.

[10] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

[11] https://www.unisdr.org/we/coordinate/sendai-framework.

Sustainable Development

Geoscientists recognise that natural resources in the Earth system are finite. Sustainability as a value (in some form) is almost universally acknowledged by human cultures, although it is not obvious how to define sustainability in different contexts.

In 1987, the Brundtland Commission of the United Nations introduced the concept of 'sustainable development', as follows:

> Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits—not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. (WCED 1987)

This definition links the concept of sustainability to the need for natural resource use and the right to economic and social development, especially for the world's poor. In the case of geo-resources, among others, sustainability is a concept deeply linked to human needs (Grunwald 2015). In a wider sense, this definition implies ideals of social and environmental justice, intergenerational justice, the fair distribution of resources and opportunities (equity), and the concept of democracy, since it calls, even if not explicitly, for a shared governance at the local and global level, triggering the concept of 'sustainability ethics' (Becker 2012; Ott 2014; Ness et al. 2017).

Sustainability is a value that, in practice, is still often disregarded or at least undervalued in current human development models and decision-making. Including it systematically and simultaneously in its environmental, social and economic dimensions needs a pervasive and ongoing cultural shift. The tangible results of human action affecting the Earth system are increasingly evident.

Treaties, agreements and conventions are beginning to establish internationally agreed principles and rules on which to base our behaviour regarding resources, pollution, climate and sustainability, and to find an acceptable balance between environmental protection and economic and social development. At the root of geoethics is the idea that there is a unique community of life on Earth, of which humankind is an inseparable part. Earth is humankind's home, on which our life and future depend. Therefore as humans we must respect the Earth and its natural systems and pay attention to how we interact with it, with the awareness that being part of this community of life involves considering the prudent use of its resources and the conservation of its ecosystems. But it is equally evident that it is necessary that development and sustainability must coexist and that we should explore how they can be reconciled, for example, through concepts such as 'restorative sustainability'—that is, ensuring that interventions like resource extraction do net good rather than net harm (Wessel 2016).

The contribution of geoscientists is indispensable on different levels (Stewart and Gill 2017), not least in revealing some hidden contradictions and ambiguities. Often, choices that are widely considered more sustainable or more environmentally friendly than others may not be, at least in an absolute sense. For example, many technologies and strategies for reducing fossil fuel use will require very significant quantities of mineral resources—these include many metals which have not previously been widely used, as well as bulk metals like copper (Nickless 2017). The extraction and processing of these minerals and the complex interlinked global supply chains that stem from them, if not carefully managed, pose significant environmental risks, as well as potential social harm in the form of 'conflict minerals', human rights abuses in the artisanal mining sector (including in relation to child labour) and many other less visible impacts on communities. Such contradictions and ambiguities must be identified and addressed with relevant stakeholders and communities. The geoscientist also has the ethical responsibility to use geoscience knowledge to help frame these problems, inform decision-making and facilitate effective and sensitive implementation of these decisions.

Prevention: A Common Resource for Defence Against Georisks

As clearly indicated in the Sendai Framework for Disaster Risk Reduction, strategies aimed at protecting communities against georisks require the engagement and partnership of all parts of society. In line with concepts developed in the framework, geoethics aims to improve the relationships between the geoscience community and other actors in society (such as decision-makers, local authorities, government agencies, the media and citizens) during all the phases that characterise the disaster cycle (from prevention to emergency and recovery phases). Each of these actors, with a specific role, commitment and responsibility, is part of a 'defence system' against impending risk (Di Capua and Peppoloni 2014; Dolce and Di Bucci 2015; Peppoloni and Di Capua 2017b).

Moreover, geoethics contributes to strengthen the science–society interface, promoting some important actions that involve the social responsibility of the geoscientist (Di Capua and Peppoloni 2014; Limaye 2015; Peppoloni and Di Capua 2017b), such as the accurate and appropriate dissemination and communication of results of scientific studies on geohazards (Liverman 2009; Marone et al. 2015a, b; Foresta Martin and Peppoloni 2017), the development and promotion of geo-educational tools to improve knowledge about risks and improve the preparedness of the population (Frankenberg et al. 2013) and the participation of hazard-prone populations in bottom-up risk communication approaches (Ickert and Stewart 2016; Stewart et al. 2017) to increase community resilience.

However, we must not neglect some current limitations to the effectiveness of risk communication, well highlighted by Wachinger et al. (2013)—what seems obvious, namely that a high level of risk perception will lead to personal preparedness and to subsequent risk mitigation behaviour, is not necessarily true. This point should be considered for the purposes of risk governance and communication, and when considering the willingness of individuals to invest in risk preparedness or risk mitigation actions.

Nowadays geoscientists are able to predict or forecast, with varying degrees of uncertainty, the onset and development over time of some natural phenomena. Concepts such as probability, error and uncertainty are expressed mathematically in order to assess hazards and develop appropriate policies in risk management, even in the absence of complete scientific certainty about causes and evolution of phenomena (Albarello 2015; Potthast 2015; Tinti et al. 2015; Beven et al. 2018a, b). Moreover, the progress made in science has facilitated the generation of new tools to defend society against natural risks, such as new methods for the continuous monitoring of phenomena, use of early warning methods, efficient building techniques to ensure safety, adequate prevention programmes, careful land management and appropriate education for citizens. All these activities can be considered 'prevention', as framed earlier. Prevention in this broad sense can make multiple contributions to achieving safer ways to live with georisks.

Risks are not entirely avoidable, but they can be reduced below a threshold that society considers acceptable. The earthquake engineer Giuseppe Grandori (1921–2011) defined the acceptable limit of risk to society through this short statement:

> Defending oneself from earthquakes means reducing the consequences of earthquakes (casualties and property damage) below a limit that society considers acceptable, considering the costs that a further reduction of the limit would imply.

This statement reminds us of the need for prudence and common sense, concepts on which the general vision of geoethics is based. Applying the values of prudence and common sense to real-world cases helps us to limit mistakes and overcome doubts about the choices to be made to minimise negative consequences.

In every circumstance where a risk is present, it is necessary to assess the benefits as well as the costs of a risk mitigation strategy. A strategy which today may seem wasteful could be effective when evaluated in a broader perspective, looking at all likely outcomes. As a consequence, prevention must be considered not only in terms of cost savings but primarily as a social and cultural attitude that bears fruit especially when taking systemic and long-term perspectives, so as to avoid irresponsibly transferring the social and economic costs of a disaster onto the shoulders of future generations or distant communities (Di Capua and Peppoloni 2014; Hocke 2015; Peppoloni and Di Capua 2017b).

In these terms, prevention is a value, despite human societies not perceiving it as such. It should be the duty of geoscientists, as experts in risk, to transfer this value to society, as a rational and responsible response to the right to safety of each citizen.

Adaptation to Climate Change

With reference to biological systems, 'adaptation' is the process by which living beings adapt morphologically and physiologically to environmental conditions, determining not only the fate of individuals and populations but the success or failure of a species in evolutionary terms.

Humanity has always had to adapt to environmental changes, initially in biological terms but also through cultural adaptation (Foley et al. 2013). Today, adaptation signifies the need for technological, energetic, economic and cultural change processes, in response to changed environmental conditions (Klein 2011). In this perspective, in times of climate change, adaptation becomes a necessary social and cultural programme, however successful (equally necessary) prevention efforts may be. Making ethical decisions to inform adaptive programmes will require a new way of understanding the interdependencies between socio-technical human systems and Earth systems.

Climate change adaptation seeks to reduce the vulnerability of social and biological systems and to mitigate and offset the effects of global warming, albeit with 'barriers, limits and costs which are not fully understood' (from Climate Change 2007: Synthesis Report[12]). Adapting and mitigating can mean reducing vulnerability and increasing community resilience (Adger et al. 2005), reducing system or community sensitivity or building capacity to adapt. It may also present opportunities for development (Betsill 2001; Conway and Schipper 2011), for example, as a result of investing in new research and technologies, a reduced vulnerability to other hazards or development of novel and sustainable economic pathways. Increased global awareness of our interdependence and therefore the need for common responses is also a significant consequence in itself, which could push citizens and governments to assume a more active attitude.

The challenge for human communities is to govern this adaptation responsibly, not only in technological but also cultural terms. From this point of view the COP 21 Paris Agreement, despite having debateable direct impact, demonstrates the growing political will of the international community in this direction—a common conscience is developing. An earlier exemplar is the successful adoption of policies to counter the destruction of the ozone layer, which are now recognised as having done much to reverse ozone depletion in the 2000s, thanks to the 1987 Montreal Protocol.[13]

In light of these new societal conditions, the geoscience community has a momentous ethical responsibility (Kowarsch et al. 2016). Geoscientists exploring the implications of geoethics should not shy away from contributing innovative and context-specific responses to inform responsible decision-making and actions.

Geo-Education: A Duty for Geoscientists, a Benefit for Society

The advancement of geoscience knowledge has been fundamental for humankind, facilitating the development of modern thought and culture, and ensuring progress and well-being for societies. In the past, geoscience has posed philosophical problems, and even today it continues to be a fundamental part of human culture (Peppoloni and Di Capua 2012).

[12] https://archive.ipcc.ch/publications_and_data/ar4/syr/en/spms4.html.

[13] http://ozone.unep.org/montreal-protocol-substances-deplete-ozone-layer/32506.

Geoscience, with its methods, objectives, reference values and ways of thinking about nature, is not only a corpus of technical and scientific knowledge, useful for solving the complex problems of management of the planet, but also an essential cultural support that should accompany the practical response to such problems.

As asserted by Henri Poincarè (1854–1912) and others, science is a fundamental aspect of culture. Since geoscience is science, this implies it is part of culture (Peppoloni 2012). Indeed geoscience, through its discoveries, visions, methods and definitions, has made and makes culture, by building a constellation of concepts to be used to understand the world (Seddon 1996; Raab and Frodeman 2002; Peppoloni and Di Capua 2012).

Geo-education is the activity that allows geoscientists to use those visions, methods and definitions to transfer to others a way of conceiving the cosmos. Scientific concepts and theories, such as deep time, evolution and plate tectonics, are fundamental keys for interpreting the universe and the observations, technologies and hypotheses through which we perceive reality. Geo-education implies ethical responsibilities. It is not a neutral and value-free activity. It provides a framework for transferring knowledge about forms, processes and products of natural or human-induced dynamics, past and present, on our planet and other celestial bodies. But it is also a tool for stimulating critical thinking.

Geo-education has great potential in ethical terms, due to the strong connection between geoscience knowledge and societal benefits. It can shorten the distances between scientists, public audiences and decision-makers, increasing public trust in science, preventing the cultural and social marginalisation of scientists and fostering the development of a 'knowledge-based society', in the best sense of that term (Bobrowsky et al. 2017; Peppoloni and Di Capua 2017a).

This is clearly evident when considering protection strategies against risks, where insufficient preparedness results in low risk perception, exposing communities to greater vulnerability to possible natural phenomena. Citizens are usually considered as passive actors in risk scenarios or in decisions on land management, while in fact they can play a key role (Stewart et al. 2017). They must be empowered to contribute constructively.

Activities grouped under the concept of 'citizen science' (discussed further in Chapter 3) are developed with this objective in mind. The

Oxford Dictionary[14] defines 'citizen science' as 'a scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions'. It is a scientific activity in which non-professional scientists voluntarily participate in the collection and analysis of data, the development of technologies or studies of natural phenomena, among other activities. Citizen science is based on the idea that scientific knowledge and communication is not a one-way street (De Rubeis et al. 2015) and that citizens can provide scientists with support, increased capacity and capabilities, a wider range of perspectives and indeed insights that otherwise may have been overlooked. Citizen science has both great educational and ethical value in that the involvement of citizens in scientific endeavour generates knowledge, understanding, awareness and responsibility. Citizens benefit from taking part in research, contributing to scientific evidence and addressing local, national and international issues that are relevant to them. In doing so, they can become better equipped to engage in societal debates and influence political choices.

Promoting geosciences in society through geo-education implies introducing innovative methods and tools to teaching, aimed at developing students' and citizens' critical thinking and observational capabilities. Geoscientists involved in geo-education exemplify geoscience practice as a geoethical duty towards society.

2.4.4 *Tools for Geoethics-Oriented Practice*

As noted above, the translation into practice of geoethical values is represented in professional settings by codes of conduct, which prohibit inappropriate practices and foster proper ones. Codes are a very useful tool to prevent, monitor and control inappropriate practices and policies. But their adoption is not always sufficient on its own to increase the ethical standards of a scientific and professional community. Poor practice, unethical behaviour, research misconduct and conflicts of interest continue to threaten the credibility of the geoscience community (Peppoloni and Di Capua 2017a).

The observance of ethical practices included in such codes should not be confused with the essential ethics education and training that each

[14] https://en.oxforddictionaries.com/.

geoscientist should receive in their university education, to assimilate ethical values and foster high standards of personal integrity and responsibility. It is essential to embody the value before the code, to make sense of an ethical action (Cronin 2017; Peppoloni and Di Capua 2017a). To encourage ethical behaviour in the geoscience community, geoscientists should be motivated to respect professional codes. This means transferring to them the values that lie behind them. Ethics must also constitute a fundamental part of continuing professional development and lifelong learning. Geosciences are based on experience, so the reference values of geoethics that must accompany the practice of geosciences should be constantly redefined and verified in light of evolving knowledge, experience and context.

The importance of promoting ethical behaviour within the geoscience community was clearly highlighted in the Report of the GSA Presidential Conference held in Oregon in 1997 (Geological Society of America 1997):

> Individual integrity is not enough: to be truly ethical, one must have personal integrity as well as an on-going awareness and insight into the ethical problems existing throughout the geoscience profession. In other words, geoscientists must become alert to, and active in, the subject of ethics in order for the practice of geology to be truly ethical.

The need to increase awareness of the ethical obligations of geoscience activity was formalised in (2014) by Matteucci et al., with the publication of the 'Geoethical Promise'. It is a Hippocratic-like oath for geoscientists, previously suggested by Ellis and Haff (2009), aimed at early-career researchers and professionals but also helpful to motivate the geoscience community as a whole. It is a symbolic document to highlight the ethical and social value of the geoscience profession and the cultural and educational power of geosciences. The Geoethical Promise is founded on the idea that a standard or a code cannot be enough to ensure ethical behaviour and that ethics must be something inherent to one's daily action, a committed adherence to a *modus vivendi et operandi*.

In its formulation, some principles and reference values are stressed: the necessity to be aware of the societal implications of geoscience practice; responsibilities towards society, future generations and the Earth for sustainable development; the obligation to act for the protection of the Earth system and the benefit of mankind; the need to maintain intellectual honesty in conducting one's work, being aware of the limits of one's personal competencies and skills; and the commitment to continue a lifelong development of one's geoscientific knowledge.

In 2018, the Geoethical Promise was included as an official declaration during ceremonies for geological master's degrees in Italian universities and has been translated into 35 different languages (Peppoloni 2018).

Another significant achievement in promulgating geoethical thinking has been the release of the Cape Town Statement on Geoethics (CTSG)[15] in 2016. This document provides a definition of geoethics, sets out its purpose, scope and fundamental principles, and outlines its application and the ethical responsibilities of geoscientists in the context of global challenges. It is founded on a coherent conceptual framework structure and constitutes an important step in promoting geoethics to the wider geoscientific community and beyond (Di Capua et al. 2017).

The CTSG aims to focus the attention of geoscientists on the development of shared policies, guidelines, strategies and tools, with the long-range goal of fostering the widespread adoption of ethical practices in the geoscience community. It encourages geoscientists to become more aware of their responsibilities, to strengthen the credibility of geosciences in order to secure societal trust in light of global challenges and to reaffirm an ideal dimension to the geoscience profession, going beyond simple personal success.

The global impact of the CTSG on the geoscience community has been assured by the support of many international geoscience organisations. Its translation into the most widespread languages worldwide (Peppoloni 2018) has emphasised the importance of sharing universal values and creating a common professional identity across diverse societies and cultures.

One of the first concrete applications of the values expressed in the CTSG has been the 'White Paper on Responsible Mining', released in December 2017 (Arvanitidis et al. 2017).

The White Paper addresses values, concepts and best practices to be considered when undertaking mining activities from the perspective of sustainable development. It is an orienting document, aimed at providing essential reference elements to frame mining activities in an

[15] http://www.geoethics.org/ctsg.

ethical perspective, and to urge different stakeholders to ensure that geo-resources are extracted and used responsibly. This requires the protection of natural environments by minimising the impacts of mining activities, increasing respect for local populations and awareness of their needs (Groulx et al. 2017), the adoption of high standards and improved health and safety conditions in the working environment, as well as the development of innovative technologies and the implementation of environmentally and socially sensitive best practices.

The White Paper highlights that:

> … responsible mining demonstrably respects and protects the interests of all stakeholders, human health and the environment, and contributes discernibly and fairly to broad economic development of the producing country and to benefit local communities, while embracing best international practices and upholding the rule of law.

2.5 A 'Responsible Anthropocentrism'?

It is evident that the biotic and abiotic components of the Earth system (including humanity) are closely interlinked. Some authors have gone further, arguing that our planet essentially behaves like a single living organism with its own physiology and metabolism. Pierre Teilhard de Chardin (1881–1955) and Vladimir Vernadsky (1863–1945) theorised about the development of the Earth, from the geosphere (inanimate matter) to the biosphere (living matter) to the 'noosphere' (the sphere of human thought—a concept discussed further in the following chapter), and the interconnectedness of these systems. In 1979, James Lovelock developed the 'Gaia hypothesis' in his book *Gaia: A New Look at Life on Earth* (Lovelock 1979), in which he conceived the Earth as a complex and living super-organism capable of regulating itself. Although not universally accepted by geoscientists, as in the case of the paleontologist Peter Ward and his 'Medea hypothesis' (Ward 2009), it has been profoundly influential on Earth systems science, our growing understanding of the feedbacks between life and the planet and our appreciation of their significance.

The hypothesis of Earth considered as a single living system has over time been the key point of reference for many ecological visions. Today, the idea of humanity being part of a greater whole, encompassing the planet and all living things, is undoubtedly influential on the growing recognition that we must pay greater attention to the environment and its protection. But this conception is certainly not new. For example, Seneca (4 BC–AD 65) in the *Naturales Quaestiones* (III, 15, 1) writes: 'placet nature regi terram' (meaning 'it is a shared opinion that the Earth is supported by Nature'). In describing his idea of the Earth system, he compares the water that flows in a river with the blood flowing in human veins and with the lymph that flows along the trunk of a tree. Two thousand years later, this analogy invites us to reflect on the fact that all things belonging to the Earth system (living or otherwise) are closely connected. It is up to human beings to consider this close connection while taking decisions about the environment and our interactions with it.

The extent to which humanity now affects the Earth system, including the geosphere (referring here, and throughout this book, to all abiotic elements of the Earth system—not just the solid Earth), is reflected in the proposal currently under consideration to declare a new human-influenced geological epoch—the Anthropocene. This notion is contested and criticised, and not only on geological grounds or among geoscientists (see Cuomo 2017, for example)—as are 'anthropocentric' world views more generally. Even more contentious are explorations of whether a 'good Anthropocene' is possible and what this might look like (Preiser et al. 2017). This is perhaps unsurprising given the utopian optimism of some 'ecofuturist' scholars who embrace the term and are convinced that human ingenuity and technologies will be able to fix and control natural systems (Asafu-Adjaye et al. 2015; Bohle 2017). But other scholars explore the concept of the 'good Anthropocene' in a more nuanced and inclusive way, fully recognising that, while we already live in a world that has been irreversibly changed by human intervention, we must do all in our power to understand and minimise our future impacts and shape a future that addresses the needs of people, communities and ecosystems (Biro 2015; Dalby 2016; Pereira et al. 2018). The question of how humankind should live responsibly in such a world is explored in greater depth in the next two chapters.

Whether or not the Anthropocene is formally recognised as a new geological epoch, humanity is now undeniably a significant geological force acting on natural environments. A worldview that fails to acknowledge the central role of human impacts on Earth systems and the need for humanity to take responsibility for this is simply one of denialism (Jonas 1984). The unavoidable reality of anthropogenic change makes a degree of anthropocentrism a necessity.

Geoethics encourages geoscientists and wider society to become fully aware of humankind's role as an active geological force and of the huge ethical responsibility that this implies. It also provides professional geoscientists with the tools to work for the good of society and the planet as a whole in order to meet this responsibility, through ethical behaviour and practices, respectful of all humanity, as well as geodiversity and biodiversity (Peppoloni and Di Capua 2017a). With its emphasis on the individual and collective responsibilities of human actors (geoscientists and others), geoethics can help guard against fatalistic or opportunistic acceptance of anthropogenic change and against human wants and needs (especially those of the wealthy) being given primacy at the expense of impacts on wider systems that might otherwise be framed (by those wishing to brush over environmental concerns) as simultaneously peripheral and inevitable.

What is at stake is not the survival of the Earth, which will be able to absorb the consequences of human activities, but the wellbeing of living things and ecosystems, people and communities, and perhaps the very existence of humanity on the planet. To ensure that we survive and thrive, the first step to take is to empower people—geoscientists and others—to be responsible. Geoethics has a vital role to play in achieving this.

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CHAPTER 3

Exploring Societal Intersections of Geoethical Thinking

Martin Bohle and Rika Preiser

Abstract This chapter explores geoethical thinking as a means for offering alternative modes of living in a world where humans and natural systems are inextricably linked. Real-world examples demonstrate the societal relevance of geoethics. Four essays illustrate different aspects and specific contexts. The first explores the societal significance of geoscience as a 'stewardship-science' and elicits the often hidden influence of geoscience in contemporary societies. The second describes an adaptive and collaborative governance approach affording more sustainable futures for small-scale fisheries. This approach combines universal values with contextual practices to inform geoethics-inspired governance approaches. The third argues that more rigorous engagement with citizen science

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would demonstrate the societal relevance of geoethics. The final essay explores how 'society–Earth-centric' narratives can help citizens better understand their (inter)actions within the Earth system.

Keywords Geoethics · Earth system · Stewardship · Planetary human niche · Citizens' narratives

Global shifts are occurring in interconnected social, technological and environmental systems at such a scale and rate of change as to reshape the context in which decision-making and sustainable development interventions are taking place. In the face of global pressures on the environment and societies, like climate change, governments and other actors are increasingly dependent on reliable foresight capabilities to help them plan and test for potential future climate conditions and their interactions with other (economic, political, socio-cultural) uncertainties (Vervoort and Gupta 2018). Seeking to guide action for the unknown and unknowable future trajectories of changes to the Earth system is fraught with normative and scientific uncertainties and governance challenges. Now, more than ever before in the history of human niche-making endeavours, the drivers of global Earth system changes are linked to the unintended and non-linear effects of the cross-scale impacts of human actions (Ellis 2015; Steffen et al. 2015; Turner et al. 2016).

The central challenge of this interlinked condition of social and natural systems lies in the recognition that humans are dependent on natural systems for sustaining their lifestyles and livelihoods. At the same time this dependency is changing natural systems and resources in profound ways, resulting in unpredictable effects on natural systems, lifestyles and livelihoods (Fischer et al. 2015; Homer-Dixon et al. 2015). One of the most critical challenges facing people navigating this interdependency is examining and governing the trade-offs that inherently characterise land-use and sea-based activities to produce food, and the associated demands on water, energy and the environment (Kramer et al. 2017; Cashion et al. 2018).

Affluent human development is associated with processes of rapid global change. Many of the world's cities and regions now stand on the brink of making significant infrastructure investments (Elmqvist et al. 2018). The next few decades are likely to see a remarkable increase in global infrastructure investment, which will have profound impacts on the geosphere. The unpredictability of the effects of the decisions made, and trade-offs chosen, is of course linked to the fact that we now know that human actors are an integral part of the biophysical world (Schoon and Van der Leeuw 2015). The subsequent physical changes that we can observe in the geosphere are a direct result of the normative and value-driven decisions that influence land/sea-use changes and niche-making practices.

The aims and values proposed as constituting geoethical thinking in this book imply that addressing this challenge requires integrated governance approaches that account for the multiple interlinkages and dependencies that characterise coupled socio-ecological systems (Walker et al. 2006; Galaz et al. 2012; Biggs et al. 2015). Recognising that the interlinked dynamics of environmental and societal change can be better understood as being complex adaptive systems (Preiser et al. 2018; Liu et al. 2007) empowers geoscientists, other professionals and societal actors with conceptual frameworks and practical methods to study and navigate these dynamics more effectively (Audouin et al. 2013).

Developing normative guidelines for navigating uncertainties and non-linear dynamics requires conceptual innovation and integration across disciplinary boundaries. As Schmidt et al. (2016, p. 2) argue, traditional ethical frameworks that seek to generate 'universal maxims for right action (deontology) or those that make calculations of human welfare (consequentialism) mistakenly apply old normative categories in a new era that demands new conceptual foundations'.

In its aim to amalgamate views from various inquiries into geoscience research, professional best-practice guidelines and the imperative for societal engagement, this chapter offers examples of how conceptual innovation can be stimulated. Explicitly considered are: (1) the broader societal implications and relevance of the geosciences; (2) examples of policy innovation in processes that guide human niche-building practices; (3) promoting processes of participatory knowledge co-creation and sharing; and (4) developing society–Earth-centred narratives. This chapter comprises four essays that illustrate the possible ways to integrate normative strategies spanning a diverse set of knowledge and experiential domains. Crafting novel futures together in a world defined by complexity, diversity and uncertainty calls for creative, collaborative and experimental tools and methods that create spaces for transformative understanding and action (Pereira et al. 2018).

As such, the first two essays show how contemporary societies apply geoscience expertise, and hence depend on geosciences for their general functioning and governance of socio-ecological systems. The third essay describes why geoethical thinking and participatory research processes align. The fourth essay offers a framework for society–Earth-centric narratives, for fostering sense-making capacities drawn from geoscience expertise. Together these four essays demonstrate the societal relevance of geoethical thinking and the implications of geoethics in a broader context that extends beyond the habitual reach of geoscience professions.

By highlighting what kind of policy innovations are needed to guide, for example, small-scale fisheries in developing economies, we demonstrate that geoethical conceptual innovation should provide guidelines for navigating the uncertainty of human-induced change, the impacts of technological development and the effects of climate disruption. In response to these challenges, geoethical practices should foster context-specific governance strategies that are adaptive and collaborative to build resilient governance capacities. To enhance social resilience, for example, management policies that promote the actions of ecological stewardship groups should foster more collaborative people–place connections to build social capital based on knowledge sharing and learning. This goal suggests developing new, more engaged governance forms, like co-management, with a diverse set of multi-sectoral stakeholders.

Referring to issues that were outlined above, agent-centric governance approaches are to be favoured where human agency is considered to be accountable and responsible for its actions. Such governance approaches foster participatory knowledge co-creation between multiple stakeholders by encouraging dialogue between geoscience experts and citizens to develop capacities across various science–policy and societal interfaces. By aiming at conceptual innovation and normative resilience, geoethical thinking needs to critically reflect on the values that underpin the behaviour and practices that inform cultural and societal institutions. Geoethical thinking has the potential to co-shape cultural values by facilitating society-Earth-centric narratives that are essential sense-making tools for catalysing networks as well as collaborative and responsible action (Ingram et al. 2015; Lövbrand et al. 2015). Cultivating an understanding of what kind of norms and practices could inform responsible action is of course a crucial challenge for any ethical framework, especially if these actions are to inform context-dependent governance strategies. Developing new social norms (as geoethics is endeavouring to do, as presented in this book) goes hand in hand with the generation of knowledge and various platforms for communicating and disseminating new insights. Stimulating and fostering new narrative strategies as a form of knowledge sharing and sense-making, geoscientists, practitioners and community members may establish situational awareness and understanding of the conditions in which governance responses and geoethical considerations are to be realised. As a means of orienting oneself in domains of uncertainty and complexity, sense-making offers some practical reflections that enable the integration of diverse knowledge and experiences to inform more effective action and interventions.

The four essays relate to one another, yet each of them can be read on its own. The presentation is brief and simplified to align with the conceptual suggestion made here and the purpose of this publication. These concepts could be developed in more detail in the future, as such an exposition is beyond the scope of this book.

3.1 First Essay: Knowledge Base—Geosciences as a Stewardship Science

This essay illustrates the all-embracing use of geosciences in contemporary societies, be it for their economic activities or for setting values in social, cultural and individual contexts. Stated simply, understanding the features of rock, soil, water and air is essential to producing many goods. Artisans, technicians, architects and engineers apply geoscience expertise when altering environments or creating objects. Likewise, affection for the landscape, sea or minerals is part of a person's identity and influences their perception and attitudes towards the world (Peppoloni and Di Capua 2012). Here and in the following, the term geosphere shall name collectively the abiotic parts of the natural Earth system, consisting of the lithosphere, atmosphere, hydrosphere and cryosphere. In juxtaposition, the term biosphere shall be used to name the biotic parts of the Earth system collectively.

To capture the scale of how geoscience knowledge is used in contemporary societies, the meaning of the notion 'engineering' must be detailed. This essay will use the English word 'engineering' in the sense that it has, for example, in French or German languages. These languages refer to 'engineering' as '*génie civil*' (French for '*civil genius*' or '*Ingenieurskunst*' (German for 'art of engineering'), respectively. The rather restricted meaning of the English term 'engineering' does not capture the richer interpretation and connotations that the French or German languages allow, which communicate a more substantial meaning, namely the design and operation of purposely built and often larger scale environments of artefacts like human dwellings, production systems and consumption patterns. This re-framed interpretation of what 'engineering' means is essential to understanding the central position held by geosciences in the knowledge base of contemporary societies.

3.1.1 Intersections with the Geosphere, an Illustration

The phenomena that describe the intersections of human activity and the geosphere are pervasive. However, they may go unnoticed by many because they are implicitly present in the conceptual and practical structures of people's meaning-making. Hence, they constitute part of the cognitive frameworks that form people's practical knowledge, general education or specific vocational training. As such, insights into human–geosphere interactions may not be recognised because they are an integral part of our tacit cognitive understanding, interactions or experiences of the world.

Examination of the purpose and function of human engineering endeavours shows that they aim to design processes and mechanisms that give people access to resources to produce commodities, goods or services, such as transport, energy, dwellings, food or waste treatment. To achieve their purpose, engineering efforts must couple economic activities with processes in the geosphere. Hence, the overarching function of many engineering endeavours is to connect human activities with the geosphere. There are many specific examples (Viollet 2000; George 2000). Civil engineering works lead to visible interconnections between human spheres and the geosphere, for example, dredging a waterway, building a bridge or constructing a hydroelectric power plant. Other engineering works lead to subtler geomorphological changes to landscapes (Brown et al. 2017; Tarolli et al. 2018). Less visible intersections are the fluxes of matter, energy and information, which are embedded in the design of production systems and consumption patterns that couple human activity and the geosphere.

Vast aggregations of engineering exertions, like urban built spaces, constitute both a visible intersection with the biogeosphere and an invisible coupling through exchanges of matter and energy. These fluxes are massive. For example, cities receive drinking water and discharge wastewater, receive electrical power and fuels and emit heat, receive food and produce manufactured goods. At the end of their lifecycles these goods are discarded or recycled, either locally or elsewhere across the globe.

The accumulated impact of engineering of systems of production and consumption (Ellis 2011; Schwägerl 2014; Waters et al. 2016), which are harnessed to sustain a human population of currently 7 billion people, might be called 'terra-engineering'; see Chung et al. (2010) for 'terra-forming' that describes a hypothetical alteration of other planets to meet human needs. The successful engineering of Earth can only be made possible through concerted efforts to use geoscience expertise competently and responsibly. In this spirit, any engineering of solar radiation (an instance of what is habitually called geoengineering or climate engineering) is a deliberate use of geoscience expertise at the planetary scale, with a dedicated engineering purpose (Morton 2015). This kind of engineering at the planetary scale is not new, even though it was not described as such in the past. The Haber–Bosch process for the industrial fixing of nitrogen, supporting the modern agricultural industry, is one such example. Since the beginning of the twentieth century the global nitrogen cycle has been deeply altered (Zhang et al. 2015; Ren et al. 2017). The planetary change to the nitrogen cycle can be taken as a classic example of industrial 'terra-engineering/geoengineering'.

Besides physical interactions, the intersection of engineering systems and the geosphere is constituted as a societal process (Di Baldassare et al. 2015). How storm surges in the harbour of Hamburg have changed may serve as an example (von Storch et al. 2015). In recent years the River Elbe, downstream from Hamburg, was dredged so that bigger ships could reach the Port of Hamburg. The harbour is situated about 100 km upstream of the mouth of the Elbe estuary. After dredging, storm surges flowed more effectively through the deeper river channel and the flood risks in Hamburg increased. In response, river dykes in Hamburg had to be raised. During the decision-making process about how the hydraulics of the river might be altered, the possibility of relocating the harbour (or part of it) to the mouth of the estuary to keep the river channel unchanged was not a politically viable option. However, during the same period, construction of a new harbour on the German North Sea coast was undertaken: the 'Jade-Weser-Port' 150 km west of Hamburg (Weber 2005). Operating the Port of Hamburg at its current location and dredging the Elbe River was the best strategy for maintaining existing production patterns and also for maintaining Hamburg's political and cultural standing as a 'first class' international port. Surprisingly, given the expected long-term sea-level rise due to climate change (Slangen et al. 2016), a gamble is currently being taken; namely, whether the Port of Hamburg will be safe, whether the line of dykes can be kept and whether the 'Jade-Weser-Port' will be flooded.

3.1.2 Niche-Building and Stewardship

Generalising the reflections made so far in this essay, when considering socio-ecological systems on the planetary scale, the concepts 'human niche-building' (Ellis et al. 2013; Steffen et al. 2011; Ellis 2015; Fuentes 2016) and the 'Anthropocene' come to mind (Steffen et al. 2016; Zalasiewicz et al. 2017). The notion of the 'human niche' stems from ecological research and describes the processes and practices that people employ to make the biological environment fit for supporting human well-being. The notion 'Anthropocene' indicates that human niche-building goes well beyond shaping only biological environments.

Regarding the notion of the 'Anthropocene', it was initially coined by natural science research communities. Scholars in the social sciences and humanities have subsequently questioned it because it conceals responsible actors and historical contexts (Sayre 2012; Palsson et al. 2013; Haraway 2015; Lövbrand et al. 2015; Autin 2016; Rosol et al. 2017; Olsson et al. 2017). A comprehensive introduction to the current global changes and related societal impacts constituting the Anthropocene can be found in the book by Frank Biermann (2014, pp. 2–8). Notwithstanding scholarly debates, the term 'Anthropocene' seems a suitable shorthand for our times (Clark and Gunaratnam 2017; Walton and Shaw 2015; Veland and Lynch 2016; Lorimer 2017) because 'the genie is out of the bottle' (Lorimer 2017, p. 123).

An illustration of both notions (human niche and Anthropocene) can be giving by the damming of rivers. On one side, the design of a dam for a hydroelectric power plant relies on adherence to safety rules and the laws of hydrodynamics. On another side, the retention of water in the lake behind the dam depends, among other things, on the hydrological regime of its catchment area, the intended use of water downstream of the dam (e.g., for irrigation and shipping) and the societal needs for electrical power (Linton and Budds 2014). Hence, the design and operation of the dam in regular and extreme situations are done to appropriate resources for human use. To that end, the design decisions and rules of operation for dams in a river basin lead to value-driven societal choices that assess opportunities and risks (Sternberg 2008), often extending beyond single national constituencies. Only to a first approximation do dams only impact river hydrology (Sivapalan et al. 2012; Sivapalan 2015). Damming of rivers, for example, may result in the retreat of deltas (Syvitski et al. 2009). The Aswan Dam provides one well-studied example (Donia 2013; Abd-El Monsef et al. 2015; Sutcliffe et al. 2016). So far, a global consequence of damming many rivers is a relative, anthropogenically driven decrease in mean sea level of about 3cm (Fiedler and Conrad 2010; Slangen et al. 2016; Dangendorf et al. 2017).

Illustrating the Extent of Geosciences

The following list of geoscience disciplines, albeit eclectic and incomplete, offers an initial sense of the different disciplines that are included by the overarching notion of 'geosciences': atmospheric sciences, biogeosciences, cryospheric sciences, engineering geology, geochemistry, geodesy, geography, geomorphology, geology, geophysics, glaciology, hydrological sciences, limnology, meteorology, mineralogy, ocean sciences, petrology, physical geography, soil system sciences, sedimentology, seismology, tectonics, volcanology and more. Each of these disciplines has its own societal application. Hence, it can be seen that geoscience expertise is used by people in their daily endeavours, at least implicitly.

Nowadays, to support affluence in industrialised societies, organising global supply chains is the primary driver shifting the dynamics of the Earth system (Heede 2014; Golden et al. 2017). The ongoing globalisation of supply chains sets the extent to which contemporary geosciences are relevant for both the functioning of production systems and consumption patterns and people's daily lives, spanning work and leisure activities. Here are some examples. Geosciences inform architectural plans and practices that shape urban spaces with regards to choices concerning the stability of foundations for buildings and their exposure to natural hazards. Geosciences enable global positioning systems to make reliable estimates, despite magnetic storms hitting Earth. Australia will adjust its geodetic datum due to the rapid drift (~7cm/year) of continental plate on that it is situated.[1] Finally, in an obvious manner, geosciences infiltrate our homes by means of television weather forecasts.

Geosciences for Engineered Structures and Culture

At times of anthropogenic global change, all geoscience disciplines have societal relevance, albeit to variable degrees. As already emphasised, geosciences are applied rigorously in the engineering of production systems

[1] http://www.ga.gov.au/scientific-topics/positioning-navigation/datum-modernisation.

and consumption patterns. This feature is at the root of the societal impact and scope of geosciences. However, the societal scope and relevance of geosciences are also witnessed in the history of natural sciences and the cultural perception of nature, including its non-living parts.

Simplified, some centuries ago, geosciences included two or three main fields of study, namely mineralogy, geology and physical geography. Regarding the latter two, one discipline referred broadly to matters below the subsurface and the other to anything else. Both disciplines were deeply related to the quest to discover the Earth and to explore and exploit natural resources. To illustrate this point, in 1855 the US Navy officer M. F. Maury published the first modern treaty in oceanography (about the Gulf Stream along the east coast of the United States) to facilitate coastal transport. The publication followed shortly after a first international meteorological conference in history, which had been convened 1853 in Brussels to standardise marine observations (Dirección de Hidrografía 1863). Very soon after, the French hydrologist P. A. Terquem translated Maury's book under the title *Géographie Physique de la Mer* and published it in the Librairie Militaire, Maritime et Polytechnique (Maury 1858). Thus it can be noticed that the societal scope and relevance of geosciences in the past and present are similar, namely to support 'human niche-building' through intersecting with the geosphere.

It is becoming increasingly evident that people have purposefully altered their environments since prehistoric times at local, regional and/or continental scales. Such human niche-building is a historical process that has accelerated greatly since the mid-twentieth century and now also includes coastal zones and open seas (Mee 2012; Ellis et al. 2013; Bonneuil and Fressoz 2013; Duarte 2014; Latour 2015; Catlin 2016; Chew and Sarabia 2016). Since then, the human population has tripled, the world has become much more urbanised[2] and the affluence of people living in the developed world has increased very rapidly (Zalasiewicz et al. 2015). Under such circumstances, maintaining the correct functioning of socio-ecological systems has become a 'wicked' task, resulting in additional challenges to governance structures and people's capacities for sense-making (Brown et al. 2014; Hämäläinen 2015; Pollitt 2016; Termeer et al. 2016; Bohle 2018). Under such circumstances,

[2] United Nations, 2014: http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html.

geosciences also gain societal relevance because of the cultural and emotional relations and narratives that they can offer people to help them understanding the environments in which they live (Kleinhans et al. 2010; Stewart and Nield 2013).

To illustrate this, the cultural and emotional relations of people with geosciences take different forms. In some cases, the phenomena that geoscientists study trigger people's affective relations. For example, people like the sea, the mountains or minerals, and subsequently they may value geosciences that relate to the objects of their affection. Another relation to geosciences may be established through cultural activities, for example, people may visit geoparks or may admire geoheritage. Similarly, people's relations with geosciences may be established through points of intellectual reference. People may favour scientific concepts, such as ecosystem services or global change, because they relate to their values or to the worldviews to which they adhere. People may even appropriate a philosophical view and conceptualise the Earth as being a living planet (Hazen 2012).

Moreover, people may assign ethical values to the notion of pristine nature or a historical landscape. People may also be concerned about the morality and actions of others (individuals or groups) or may search for ways to relate to nature through artistic practices. A wide range of artworks portray geoscience phenomena in various forms because they triggered the curiosity of artists (Pizzorusso 1996; Bohle 2015; Pizzorusso 2015).

People's cultural and emotional relations with geosciences may be something other than 'to like' or 'to favour' something. They can also be negative, denialist, etc., for example, in relation to climate change; or they may be motivated by fear, for example, because of the threat of natural hazards. Furthermore, relations can have a different quality or strength and they can be ambivalent or may follow affective connotations that escape semantic logic (Salvatore et al. 2018a). Although such cultural and emotional relations as sources of the relevance of geosciences are somewhat evasive, they represent what people perceive as reality. Hence, they shape people's identities, including their attitudes towards geosciences, and contribute to what people value and share as part of their worldviews. Therefore such cultural and emotional relations support the societal relevance of geosciences and are part of its scope (Moores 1997).

Finally, these cultural and emotional sources of geoscience relevance are very much dependent on interactions between people and their symbolic practices that, in turn, enable them to share and communicate established norms and worldviews (Salvatore et al. 2018b). Once aggregated, they shape decision-taking and societal action and hence, ultimately, the dynamics and functioning of socio-ecological systems. Hence, the societal roles and responsibilities of geoscientists include to nurture the cultural and emotional relations of people with the subjects of geosciences, for example, through fostering Earth science literacy (Wysession et al. 2012).

Daily Niche-Building

So far, this essay has offered some perspectives to support the argument as to why geoscience expertise is vital for the functioning of contemporary societies; and thus why it is a kind of embedded house-holding expertise for the functioning of socio-ecological systems. Initially, it might seem that these perspectives offer only an account of some visible phenomena and physical features. However, a closer look suggests a complex image comprising societal features and mental processes. Geoscience expertise seems to be, to use a figurative saying, somewhat 'hidden underground', that is, in the depths of societal processes and people's behaviour and thinking. This makes it all the more difficult for the citizen to be conscious of how much the human niche depends on geoscience knowledge.

Geosciences, geoscientists and their work do not usually belong overtly to the regular and daily experiences of citizens. Typically, geoscientists are 'hidden away in the engine room of society'. The lucky exception is the weather report that shows a geoscientist in action on the television screen. Even if it is a presenter who is reporting the news, at least some geoscience expertise is being utilised in direct application to daily life.

To elaborate, the 'weather' represents possibly one of the most evident geoscience phenomena that sits at the intersection of the geosphere and human activities. Weather is a topic of primordial interest for most people (Orlove 2003; Strauss 2003; Veland 2017). Consequently, it offers an exemplary narrative of the relevance of geoscience expertise (meteorology), how such expertise has evolved over the last two centuries and how (scientific) weather-forecasting practices have become embedded in the functioning of contemporary societies. Other geosciences are comparably embedded in societal functioning but have not (yet) reached similar regular public visibility as meteorology, other than in the case of disasters and natural hazards.

The weather has had a significant impact on people (Sirocko 2012), whether in connection to where they live and settle, their food, mobility, production or conflicts. Weather news went ‘prime-time’ during the early 1950s. Since then, regular broadcasting of weather forecasts has become common. Meteorologists inform the public daily about their work. Before that state of public broadcasting was achieved, the art of systematic weather observations was practised for several centuries, supported by the development of instruments, communication technologies and common observation protocols and organisations (Dirección de Hidrografía 1863). Weather reports for specialised professional audiences have been produced manually and published since the mid-nineteenth century with increasing regularity. Numerical weather forecasting became feasible since the early 1950s. From those early days, it took half a century to build our current web of weather product providers and consumers (Lynch 2008; Bauer et al. 2015). Modern media combine, in a single narrative, weather forecasts with additional information on meteorological phenomena and news about potential impacts on economic and social activities. The reliability and accuracy of these forecasts directly impinge on the work and life of people who are dependent upon reliable information and professional practice.

A similar narrative about the development of a specific geoscience discipline, consisting of systematic observations, development of instruments, communication technologies, protocols, organisations, specialised professional audiences, numerical forecasts, providers of products, consumers, reliability, accuracy and sound professionalism, could be spun for geosciences other than meteorology, aside from the part relating to achieving regular public visibility.

Simple, Yet Abstract Concepts

Drawing on the examples that have been presented in this essay so far, we can attempt to derive some insights. To that end, some abstract concepts are outlined. (They will be taken up systematically in Chapter 4; building also on further explorations of the societal relevance of geosciences that will be presented in the remainder of this chapter.) These concepts aim to consolidate the contention that geoscience knowledge and the sound professional ethics of geoscientists are public goods.

Socio-ecological systems are constituted by natural and societal processes and consist of human systems and practices, natural systems and processes, and their dynamic intersections. Socio-ecological systems can change at various scales and exhibit non-linear system dynamics, multiple feedbacks and counterintuitive behaviour (Liu et al. 2007; Hulme 2011; Tickell 2011; Smith and Zeder 2013; Monastersky 2015; Seitzinger et al. 2015; Schimel et al. 2015; Bohle 2016; Head and Xiang 2016).

For the following, we conceptualise the global 'socio-ecological system' to be composed of a geosphere, biosphere and noosphere. The notions geosphere, biosphere and noosphere offer a simple answer to the question 'what is the Earth system?', to facilitate a better understanding of expressions like 'socio-ecological system' or 'composite of natural and societal processes'. The following discussion will start by describing the three notions geosphere, biosphere and noosphere in a manner that leads to a conceptual framework, which will enable readers to orientate themselves to understand the societal relevance of geosciences.

A century ago, when these three notions were coined, the notions biosphere and noosphere had a strong metaphysical undertone. Since then, scientific engagement with these concepts has resulted in the demystification of the notion biosphere. Still, the meaning of the notion noosphere might provoke metaphysical interpretations and may appear to be disconnected from the conceptual meanings attributed to the notions geosphere and biosphere (Moiseev 1989; Oldfield and Shaw 2006; Korobova and Romanov 2014; Hamilton and Grinevald 2015). Nonetheless, the meaning of noosphere can be amended so that it loses its metaphysical connotation. Instead, it can offer an orientation that relates to the meaning of geosphere and biosphere. Such an altered notion can help to explain why the intersections of people's activities and the Earth are much more than matters merely pertaining to geosciences, technology and economy but are as much a mirror image of their value systems, cultural choices, lifestyles, virtues and the practical justifications of their actions.

The terms biosphere and geosphere refer to two distinct categories. On the one hand, they refer to the physical features of the Earth system that comprises natural biotic and abiotic parts. On the other hand, the same terms are also used to describe the temporal and spatial processes that govern the interactions and transformations of these parts within the Earth system. Hence, the notions biosphere and geosphere refer to objects and their physical features as well as to how these are being processed. Both notions are used in a dichotomous manner to distinguish nature, and hence the biogeosphere, from the human sphere.

In its habitual usage, the notion noosphere does not refer to temporally and spatially dependent processes that govern the interaction of physical objects. Specifically, such an interpretation is proposed in the following, that is, that the term noosphere should refer to temporally and spatially dependent processes that govern the interaction of objects that have physical features. The proposed reinterpretation also captures the purpose of engineering, that is, to design, build and operate technological objects to sustain people's lives. So, to reinterpret the notion noosphere; first, the 'objects in the noosphere' are those physical structures and processes (objects) that are designed and engineered by humans. People, when making and using objects, undertake complex processing of their insights, whatever those insights might be. The processing is cognitive, highly flexible and may draw on multiple associations. It entrains people's cognitive and behavioural traits in building a mental model of the object, which is highly adaptive. Second, the 'processes in the noosphere' are constituted by the mental worldviews and processes that shape and govern human interactions. These processes include, for example, the mechanisms by which personal insights are developed (e.g., how to design, engineer and use physical artefacts), how these insights are shared among people and how they lead to people's actions (intentional and unintentional).

When altered in this manner, then, the notion noosphere refers to physical objects (e.g., engineered systems) and processes (e.g., thinking about how to engineer objects and their interaction). Thus the structure of the reinterpreted notion matches the structure of the notions geosphere and biosphere. By combining the notions geosphere, biosphere and noosphere, a conceptually simple description of the entire Earth system is possible, namely, of physical objects and processes that govern the interactions of these objects, including in relation to people who act and interact. Consequently, a unified description of the Earth system is conceived: 'a kind of hybrid Earth, of nature injected with human will, however responsibly or irresponsibly that will may have been exercised' (Hamilton 2017, p. 68). When considered like this, the Earth can be described as a multitude of socio-ecological systems, which comprise individual people and their activities, motives and knowledge, the interactions of people, human agency and societal processes as well as manufactured technological objects (simple and complex) and natural environments.

Conceptualising the Earth in the manner outlined above has implications for practising geosciences and understanding its societal meaning. First, when applying geoscience expertise, people are understood to be an inherent part of the system. Geoscience expertise is an operational skill of societal relevance. Second, whenever the intersections of the noosphere, biosphere and geosphere are altered, and hence the socio-ecological system is modified, these changes will impact on people. Consequently, people will judge alterations according to their values and insights into these intersections, and frame their actions accordingly.

To summarise the views outlined in this essay; engineering means to make and shape physical objects (or systems), which link human activity with the geosphere in a value-laden manner. Engineering also means to conceive (in the noosphere) how these physical objects (systems) are deployed to appropriate resources from the biogeosphere. Put differently, when using geoscience expertise, the engineering of, for example, production systems, urban dwellings and consumption patterns is the intended, value-driven alteration of the Earth system with the purpose of facilitating production of goods and services and, ultimately, biological reproduction. Therefore contemporary geoscience expertise and engineering are intertwined such that geosciences are among the stewardship sciences that shape the socio-ecological systems of which the Earth system is constituted.

3.2 Second Essay: Comparison—Fisheries and Geoethics

This essay, drawing on Bohle (2018), sketches what geoethical thinking may learn from other approaches for guiding the interactions of humans and nature. The guidelines of the Food and Agriculture Organisation (FAO) for small-scale fisheries (SSF) that are called 'Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication'[3] serve as an example. They were issued by FAO Member States in 2015. Based on a human rights approach, these guidelines aim to foster the sustainable development of fishing communities in coastal regions.

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

A relationship between the guidelines for small-scale fisheries and geoethics is established by combining four lines of inquiry and two ancillary notions, 'human niche' and 'Anthropocene'. The first line of inquiry, which is illustrated by the paper 'Global change and the future ocean: a grand challenge for marine sciences' (Duarte 2014), describes the state of the global ocean and coastal seas under the impact of anthropogenic global change, that is, within the Anthropocene. The second line of inquiry, which is illustrated by the paper 'Global Ocean Governance: New and Emerging Issues' (Campbell et al. 2016), describes marine issues of concern, such as small-scale fisheries, ocean acidification, seabed mining or blue carbon, for which developing better marine governance arrangements is critical. The third line of inquiry, which is illustrated by the paper 'Walking the talk: implementing the international guidelines for securing sustainable small-scale fisheries' (Jentoft 2014), emphasizes that governance is the key challenge to implementing the FAO SSF Guidelines. The fourth line of inquiry, which is illustrated by the book 'Earth System Governance—World Politics in the Anthropocene' (Biermann 2014), shows that the implementation challenge of the FAO SSF Guidelines is a realisation of the common challenge: how to govern the global commons sustainably?

The global commons are socio-ecological systems, which are composed of human systems and practices, natural systems and processes, and their intersections. Socio-ecological systems exhibit non-linear system dynamics, multiple feedbacks and counter-intuitive behavior that can change simultaneously on a local, regional and planetary scale (Hulme 2011; Tickell 2011; Monastersky 2015; Seitzinger et al. 2015; Schimel et al. 2015; Preiser et al. 2018). When considering planetary-scale socio-ecological systems, an implicit reference is made to the notions 'human niche-building' (Ellis 2015; Fuentes 2016) and 'Anthropocene' (Steffen et al. 2016; Zalasiewicz et al. 2017). As noted in the previous section, although the notion Anthropocene might be ill-conceived because it may conceal actors, responsibility and historical contexts, it is a shorthand for our times (Sayre 2012; Palsson et al. 2013; Haraway 2015; Lövbrand et al. 2015; Walton and Shaw 2015; Autin 2016; Chakrabarty 2016; Veland and Lynch 2016; Clark and Gunaratnam 2017; Lorimer 2017; Olsson et al. 2017; Rosol et al. 2017). *Mutatis mutandis*, philosophers may say that 'the Anthropocene for the first time gave birth to a universal "Anthropos"' (Hamilton 2017, p. 118) in the human niche.

3.2.1 Small-Scale Fisheries as Part of Building a Human Niche

Since prehistoric times, people have purposefully altered their environments at the local, regional and continental scale, including coastal zones (Mee 2012). Niche-building is a historical process (Bonneuil and Fressoz 2013; Latour 2015). It is acknowledged (by many) that cumulative anthropogenic change in natural environments has triggered a new stage of the Earth system—the Anthropocene—that, for some, is functionally different from the Holocene (Waters et al. 2016). Some consider that the onset of this new stage happened at the middle of the twentieth century (Zalasiewicz et al. 2015). Since then, the human population has tripled and, more importantly, the affluence of people living in the developed world has increased dramatically. The subsequent impact on the marine environment is recognised in the 14th United Nation's Sustainable Development Goal, that is, to 'conserve and sustainably use the oceans, seas and marine resources'.

Aimed at building and maintaining prosperous standards of living in industrialised societies, the many processes of production that together constitute global supply chains are the main drivers that are currently shifting the dynamics of the Earth system (Heede 2014; Golden et al. 2017). The cumulative effects of local or artisanal activities also have an impact, triggering shifts in environmental systems already strained by industrial exploitation. The collapse of the small-scale fisheries off Central West Africa may serve as an example (Galaz et al. 2011, pp. 7–8):

> Fish stocks have declined along the Central West African coast to a large extent due to rapid exploitation by high-tech international fishing fleets and due to the degradation of mangrove forests, seagrass beds and coral communities because of, for example, climate change and pollution. Consequently, diets and trading activities shift to so-called 'bushmeat' such as chimpanzees and flying foxes. These are well-known sources of zoonotic diseases such as Ebola, Marburg viruses and human monkey-pox … The combined impacts of fish stock decline, epidemic outbreaks, additional losses in ecosystem services, water stress, and poverty put already fragile states such as Congo and Cameroon under severe pressure.

Turning from this example to understand more general patterns of transformed marine systems, small-scale fisheries in the context of industrialised use of the coastal zone provide a key example of how people are changing the marine environment (Newton et al. 2012; Pauly and Zeller 2016). The small-scale fisheries business (artisanal, subsistence and recreational) contributes about half of the global catch of fish and employs about 90% of the respective workforce, as outlined in the FAO SSF Guidelines (p. 4). Small-scale fisheries have the potential to contribute to better sustainable development approaches of many (not only developing) countries because they contribute directly to food and livelihood security, balanced nutrition, poverty reduction and wealth creation, foreign exchange earnings and rural development. Therefore in June 2014, after a decade-long process, FAO Member States endorsed voluntary FAO SSF Guidelines, offering a comprehensive framework consisting of several building blocks.

Facilitated by the political choice to make the adherence of stakeholders voluntary, it was possible to make the FAO SSF Guidelines comprehensive in terms of topics covered. They could integrate social, cultural and economic sustainability issues and address resource access (allocation) as well as being guided by human rights principles. Founded on human rights-based approaches to social development and an empowerment process for community organisations (including the decision-making power of women), the FAO SSF Guidelines argue in favour of adaptive co-management strategies that acknowledge the importance of traditional knowledge systems and the customary rights of indigenous communities. Further essential building blocks of the FAO SSF Guidelines highlight the need to protect (and to legislate for) the rights of small-scale fishing communities to fishery resources and land, and to promote market access through improved post-harvest handling and access to credit. Furthermore, emphasis is also placed on supporting diversified livelihoods, including access to essential social services and overarching capacity building interventions and networking opportunities. Hence, the FAO SSF Guidelines provide an opportunity to develop a coordinated strategy for institutional and individual actors to safeguard the sustainability of small-scale fisheries and their communities. However, implementing the FAO SSF Guidelines will require developments in policy intervention and innovation on many levels, contributions of civil society organisations and academia, and the empowerment of fishers as participants in decision-making processes. Hence, effective implementation of the FAO SSF Guidelines, whether at local, national, or regional levels will have to package many threads of action in a context-specific and actor-dependent manner (Jentoft et al. 2017).

3.2.2 *Entangling Small-Scale Fisheries and Geoethics*

This section offers three threads of thought.

First Thread: Bearings, Complexity and Scales

Niche-building seems to be a generic activity of our species (Bonneuil and Fressoz 2013; Zalasiewicz et al. 2015; Fuentes 2016). It is evident that human niche-building practices also affect coastal seas. In 2016, the United Nations Economic and Social Council identified five coastal seas 'at risk from coastal eutrophication'.[4] Likewise, niche-building affects the world's oceans; Duarte (2014) gives multiple references to support this argument and summarises:

> The rapid increase in human population since the industrial revolution and their preferred settlement in coastal areas … has led to a major physical transformation of the shoreline … associated with the widespread loss of habitats fringing the shoreline … Together with human settlement in coastal areas, changes in the land use in watersheds and river regulation through the massive construction of reservoirs over the past 60 years have affected the delivery of materials, from sediments and organic matter to nitrogen, phosphorous … Efficient atmospheric transport also delivers dust, organic carbon, nitrogen and pollutants to the most remote regions of the ocean …. (pp. 4–5)

He mentions further the underlying issues that represent stumbling blocks to addressing these changes to global socio-ecological systems:

> … the largest source of uncertainty rests with human drivers, as not only social dynamics and shifts in the consumer attitudes are difficult to forecast, but the introduction of new, disruptive technologies are intrinsically unpredictable … A third source of uncertainty is the prevalence of non-linear systems that can lead to abrupt changes … departing from the linear, smooth responses that are amenable to prediction …. (p. 6)

These three general issues, namely the uncertainty regarding human drivers, the impact of disruptive technologies and the behaviour of non-linear systems, are frequent features of terrestrial and marine socio-ecological

[4] https://unstats.un.org/sdgs/files/report/2016/secretary-general-sdg-report-2016--EN.pdf, Vol. E/2016/65, p. 18.

systems. These features make sustainable governance of these systems a tough problem. The multiple spatial scales (local, regional and global) of these systems, the diversity of actors and their shifting attitudes towards exploitation and governance of resources add to the complexity. Geoscientists have shaped geoethical thinking to handle uncertainty and to address multiple scales and the diversity of actors; hence, geoethical thinking aligns with thinking underpinning the FAO SSF Guidelines.

Second Thread: Context Dependence in Socio-Ecological Systems
Over the last 200 years, people have considerably developed their skills to appropriate resources from terrestrial and marine environments. Depending on how skills have developed, the perceptions of people have varied as to what appropriate exploitation and governance practices are. For example, Purdy (2015) describes the history of public opinion and politics in the United States relating to how terrestrial wilderness was perceived and how a specific worldview reinforced the right, or even the moral obligation, to exploit such resources. In the same manner, the marine environments were portrayed as 'unpeopled spaces of nature, but not society … [that] support a commitment to freedom of the seas' (Campbell et al. 2016, p. 519). Such a perception of freedom supports exploitation by actors that have the necessary means to do it. For example, some decades ago, the notion of a 'common heritage of mankind' qualified the conditions that would justify the mining of mineral resources on the ocean floor. Nowadays, when mineral exploitation in deep waters is more feasible, this view is challenged (Silver et al. 2015; Campbell et al. 2016; Jaeckel et al. 2017). Correspondingly, views (of the individual actor and of codified guidance) vary regarding what is sound exploitation and rightful appropriation (Vidas 2011). The context for planning, decision-making and action shifts depending on both the abilities of the various actors to exploit resources and the actors' understanding of fair appropriation rights; reflecting what, in Campbell et al. (2016, p. 519), is termed 'three environmental governance themes: "actors, scale and knowledge"'. To manage context-dependent systems requires strategies which (1) by nature are adaptive, participatory and transdisciplinary (Head and Xiang 2016), (2) apply a collaborative rationality (Innes and Booher 2016), and (3) provide for a governance capability, which Termeer et al. (2016) frame with attributes such as reflexivity, responsiveness, resilience, revitalization and rescaling. Such strategies are a genuine part of the FAO SSF Guidelines and make context-dependence an explicit part of their design (Jentoft 2014).

Geoscientists have shaped geoethics to navigate context dependence, uncertainties and ambiguous situations experienced in their professions. This feature aligns the thinking that underpins geoethics and the FAO SSF Guidelines. Analysed in that perspective, it is essential that geoethics examines and reflects upon the role of societies, people and individual citizens, their skills and insights, and their activities to appropriate geo-resources (Peppoloni and Di Capua 2015, 2016). As Bobrowsky et al. (2017, p. 207) summarise: 'geoethics is an orientation tool for geoscientists, able to provide them with the ethical dimension of their actions'. This focus encompasses (1) the responsibilities of individual geoscientists and their services to society, (2) how to conduct and communicate research, and (3) the functioning of professional organisations and commercial activities. Such considerations deeply entangle geoethics and the FAO SSF Guidelines.

Third Thread: Agent-Centric Approaches to Governance
Geoethics is distinct from utilitarian concepts, ethics of justice or conservation for its own sake—approaches which have been discussed elsewhere in respect of ocean ethics (Auster et al. 2009; Ott 2014)—and from proposals such as those 'to reclaim the concept (ecosystem services) as a useful one in terms of the wider ethical debates surrounding human–nature relations' (Jax et al. 2013, p. 266). Recent inquiries into geoethics have put the individual, the human agent at the centre of general sustainable development considerations (see, e.g., Druguet et al. 2013 [geoconservation]; Mayer 2015 [integrity]; Pievani 2015 [history]; Potthast 2015 [technology]; Peppoloni and Di Capua 2015a [societal responsibility]; Tubman and Escobar-Wolf 2016 [development]; Bohle and Ellis 2017 [individual responsibility]).

Such an agent-centric approach to ethical practices may seem obvious for geosciences because codes of practice for chartered professionals are usually are framed in this way.[5] Notwithstanding an agent-centric tradition in the ethics of chartered geoscience professions, the emergence of the notion of the Anthropocene has challenged many geoscientists. The discussion about whether to amend the geological timescale, by naming modern times the Anthropocene, bears witness to this unease (Zalasiewicz et al. 2015; Finney and Edwards 2016). Nevertheless,

[5] See, for example, http://www.geoethics.org/codes.

considering together the notions Anthropocene and geoethics sharpens focus on the behaviour of human actors (Hamilton et al. 2015; Schmidt et al. 2016). Therefore when understanding geoethics as 'research and reflection on the values which underpin appropriate behaviour and practice, wherever human activities interact with the Earth system' (Peppoloni and Di Capua 2012), as an integral part of geoscience professionalism, geoscientists can internalise a more comprehensive understanding of the human actor and the societal implications of geosciences.

Campbell et al. (2016, p. 535) emphasise that by internalising the human role 'actors, scale and knowledge (that) are relevant for efforts to govern new and emerging ocean issues' become apparent. Such ocean issues are described, for example, by Hughes et al. (2017, pp. 84–85):

> … locally, the consumption of reef fish is shaped by a combination of the size, socioeconomic status and cultural norms of the human population. By emphasising proximal drivers rather than more distant human ones, we often inadvertently simplify and re-scale a complex social–ecological problem into a subsystem that is entirely biological, which can distract from the underlying causes and ways to address them. A social–ecological approach for sustaining ecosystems is beginning to emerge that explicitly links the resilience of ecosystems to governance structures, economies and society.

Campbell et al. (2016, p. 536) generalise this example and argue that '[t]he FAO SSF Guidelines stand out as an exception …, attending as much to questions of resource access, human-rights and food security as they do to questions of fisheries ecology'. Hence, they define the FAO SSF Guidelines as actor-centric, representing an 'opportunity to create governance regimes that support environmental sustainability and human well-being' (p. 536), notwithstanding that their 'implementation … is likely to be an ongoing, adaptive and iterative process, as small-scale fisheries are dynamic' (Jentoft 2014, p. 12). Generalising such insights, Biermann (2014, pp. 22–24) argues for Earth system governance as a common normative approach for human handling of socio-ecological systems that interrelate agency, accountability, legitimacy and fair allocation; or as Biermann writes (2014, p. 146):

> … [a] global situation of large inequalities in resources and entitlements… (t)he analysis of agency in earth system governance – that is, of those actors who have the authority to set and enforce rules and norms

> – requires an understanding of the vast social divisions on our planet … questions of fairness in adaptation arise as well, including concerns about compensation and support by the global community of the most affected and most vulnerable regions.

The FAO SSF Guidelines provide an example of how to perceive the governance arrangements of a given socio-ecological system through a common normative approach. The actual design of geoethics follows a similar path, as reflected in the Cape Town Statement on Geoethics[6]:

> It is essential to enrich the roles and responsibilities of geoscientists towards communities and the environments in which they dwell … Human communities will face great environmental challenges in the future. Geoscientists have know-how that is essential to orientate societies towards more sustainable practices in our conscious interactions with the Earth system. By applying a wider knowledge-base than natural sciences, geoscientists need to take multidisciplinary approaches to economic and environmental problems, embracing (geo)ethical and social perspectives. Geoscientists are primarily at the service of society. This is the deeper purpose of their activity.

3.2.3 Outlook

This essay explores the characteristic features of the FAO SSF Guidelines and geoethics. To summarise, it illustrates how several threads of disjunct experiences encourage putting the individual human actor (its needs, preferences, thinking and actions) at the centre of concerns for context-dependent and path-dependent governance of socio-ecological systems. This shared focus entangles both experiences, enriches the related frameworks (the FAO SSF Guidelines and geoethics, respectively) and invites also to use them outside their initial realms. This essay notes further that both approaches embed participatory governance strategies. However, only the FAO SSF Guidelines address them explicitly. In geoethics, participatory governance strategies are inherent to its definition and explicit in some practices (Lanza 2014; Nurmi 2017). In some geoscience applications, particularly those connected with the extractive industries, the increasingly important concept of 'social licence to

[6] http://www.geoethics.org/ctsg.

operate' is helping to build participatory governance strategies, essential to meeting resource needs in an ethical and sustainable manner (for further discussion see, e.g., Buhmann 2016; Owen and Kemp 2013).

The operation of small-scale fisheries in the context of industrialised exploitation provides an example of the complexity of handling anthropogenic global change. It involves 'overall values, norms and principles that guide institutions and actions' (Chuenpagdee and Jentoft 2013, p. 344) to guide agents in managing the never ending succession of problems. Generalising, for citizens as agents of change, approaches like geoethics offer an 'actor-centric virtue ethic' to identify the appropriate behaviour and practices required to develop a sustainable human niche governed by mutually respectful actors.

3.3 Third Essay: Participation—Citizen Geoscience

People's 'human niche' is composed of socio-ecological systems that interconnect the biogeosphere and the sphere of human social, economic, cultural and political activities. Against this background, this essay explores the interface of geoethics and citizen participation in science and research.

In the following, notions like citizen science shall refer to participatory knowledge generation processes that include some members of the public in some aspect of scientific research (Eitzel et al. 2017), that is, activities including but going beyond people taking part in data gathering, observation and analysis. Participation may be, for example, through collaborative processes that allow the co-design of research questions, participation in data gathering and analysis, and shared communication of results. Citizen science, as one kind of public involvement in research and development domains, is a well-established mode of knowledge generation for some disciplines (Riesch and Potter 2014; Vayena and Tasioulas 2015; Grey et al. 2016). It allows for collaborative engagement that captures and communicates multiple perspectives and interpretations, and offers opportunities for shared learning from other disciplines and practice-orientated stakeholders (Bonney et al. 2014; Aceves-Bueno et al. 2015; Follett and Strezov 2015; Paul et al. 2018).

This essay starts by presenting some examples of the evolving state-of-play of citizen science in geosciences. Then a brief history of the involvement of citizens in the societal process of doing science is sketched and the definition of geoethics read from a citizen science perspective.

Reflections about citizen science are then presented that take the notion of 'niche-building' as their departure point. The essay summarises these views with a reflection about participatory geoscience research in times of anthropogenic global change.

3.3.1 Examples: Citizen Science and Geosciences

A brief review of the current uptake of citizen science in geosciences shows that participatory geoscience research is not yet very popular, although the situation is evolving. For example, when searching the Google Scholar database for 'citizen geoscience' (13 February 2018) only one result is displayed—a paper by Powell et al. (2013) about recording temporary geological exposures. However, searching more widely (Google Scholar database, 13 February 2018, no patents, no citations), a trend emerges that displays a slight increase in interest considering citizens in geosciences. A search for the two terms 'citizen' and 'geoscience' revealed 3320 publications for the period from 2013 to 2017. This number is a little less than twice the number of references (1790) for the preceding 5-year period (2008–2012). A search for 'citizen geoscience' in the blogs of the European Geosciences Union (EGU) delivered two results (13 February 2018). Roberts-Artal[7] features the gathering of (meteorological) data and Wardlaw[8] writes about image analysis projects to track geological changes in remote-sensing imagery from Mars. The programmes of major geoscience conferences may serve as a further indicator of the interest of geoscientists in citizen science. For example, the General Assembly of the EGU, which annually hosts well over 10,000 participants, has a low (although rising) number of citizen science contributions in geosciences. In 2017, it featured one session that included citizen science research and just over 10 contributions mentioned various forms of citizen science initiatives. In 2018, the EGU General Assembly hosted six sessions with contributions that included citizen science projects.[9] Aside from such big events, some specialised

[7] https://blogs.egu.eu/geolog/2014/12/05/citizen-geoscience/.

[8] http://blogs.egu.eu/geolog/2015/11/25/mars-rocks-introducing-a-citizen-science-project/.

[9] The draft programme for 2019 includes 11 session that mention 'citizen science'.

conferences featuring citizen science initiatives in geosciences have recently been organised, such as the 'Citizen Observatories for Natural Hazards and Water Management' (Venice, 27–30 November 2018).

Depending on search terms, literature searches lead to examples of citizen science in various geosciences, such as hydrology (Buytaert et al. 2014), geothermal research (Meller et al. 2018) or public awareness of natural hazards (Lanza 2014). When doing a bibliometric analysis of the 1935 publications of citizen science projects (retrieved from Web of Science in December 2015), Kullenberg and Kasperowski (2016) estimated that less than 5% of the projects were in geosciences. Overall, citizen science seems less popular in geosciences than in environmental sciences (Hyder et al. 2015; Vann-Sander et al. 2016). It might be that environmental issues are more aligned to people's interests than geosciences or that scientists perceive them as more accessible for public participation, with the possible exception of hydrology (Paul et al. 2018).

To illustrate why it is important to increase citizen science-based research in geosciences, a quote from a commentary published in *Nature* may serve as an example. The authors, El-Chichakli et al. (2016), call for more investment in the bioeconomy[10] to support the United Nations Sustainable Development Goals:

> A global bio-economy must rebuild natural capital and improve the quality of life for a growing world population. It should balance managing common goods, such as air, water and soil, with the economic expectations of people. … Also needed will be citizen science evaluations of new houses, local wood-recycling and construction efforts. Sustainable food systems will require advances in plant breeding, food products, and farming and cultivation techniques… Inclusiveness and knowledge transfer are important. (p. 222)

Besides how the role of citizen science is perceived, the authors discuss the human niche when mentioning 'common goods, such as air, water and soil … farming and cultivation techniques'. Although they identify the need to 'rebuild natural capital and improve the quality of life', the dependence of the bioeconomy on geoscience knowledge is not mentioned when 'managing … air, water and soil'. The comment argues in

[10] The bioeconomy encompasses various economic sectors, such as health, the biochemical industry, agriculture, forestry and bioenergy (see Bugge et al. 2016).

favour of interventions on a planetary scale when referring to a global bioeconomy and common goods. Literacy of the authors in terms of their geoscience knowledge can be assumed. It looks like that this knowledge is deeply integrated into their expertise but does not get mentioned explicitly in the quote.

Furthermore, the quote should be read against the insight that agriculture represents the anthropogenic land-use process that has had global impact throughout history and pre-history (Ruddiman 2013; Liu et al. 2017; Song et al. 2018), affecting the global cycles of carbon, water, dust and nutrients. Furthermore, since the beginning of the twentieth century, the industrial nitrogen fixing (Haber–Bosch) process has supported agricultural industry and has led to a profoundly altered global nitrogen cycle (Morton 2015; Zhang et al. 2015; Ren et al. 2017). This is a classic example of geoengineering through the bioeconomy, albeit unintentional.

The quote analysed above illustrates how people conceptualise the relations that characterise the links between production systems, consumption patterns and geosciences. The embedding of geoscience knowledge in the expertise of other disciplines conceals it or favours a restricted relation, like engineering geology (Srbulov 2014).

Throughout this book, however, we demonstrate the benefits of embracing a comprehensive concept of geosciences to understand the interconnectedness of the biogeosphere and the human sphere. It also becomes apparent how many knowledge domains impinge on the geosciences. These mutual relations should be made more explicit. Consequently, citizen geoscience, and hence public engagement with geoscience practices and approaches, would increase the public visibility and exposure of geosciences. To this end, it is vital to encourage participatory research processes and practices in geosciences. Advocating citizen science in geosciences should thus be inherent to geoethical thinking and practice.

3.3.2 History: Geosciences, Citizens and Participation

The present-day relationship between geosciences and citizen science is part of a more common historical trail:

> Two centuries ago, almost all scientists made their living in some other profession. Benjamin Franklin (1706–1790) was a printer, diplomat and politician; Charles Darwin (1809–1888) sailed on the Beagle as an unpaid companion to Captain Robert FitzRoy, not as a professional naturalist.

> The rise of science as a paid profession is a relatively recent phenomenon, dating from the later part of the 19th century. However, citizen scientists have never disappeared, particularly in sciences such as archaeology, astronomy and natural history, where skill in observation can be more important than expensive equipment. (Silvertown 2009, p. 467)

Joel Mokyr's book 'A Culture of Growth—The Origin of Modern Economy' (2016b) inspires the following sketch, which *mutatis mutandis* also applies to geosciences.

The development of modern science and research in Europe began in the seventeenth century among a small number of mainly urban citizens that had opportunities to study natural phenomena. Renaissance scholars such as Leonardo da Vinci or Galileo Galilei had pursued a diversity of activities, such as developing techniques for painting (perspective, colours), observing natural phenomena (rocks, plants, water flows) or designing engineering plans for bridges, fortifications and instruments. For this purpose, they experimented with new, innovative tools, such as lenses and telescopes. Often, creative individuals served influential leaders who provided them with resources and protection against persecution. Even when sponsored in such a manner, new insights usually trickled down slowly into daily experiences and understanding of the world.

Nevertheless, the cumulative effects of these insights can be traced through changes in production systems (Mensing et al. 2016). It took about two centuries of social, economic and political developments before more individuals (gentry or bourgeois, men and some women) engaged in scientific activities and modern scientific educational and professional structures started to emerge (Mokyr 2016a). For the better part of the eighteenth century, it was a small network of privileged people across Europe who engaged in scholarly discoveries and research, often using their wealth to support their studies. New developments were stimulated by government prizes, like the 'longitude prize' (navigation), investments in infrastructure (bridges, roads, channels, and mapping of the landscape) and mining technology, and developing the means for military power; many of these required a significant share of geoscience expertise. Much trial and error (including terrible accidents) were needed before citizens and authorities accepted them (Fressoz 2012).

In the wake of industrialisation and the consolidation of capitalist production forms in the nineteenth century, the social and cultural basis for doing research, science and technological development was broadened (Mokyr 2016b). Scientific expertise, technological means and a culture that valued knowledge and purposeful expropriation developed as new societal norms (Purdy 2015). Finally, in the wake of the Second World War the number of researchers, scientists and engineers grew massively.[11] Since the middle of the twentieth century, a significant percentage of the population in developed countries work as researchers, scientists or engineers. Their expertise has facilitated regional infrastructure development, the production of goods and the provision of services in industrial and post-industrial cultures, supported massively by governments, wealthy individuals and corporations (Wolfle 1957; Waterman 1960; Bronk 1975). The present-day network of inequitable global supply chains has developed, and our contemporary affluent knowledge-based societies have taken shape, resulting in massive alterations to natural (and social) environments as a consequence of production systems and consumption patterns. Consequently, the spirit of technological progress which characterised western cultures a few decades ago has partly faded.

Over a centuries-long process of change, the domains of science and research have become professionalised, and industrialised production forms have shaped the societal institutions that nowadays segregate daily life, culture, the development of technologies and the search for scientific innovation. Generally, the assessment of innovations is regulated. This is done by specialised institutions tasked with protecting the public against risk, accidents and disastrous failures, as experience had taught us to do (Fressoz 2012). Subsequently, as they spread through societies, innovations cause debates, political and legal struggles, for example, about environmental risk, squandered opportunities or doubts about the assessment process itself. The fate of carbon capture and storage technologies may serve as a geoscientific example of such an experience (Lofstedt 2015).

Furthermore, in a citizen's daily practices innovation often comes in the form of a bundle of changes. The regional management of the Ebro River (Spain) delta is one such example (Zografos 2017). Outcomes of bundled changes, which are difficult to forecast and understand, may be unexpected and therefore strain the intrasocietal links of citizens (and authorities) with professionalised research and development processes (David and Foray 2002; Allenby and Sarewitz 2011; Roco and

[11] https://futureoflife.org/2015/11/05/90-of-all-the-scientists-that-ever-lived-are-alive-today/.

Bainbridge 2013; McNie et al. 2016). The case of stratospheric ozone depletion and its management may serve as an example of how to handle such a strain of intrasocietal links successfully (Jacobs 2014).

Nevertheless, the societal strain may be overbearing when systems exhibit hysteresis and locking-in, and when environmental change and alteration of societal infrastructure and practices are therefore path-dependent and difficult (or impossible) to reverse. It is this feature that makes anthropogenic global change so difficult to tackle. The case of greenhouse gas emissions illustrates such an overbearing strain. To handle the dynamics of change in a competent manner requires strong integration of scientific research and technological development with day-to-day societal practices and governance arrangements. To that end, participatory research approaches, development practices and implementation strategies are needed, which enable co-creation of knowledge and collaboration with citizens (scientists); and appropriate methods must be developed. One example is scenario analysis:

> Mapping policy pathways in assessments is an iterative exercise that frequently requires adjustment if new forks in the road, alternative destinations, pitfalls and uncharted territories turn up. Due to the high uncertainties, long-term issues, such as global environmental change, require trial-and-error policy-making. Assessments can strongly support this through ex-post policy analyses. In the light of newly discovered practical consequences, objectives might be revised and means can be adjusted. Mistakes in policy-making can occur, and from them, society as a whole can learn for the future. (Edenhofer and Kowarsch 2015, p. 63)

When bound into participatory processes, working in such a manner would enhance public literacy in the respective scientific fields, *mutatis mutandis* in geosciences. Hence, the explicit involvement of citizens in science and research is to be recommended all the more when considering the relevance of geosciences for the functioning of contemporary societies.

3.3.3 Citizen Science: A Generic Application of Geoethics

Geoscience professionals should be well placed to recognise people's diverse economic, social and cultural living conditions when acting in their professional capacity (Peppoloni and Di Capua 2015a; Bobrowsky et al. 2017).

The wide range of applications of geosciences mirrors the diversity of the global social sphere and offer incentives for the participatory conduct of science and research. Furthermore, a conceptual relationship between geosciences and citizen science is implicitly built into the frameworks and professional codes that underpin geoscience professions. In professional practices, for example, the relationship of geosciences and citizens forms part of the risk analyses and impact studies (Di Capua and Peppoloni 2014; Hall et al. 2015; Hino et al. 2017). Notwithstanding this ample conceptual relation, 'citizen science' and other ways to conduct research and science in a participatory manner seem little used in geosciences.

Driven by professional practices, the relationship of geosciences and citizens is enshrined implicitly in the definition of geoethics[12] (Peppoloni and Di Capua 2017), which states that it 'consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system'. The phrasing 'wherever human activities interact with the Earth system' is inclusive of any human agent. The definition posits further that geoethics 'deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and responsibility of geoscientists in conducting their activities'. The notions of social role and responsibility offer another lead to the potential of citizen science in geosciences.

The application case of geoethics, namely 'appropriate behaviours and practices, wherever human activities interact with the Earth system', is about building the 'human niche'. Hence, geoethics is about the conduct of (all) people, their professional activities and individual lifestyles.

Drawing on the above, 'geoethics' is equally cognisant of citizen knowledge as it is about geoscientific knowledge. Hence, geoethical thinking calls for us to configure our perceptions of citizens and geoscientists, their professional activities and their lifestyles, to be complementary. Their active cooperation should therefore be sought, and geoscientists seem ideally positioned to initiate and coordinate participatory research practices.

[12] http://www.geoethics.org.

3.3.4 Niche-Building: A Dedicated Application of Citizen Science and Geoethics

As discussed elsewhere in this book, the effects and impacts of the interactions of human activities with the Earth system are ubiquitous. These interactions come about through the way in which production systems and consumption patterns are designed and result in physical changes in the geosphere. In turn, such engineered socio-ecological systems then re-shape the daily lives of citizens. Consequently, many professional activities as well the daily dealings of citizens are implicitly intertwined with geoscience expertise. In some cases, the use of geoscience expertise may involve only geoscientists acting in professional capacities. However, geoscience knowledge often is embedded in established (professional and daily) practices, such as building codes or design practices for construction on slopes or on floodplains. People who apply these practices may not be 'geoscience literate', and therefore have little chance to question the 'embedded knowledge', for example, given altered environmental circumstances, like precipitation patterns. When dealing with any matter of environmental design or intervention, geoscience literacy is likely to be relevant for many informed professional activities and daily courses of action.

The manner in which geoscience expertise, production systems, consumption patterns and the daily lives of citizens are interlinked is demonstrated by the way in which people have built an anthropocentrically manipulated biogeosphere, that is, a global socio-ecological system (Fressoz 2012; Foley et al. 2013; Ellis 2015; Fuentes 2016; Waters et al. 2016). The human niche for modern societies has resulted from the increasingly effective design (or engineering) of production systems and patterns of consumption of resources. Unintended side-effects of these design activities have accumulated and are the main drivers of anthropogenic global change. The accelerating process of anthropogenic global change is not an accident. It is an unintended consequence of a historical process that was intended to maintain affluent individual well-being, mutual caretaking and (biological) reproduction.

Considering its purpose, a comfortable human niche requires a well-functioning biogeosphere that only occasionally gets disrupted by natural hazards. Likewise, its well-functioning should not be threatened by ignorance, for example, when citizens ignore natural features, such as slope stability or floodplains. Hence, when exploring societal contexts of anthropogenic niche-building and global change, geoscience expertise is a public good. Its use should promote the informed participation of citizens in decision-making processes. Geoscience expertise is only one of several contributions to the complex knowledge base our societies require to facilitate sustainable development. The basis of societal or political decision-making processes is thus rarely straightforward and seldom based only on facts (Hulme 2009; Cairney 2016; Kowarsch et al. 2016). It is this insight that requires geoscientists and citizens to share and embed expertise that stems from various sources. Participatory processes, like citizen science, are an appropriate means to ensure that collaborative processes take account of the relevant knowledge, and that this is effectively exchanged among stakeholders.

Considering geoscience research and practices, the participation of citizens in science is compatible with the professional activities of geoscientists. Participation of citizens should at least be deemed obligatory in the outreach and communication activities of geoscientists. Beyond such activities, which are either downstream of the actual research activity or related to the social and political embedding of the research, geoscience research communities should accustom themselves to involving citizens directly in the execution and design of geoscience research projects. When looking beyond the domain of geosciences, there are abundant examples of collaborative research practices and multi-stakeholder engagement processes that demonstrate how participatory processes can successfully contribute to delivering high-quality research outcomes (Tengö et al. 2014; Reyers et al. 2015). Within geosciences, the approach termed 'social licence to operate' provides an example (Dare et al. 2014; Moffat and Zhang 2014; Hall et al. 2015; Buhmann 2016). This approach, which has its intrinsic difficulties (Boon 2015; Falck 2016; Moffat et al. 2016), is used in the mining industries to facilitate long-term (mining) operations. Seeking a social licence to operate focuses on commercial activities and their social embeddedness. Informed by these experiences, which have had mixed results, geoscientists should explicitly further 'citizen geoscience' to deepen the involvement of citizens in their research and practices. Against the additional backdrop that geosciences knowledge is a public good, citizen geoscience is valuable to advance citizen empowerment beyond participation in geoscience research.

3.3.5 Outlook

In their paper ‘The Anthropocene is functionally and stratigraphically distinct from the Holocene’, Waters et al. (2016) emphasise the ongoing functional changes to the Earth. The behaviours and practices of people, in creating current production systems and consumption patterns, have caused these changes (Steffen et al. 2015). Participatory research and development practice in geosciences, also involving citizen science, is needed to reduce the strain that upcoming changes in living conditions imply (Kowarsch et al. 2016).

The current unfolding of anthropogenic global change will cause significant adjustments to people’s living conditions in most parts of the globe. To tame these change processes and to change the direction of current development pathways, much geoscience expertise will have to be installed within societal practices in a socially sustainable manner. To this end, the depletion of stratospheric ozone that was caused by emissions of some industrial gases provides an informative example (Wu et al. 2013). From a geoscience perspective, the underlying cause–effect relation was quite simple. The single cause was the use of gases (chlorofluorocarbons and other substances) in cooling installations and foams. These gases persist in the atmosphere and reach cold stratospheric clouds in polar regions. In the presence of ice and light, chlorofluorocarbons break up ozone molecules that otherwise would absorb ultraviolet radiation, which instead reaches the Earth’s surface and can damage cells. The solution to the problem was technically unassuming, namely to substitute some specific substances. The economic impact of the required technological change was limited. The changes for citizens were humble, namely to replace appliances (fridges) in a controlled manner. The societal process that prescribes how to govern emissions was put in place (through an international treaty), and satellite-based monitoring of emissions of ozone-depleting substances was implemented. Hence, societal processes delivered a solution to a well-defined problem. Implementing the solution did not need much citizen involvement; technical and political elites could handle the issue. Compared with the experience of managing the replacement of ozone-depleting substances, efforts to mitigate the effects and damaging impacts of climate change pose a different challenge. The required modification of production systems and consumption patterns (de-carbonisation) is much more profound, the monitoring of implementation agreements is much more demanding and the ethical dilemmas regarding justice or choices of development paths are much more severe. Hence, the societal processes required to deliver a solution are challenging, implementing the solution needs much citizen involvement, and technical and political elites alone likely cannot handle this issue.

Encouragingly, the notion of the Anthropocene has rapidly attained intellectual and public attention over the last decade. Now it is driving debates among many audiences and resulting in a call to rethink how to understand humankind's place in the world (Latour 2015; Hamilton 2017). This societal feature offers a metric of the perceived urgency and expectations, given the scale and momentum of the changes anticipated. Under such circumstances, organising research and development in a responsible and participatory manner would strengthen the intrasocietal links between geosciences and citizens. Means for achieving this include, for example, increased transparency of research and development initiatives and increased awareness of how abiotic environments are linked across various scales and societal domains. In this context, citizen scientists are a known resource, both to provide experiences that are rooted in conventional societal practices and to facilitate uptake of geoscience-based practices in everyday societal dealings. Societies that face anthropogenic global change need both of these features in order to orient research and to guide practices. Consciously applying geosciences and geoethics is a common good which needs the active participation of citizens to bear fruit.

3.4 Fourth Essay: Narratives and Sense-Making

This essay explores how storytelling may be framed to be a vehicle for geoscience narratives. The essay reflects on how people's awareness is related to their storytelling practices to communicate insights and to induce or inspire behaviour (Bohle et al. 2017).

Anthropogenic change in natural environments has caused public concern since the onset of the industrial revolution (Fressoz 2012). More recently, humankind's economic activities have intensified and grown to the extent that they have significant impacts on the mechanisms that drive Earth system dynamics (Ruddiman 2013; Waters et al. 2016; Steffen et al. 2018). Hence, studying Earth system dynamics at the present time necessitates interdisciplinary engagement that draws from both the natural sciences and humanities (Smith and Zeder 2013; Bergthaler et al. 2014; Castree 2017). The interactions between people (technical, economic, social, cultural, artistic, public, collective or individual) are incorporated into the understanding of Earth system dynamics (Biermann 2014; Bauman 2015; Ellis 2015; Clark and Gunaratnam 2017; Hamilton 2017; Kunnas 2017).

Due to anthropogenic global change, people will have to appraise their preferences regarding lifestyle choices and the impact that production and consumption patterns have on Earth's geochemical and physical systems. Hence, governments, elites, influential individuals and other citizens should adopt frameworks that consider both the intertwined nature of Earth system dynamics and human activities and also the values, world-views and cultural or social prejudices which influence each other and shape human activities (Press 2008; Rickards 2015a, b; Wright et al. 2018). Navigating the dynamics of human and Earth system linkages requires integrated governance approaches that combine the value-driven ethical, social and cultural influences that shape human activities with rigorous scientific findings and engineering expertise (Steffen et al. 2011; Wilson 2014; Murphy et al. 2015; Veland and Lynch 2016).

Engineering is the socially learned and socially enacted human activity by which people intersect their environments, including the abiotic subsystem of the Earth system, the 'geosphere' (Ellis et al. 2013, 2016; Bohle 2016, 2017). Intersections of human activities with the geosphere may happen by means such as engineered infrastructures, production systems for goods and services or social activities like politics or lifestyles. Some intersections are more evident than others, such as motorways, irrigation systems, hydro-power plants or shore defences, because they more visibly change the geomorphology (Brown et al. 2017). Other intersections are less visible, such as slope destabilisation, pumping of groundwater, sewage water treatment, beach nourishment, anthropogenic climate change, ocean acidification or enhanced nitrogen/phosphorous cycling. These ordinary intersections of human activities with the geosphere seldom become part of citizens' narratives. There are exceptions, such as dramatic events (e.g., tsunamis) that reach the headlines and, only after years of effort, climate change (Krauss 2015).

As anthropologists have found, the cultural evolution of the human species can be tracked by our capacity to be storytellers (Pagel 2012; Wilson 2012; Lynam and Brown 2012; Lieberman 2013; Stewart and Nield 2013; Arroyo 2017). Throughout the history of humankind, narratives have formed the symbolic means by which societies have shared their perceptions and insights, which in turn have shaped the moral imagination to develop shared values that aim to guide social dynamics and behaviour. Hence, it is likely that this universal human trait, namely to make sense of the world using narratives, could provide an entry point for introducing issues that concern geoscience into public debates. To that end, this essay will reflect on how different concerns can be woven into common threads that might then be made more visible and tangible, so that people might become more aware of the interconnectedness of human actions with the geosphere.

3.4.1 Traditional and Modern Earth-Centric Narratives

As an example, a set of western cultures is considered as a point of departure for reflecting on how narratives might shape a more general understanding of geoscience phenomena. In some traditional, rural European cultures narrative devices were used to conserve and transmit their traditions, myths and cultural identities to new generations over many centuries.

Durand (1960) describes the narratives of some traditional rural communities, their symbols and beliefs. In these communities, for example, the 'red moon' anticipated disasters (catastrophic crop failures). The 'red moon' is a total eclipse of the full moon, which in former times was hard to explain other than by referring to the 'sacrum'.[13] Therefore from Brazil to Armenia, people consider the black or red moon to be

[13]The concepts of 'sacred' and 'sacralization' have been used, for example, and among others, by Durkheim, Caillois, Eliade, Lévi-Strauss and Ries (see Fabietti and Remotti, 1997, and references therein) as having a specific meaning. Therefore it is cautiously proposed to use the term 'sacrum', which does not correspond to a specific definition used in anthropology nor ethnography but is related to the above and to the concept of the 'supernatural'. The latter is used as an additional element mediating the opposition between nature and culture, i.e., the three-term relation of culture/human–nature–supernatural. When inquiring into the relationships between culture and environment, the available technology may instead be considered as a third element. More recently Philippe Descola (1986, 2011) developed the teaching of Lévi-Strauss to overcome the traditional western dualism between culture and nature, stating:

> To the question 'who owns nature?' the answer in the present case is indeed 'to each and every one of the species that make it up', but, as none of them, excepting our own, has made its feeling known on the matter, it is some of its members' point of view which is bound to prevail. It should, therefore, be stated that any ethics of nature is by definition anthropogenic and that it necessarily articulates values propounded by humans.

http://www.laviedesidees.fr/Who-owns-nature.html (2008, interview with Philippe Descola).

malevolent. For example, a severe drought that impacts a community is understood to occur because of the disrespect of a well-known prescription by one of its members.

Compared with such supernatural associations, narratives from the Aosta Valley may serve as an illustration of more Earth-bound views (Sibilla 2012). Dwelling in rough natural environments on the border between Italy, France and Switzerland, local people have kept alive traditional thinking in the form of narratives, symbols and beliefs. Despite the ongoing urbanisation processes in their region, these communities have preserved much of their former cultural identity, such as that expressed in the narrative of the 'Lost Valley', whose boundaries are set by Mount Rose (*Monte Rosa*). This narrative captures the fascination of the unknown and boundaries with 'the other'. It includes the potential dangers of overcoming limits that are natural and physical but also cultural. Finally, the narrative portrays the rough nature that protects its greenest and most fertile territory, which is just on the other side of the glacier.

Many narratives of rural communities of earlier times have been lost or modified radically in the global urbanisation and industrialisation processes. These traditional narratives were 'Earth-centric' to encapsulate advice and justification for behaviour to sustain stable human–geosphere intersections. They guided the use of natural resources, such as plants, animals, soil, farmland, water or ecosystems, like forests. These narratives were part of a more complex social and economic fabric. They were an essential although not sufficient means to sustain the intersection of people's activity with the geosphere (Diamond 2005). To stay effective, these traditional narratives related to the '*sacrum*'. They were explained with faith-based reasoning, based upon values and beliefs referring to the supernatural, which were common and shared in the community (Botero et al. 2014). The reference to the 'sacrum' took different forms, for example, in Greek mythology, gods and people were directly affected by forces (agents) of Earth. In Jewish/Christian traditions, faith-based reasoning alternates between claims to subjugate the environment or to respect creation; nevertheless, divine command of environmental processes comes as a last resort, for salvation or punishment.

In former times, when natural phenomena were not explicable using scientific understanding of processes and technologies, shared social constructions (values and beliefs) ruled explanations. Although based on faith and beliefs, traditional thinking was functional because it encoded accumulated experiences into a stable frame of reference, or worldview.

The combination of faith and experience had the function of coercing the believer into distinct behaviours that were favourable for existence (Purzycki et al. 2016; Johnson 2016). The rituals that ruled such behaviours navigated a balance between Earth-centric and society-centric goals. It takes time and effort to accumulate and to encode tested practices into rituals (Whitehouse and McCavely 2005). Hence, once established, these rituals are stable despite being costly to people. Among other purposes, such rituals enshrine how human activities and the geosphere intersect in a sustainable manner (Brown 2012).

If faith, values and beliefs are disrupted by explanations based on insights into processes and technologies, then the traditional balance between Earth-centric and society-centric goals gets broken. Consequently, traditional Earth-centric behaviour erodes because its sacrum-based philosophical foundations are questioned. Still, the customs relating to traditional behaviour may continue to exist in popular folk cultures, without serving their initial purpose.

Modern societies require different narratives to traditional societies to promote Earth-centric behaviour. Nowadays, people can base their Earth-centric behaviour on a substantial knowledge base. However, the intersection of people and the geosphere does not form part of the storylines of historical sciences (Carpentier et al. 1992; Roberts 1997), exceptions apart (Diamond 2005). Nevertheless, modern storytellers can draw on rich conceptual and methodological contributions from the humanities for putting Earth-centric narratives into a historical context. For example, Viollet (2000) tells a history of hydraulic engineering works for irrigation systems, waterways, power systems and sanitary systems. A description of the historical context of humankind's development path over the last two centuries (Landes 2003; Malanima 2010) also provides a robust vision of how the modern world and people's power to intersect with the geosphere has emerged:

> … *histoires nous invitent à reprendre politiquement la main sur des institutions, des élites sociales, des systèmes symboliques et matériels puissantes qui nous ont fait basculer dans l'Anthropocène* [history invites us to politically take over the institutions, social elites, powerful symbolic and material systems that have rocked us into the Anthropocene] (Bonneuil and Fressoz 2013, p. 271)

In present times, mainstream public concern focuses on issues like pollution, hazard mitigation, demographics and sustainable use of resources (Goldsmith et al. 1972; Gibson-Graham and Roelvink 2010; Schwägerl 2014). Such concerns are neither new nor unfamiliar for urban populations (Brown 2012; Fressoz 2012). It is possible that the Montreal Protocol, the international agreement on banning ozone-depleting substances concluded in 1987, marked a turning point in public perception of the global scale of anthropogenic change (Wu et al. 2013). Nowadays, global anthropogenic change is a distinctive part of the Western public's perception of the state of the globe, with people perceiving threats to their lifestyle and well-being (Steffen et al. 2011; Barnosky et al. 2012; Biermann et al. 2012; Cardinale et al. 2012; Ehrlich et al. 2012; Brown and Schmidt 2014; Walton and Shaw 2015).

Contemporary narratives of human–geosphere intersections can use natural, human and social sciences to strike a knowledge-based balance between 'Earth-centric' and 'society-centric' elements. How can such narratives be re-imagined?

3.4.2 Perspectives on Geoscience Narratives

To start with the obvious; to develop narratives that combine geoscience matters and societal concerns, landscapes, history and art provide many opportunities for a storyteller, ranging from the spectacular to the daily (Bohle 2015):

- The Colorado River has cut the Grand Canyon (United States) but no longer discharges into the ocean because its water has been extracted and redirected for the irrigation of agricultural production processes in neighbouring states.
- The motorway stretching east from Brussels (Belgium) cuts open aeolian deposits from the Ice Age that originated from the basin of the North Sea lying dry because of low sea level when a significant volume of water was bound up in global ice sheets.
- The recreational area of Lago Banyoles (Spain) has no outlet and is fed by underground springs of salty water. This geologically young lake, which hosted Olympic competitions, may transform into a saltwater lake accommodating flamingos that feed on brine shrimp.
- Human activities have marked landscapes with mining sites, irrigation channels, abandoned networks of local trains and

historical names that memorialise their past use or natural demarcations.

- At the time of the eruption of Vesuvius that covered Pompeii in ash, artists (commissioned by the wealthiest patrician households) had painted impressions of the volcano before the tragic event. Archaeologists have discovered these paintings which help them to reconstruct the shape of the volcano, the neighbouring landscape along the coast between Ercolano and Pompeii as well as the engineered artefacts of the Romans, such as aqueducts and roads.
- Crater Lake is situated in a caldera in south-central Oregon. It has neither an inflow nor outlet and is known for water clarity and thus its dark blue colour (reflecting the sky and backscattering blue light). The deep lake was formed around 7700 years ago by the collapse of a volcano (Zdanowicz et al. 1999). This unique lake was a sacred site for the native Klamath tribe. Their legends tell of battling gods of the sky and underworld, and observe the belief that Crater Lake is a spiritual site.

Going beyond such examples of storytelling that involve geoscience knowledge, modern society–Earth-centric narratives can draw comprehensively on humanities and natural sciences perspectives to illustrate the societal relevance of geosciences, for example, to daily matters, value creation (including economic or cultural value) and urban lifestyle.

Regarding daily matters. When discussing geosciences as part of the knowledge base of society, the weather was mentioned as a topic of primordial interest for most people because it impacts on humans' lives (Sirocko 2012). Weather news went prime-time during the early 1950s when numerical weather forecasting became feasible. From these early days, it took half a century to build the web of providers of weather products and their consumers (Lynch 2008; Bauer et al. 2015). Modern media combine, in a single narrative, the 'simple' weather forecast with additional information on meteorological phenomena and news on impacts on economic and social activities.

Regarding economic value. Societies apply geosciences for their functioning, and the related narratives are a common good, although they may not be recognised as such. Knowing the characteristics of rock, soil, water and air is essential for many economic activities. The production of goods or the maintenance of living conditions and individual well-being requires know-how about the dynamics of planet Earth (Langmuir and Broecker 2012). The know-how may be implicit in many general experiences, common sense, general education or specific vocational training. Artisans, technicians, architects and engineers apply geosciences when engineering artificial environments, e.g., extraction of minerals, stability of foundations or ventilation of buildings.

Regarding cultural value. Geosciences provide know-how about the evolution of life-bearing planets, the life-supporting functions of the Earth system, and the impact of humankind's activities on these systems (Hazen 2012). Narratives about these matters offer an understanding of the development of 'human geosphere intersection' and as such influence the perception of history and human development (Peppoloni and Di Capua 2012; Latour 2013). A marker for this influence on perception is the rapid spreading of interest in the notion of the Anthropocene among scholars from different disciplines. Moreover, the emotional responses of individuals influence and shape perceptions of future human and planetary well-being. The prolific emergence of apocalyptic projections that promote, for example, doomsday visions or denials of evidence is stoked by the fears of individuals about threats to their current lifestyles, and promotes related worldviews.

Regarding urban lifestyle. The Gilgamesh poem tells the story of Uruk, one of the first cities to be built 5000 years ago in Mesopotamia (George 2000). The poem is a fascinating cultural artefact of how these first city dwellers recorded their experiential connections with the geosphere. Faith-based Earth-centric features were interwoven with society-centric features about people–people interactions, earthly gods and godly earthlings. However, modern people have different experiences. Densely packed, urban people are living on a relatively small percentage of the Earth's habitable surface. Nowadays, every second person on Earth is living in a city. In 2050, urban dwellers will make up two-thirds of the global population.[14] Thus most modern people will experience their intersections with the geosphere differently. Living a modern urban

[14] United Nations, 2014: http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html.

lifestyle is altering people's experiential connections with the geosphere, up to the point that they may disconnect fully. For example, the beauty of the nightly star-filled sky is not visible when living in well-lit towns. Also, in cities, many weather phenomena may pass unnoticed. Urbanites' experiential connections with the geosphere are biased towards events that disrupt the well-functioning of the engineered structures that form their dwellings and support their lifestyles, such as air and water pollution. People are engineering their (urban) environments to shelter them from hazards, to limit dependence on the natural pace of Earth system dynamics and to appropriate and process natural resources. When sheltered by means of engineered environments, people favour their intraspecies experiences. To that end, an urban lifestyle resonates in dense people–people interactions and associated society-centric narratives, nowadays including narratives of 'virtual reality'.

3.4.3 Narratives in Times of Anthropogenic Global Change

The impact of people's activity on Earth has been noticeable for several thousand years (Foley et al. 2013). However, humankind's present patterns of consumption and use of renewable and non-renewable resources affects Earth beyond regional scales of industrial pollution, urbanisation of rural areas or replacing pristine wilderness with rural landscapes (Ellis et al. 2013; Ellis 2015). The intersection of humankind's economic activity with the biosphere and geosphere can be illustrated by various indicators. For example, more than 25% of terrestrial biomass is for consumption by humans (Krausmann et al. 2013); within just a few decades the amount of carbon dioxide in the atmosphere has reached levels last observed during the mid-Pliocene, 3 million years ago (Pearson and Palmer 2000); and erosion and the global rate of weathering of rock has approximately doubled to its current 50–80 Gt/year (Ball 2005; Smil 2007) compared to natural background. The intersections of humankind's activity with the geosphere (and biosphere) depend on both people's needs (e.g., for food or shelter) and preferences (e.g., for lifestyle, patterns of daily life or individual well-being). Whenever possible, people design (engineer) their economic activities to match both their needs and preferences, depending strongly on their culture and values. Discussions about geoengineering approaches to mitigate anthropogenic climate change are an example of this approach (Corner and Pidgeon 2010; Lawrence et al. 2018).

To handle intersections of humankind's activity with the geosphere effectively, citizens would benefit from re-imagining them as being part of their daily activities. To that end, telling stories about these intersections has to be society-centric and Earth-centric (Bohle et al. 2017).

As most people will live in cities, narratives that address them as urbanites are particularly needed. Also, the involvement of influential social groups is needed—usually urbanite with access to a high density of attractively packaged information of reliable or spurious content. People like digestible multi-faceted messages that are connected to the daily life of their social groups. Hence, their understanding of anthropogenic global change requires an attractive society-centricity to narratives; a bare Earth-centric story would not be compelling. Under such circumstances, narratives with a double Earth-centric and society-centric focus provide citizens with opportunities to develop an informed position regarding governance of anthropogenic global change, building on understanding both relevant Earth system dynamics and the appropriateness of value-systems or practices that have grown over the centuries (Hauser et al. 2014; Lanza 2014; von Storch et al. 2015). To that end, such narratives should also engage those who have more or less expert-knowledge, are practitioners or embody traditional knowledge, or share views of lobbies or political representatives (Hulme 2011).

3.4.4 A Framework for Society-Earth-Centric Narratives

The thoughts presented in the previous sections suggest a framework for society–Earth-centric narratives.

First, people shape their environment in response to their needs and perceptions as recognised by them through the filter of their worldviews and biases. The activities of present-day people intersect heavily with the geosphere. To ignore these intersections is not a viable option for them.

Second, experiences suggest that storytelling is useful for analysing the complexities of human experiences. Narratives provide cognitive tools for developing and expressing values, worldviews and beliefs, which in turn shape individual and societal perspectives. Storytelling is a means to develop abstract mental concepts, to compare observations, to construct critical thoughts or creative ideas, to assess cultural and social contexts and to make value statements. Furthermore, the ability to share narratives is a skilful human practice that allows us to show our affective relations, to describe our perception of values in different contexts and to spread or to challenge the application of both. People reinforce common views and values by sharing narratives.

Third, people's narratives about the intersections of their activities with the geosphere have evolved throughout history. Narratives of former times about supernatural agents ruling these intersections have been replaced by scientific descriptions and by the integration of traditional and scientifically valid knowledge-based narratives. These modern, content-rich, Earth-centric narratives can be harnessed to make people aware of those intersections. Such narratives do not need to employ metaphysical persuasion to enforce responsible behaviour or sustainable practices.

Fourth, to make choices and to manage uncertainties, many would benefit from understanding matters such as: How do the intersections of human activity and the geosphere function? What impacts on the economy and living conditions are possible? What are the options for mitigation or adaptation? What are the costs and consequences? What are the consequences of a 'business as usual' approach? Decision-makers, powerful individuals and elites as well as ordinary people will make their choice based on facts and value-laden worldviews. The latter will have regard to what they consider to be a satisfying life—for them, their relatives, their group or other people. Beyond such an ambivalent basis for making choices, these value-laden worldviews also determine what an individual may perceive as constituting factual knowledge or uncertainty. Narratives about the intersections of human activity and the geosphere contextualise facts within the common value-laden frame of reference of citizens.

Fifth, to create public awareness for narratives relating the nature of the intersections of people's activities and the geosphere, a double bearing is needed. Narratives must be both Earth-centric and society-centric. Society–Earth-centric narratives raise awareness of the specific processes or phenomena at the intersections of the geosphere and people's activities (e.g., engineered infrastructures, production of goods and services, arts, politics, social activity or daily lifestyles), and weave into the sphere of people–people intersections, including cognitive and affective relations.

Sixth, society–Earth-centric narratives benefit from geoscience know-how that is relevant for both economic development and cultural value-setting. Geoscience knowledge has many bearings on the production of goods, on living conditions or individual well-being, on the functioning of the Earth system and on the impact of humankind's activities on the Earth system or the evolution of life-bearing planets. When interwoven with the arts, linguistics and cultural histories, this multiple bearing offers a rich matrix for society–Earth-centric narratives of people's intersections with the geosphere.

Seventh, critical features of society–Earth-centric narratives seem to be: (1) a relevance for ordinary everyday matters and regular public presentation of work undertaken by geoscientists, (2) contribution to a broad range of value-related subjects (e.g., economic usefulness or ethical matters), and (3) addressing urbanites and their lifestyles to convey the essence of the narrative.

3.4.5 Outlook

Modern geoscience narratives should influence practices regarding how people's activities intersect with the geosphere. To that end, geoethical thinking calls for society–Earth-centric narratives that offer a full range of perspectives beyond geoscience know-how. Diverse narratives can draw on a broad range of perspectives, such as: (1) beauty or particularity of ordinary or unusual geoscience phenomena, (2) evaluating hazards for or from mundane environments, (3) relevance for everyday matters, (4) creating value, and (5) relating to people–people interactions. Likewise, these narratives can draw on the arts, humanities, history and philosophy to couple the mainstream of people–people interactions with their experiential connections with the geosphere.

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CHAPTER 4

Humanistic Geosciences and the Planetary Human Niche

Martin Bohle and Eduardo Marone

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.

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CHAPTER 5

Reframing Geoethics?

Martin Bohle, Giuseppe Di Capua and Nic Bilham

Abstract Geoethics is an emerging and expanding field which is deepening its philosophical foundations and strengthening its interactions with other disciplines. Such expansion may be in tension with the need for geoethics to be a focused framework to support geoscientists in their work. There is also a risk of 'geoethics' being used as a catch-all term for reflection and research when considering human actions within the Earth system. The chapter reflects on how the scope of geoethics might be constrained. It suggests that geoethics might be framed as relating to the practices and values of any human agent as part of the Earth

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system, whereas the complementary notion of 'geosophy' could be used to refer to the broader considerations regarding human–Earth system interactions.

Keywords Geoethics · Earth system · Professional responsibilities · Anthropogenic global change · Geosophy

Geoethics is a way of thinking that addresses the ethical implications, societal contexts and professional obligations of geosciences. This book takes stock of its state of play. It provides a framework, offers nuances and advocates extending the subjects that inquiries into geoethical thinking address. This stocktaking exercise should consolidate geoethics within geosciences. Likewise, it should serve to reach out to natural and social sciences, in general, as well as to humanities including arts.

Three generic features emerge from discussing geoethics that characterise its current state of play. First, geoethical thinking means considering the ethical implications of geoscience expertise and practices, not just in professional contexts but also in broader societal contexts. The call to the individual for conscious ethical behaviour is the central pivot of the current concept of geoethics. Second, geoethical thinking offers values but not a distinct canon of underpinning ethical norms that is specific to a given set of geoscience subjects. Instead, the norms that are proposed draw on ethics in general and the regular practices of geosciences, taking into account the diversity of the local conditions of nature and people, and of the temporal and spatial scales at which research, its application and associated professional practices are carried out. Third, geoethical thinking also addresses subjects that could just as well be considered in different thematic contexts, namely as 'environmental ethics', 'sustainability ethics', 'technological and engineering ethics' or 'professional ethics'. Although geoethical thinking can be embedded into each of these contexts, geoethics seems distinct because it is situated at the intersection of them. Geoethics has a nucleus that renders it distinct—namely, an actor-centric virtue ethic of professional geoscientists, who ground their responsible action on the corpus of geoscientific knowledge (including knowledge of its limits) and who recognise their contribution to shifting the cultural paradigms of the interwoven-ness of societal and natural environments towards more sustainable stewardship of the Earth system. Ultimately, geoethical thinking could guide the action of professionals, various societal stakeholders and citizens.

5.1 Recognising a Challenge

In the previous chapters, geoethical thinking was discussed in three frameworks, namely the geoscience professions, the societal implications of geosciences and the building of a planetary human niche. The sequence of these frameworks extends stepwise the perimeter of matters which geoethics might address, for people acting as responsible citizens as well as for geoscientists acting in a professional capacity. These frameworks illustrate the dovetailing of geoscience knowledge with the economic and societal practices of contemporary societies, which in turn emphasise the possible societal function of geoethical thinking.

While it is societally necessary and intellectually rewarding to explore the range of matters that relate to geoethical thinking, the resulting spread may cause geoethics to lose its operational focus. It is a justified concern in respect of professional practices that geoethics needs a distinct operational focus, to strengthen and deepen its effectiveness in supporting individual geoscientists, and to promote its practical adoption by these individuals. If geoethics were to be consolidated around practical (including professional) needs, this would establish it as a 'conventional norm' on Kohlberg's scale of moral adequacy (see Chapter 4). It would set geoethics at an intermediate normative level. As such, it would be insufficient to inspire, as advocated above, shifting the cultural paradigms of the dovetailing of societal and the natural environments towards more sustainable stewardship of the Earth system. Furthermore, geoethics benefits from exposure to other ways of thinking including, for example, exchanges with inquiries into environmental ethics or sustainability ethics. Hence, current inquiries into geoethics face an obvious tension between expanding or focusing, that is, expanding the subject matter, scope or ambition of geoethics in ways such as those explored in the preceding chapters, or focusing it as an effective operational support for professional geoscientists. The tension between these two justified concerns should be handled so as to avoid arbitrary choices.

Taking first a semantic view: when interpreting the etymological roots of the notion geoethics, as explored in Chapter 2, geoethics could have a vast scope. Otherwise, turning to the definition of geoethics, the matters discussed in this book demonstrate that geoethical thinking may evolve beyond either 'reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system' or 'the social role and responsibility of geoscientists in conducting their activities' (Peppoloni and Di Capua 2017, p. 2, emphasis added here). When using this definition, the application scope of geoethics is more limited than the etymological analysis indicates. Building on the definition, the somewhat vague expression 'geoethical thinking' may refer to matters that are inspired by geoethics but follow many different paths.

Anticipating the tension between expanding or focusing, three questions have been addressed implicitly in the previous chapters. First, what is the necessary corpus of geoethics that serves the professional needs of geoscientists? Second, what are matters adjacent to this corpus, that should be added into it, to further societal stewardship, exercised by an individual who is both a citizen and a geoscientist? Third, is there a case for a notion that is complementary to geoethics and provides a means to handle the tension that arises from extending the scope of geoethics? In the instance that such a notion can be found, it might capture matters that relate to the geosciences and their interactions with society and the natural world, but that concern subjects other than ethically sound (professional) behaviour. Consequently, the application scope of geoethics would be constrained, and so the risk of its deteriorating into a catch-all term would be reduced.

Regarding the first two questions, the matters outlined in the Chapter 2 of this book address how to configure the nucleus of geoethics. The matters discussed in the Chapters 3 and 4 enlarge this initial configuration very much and illustrate wider geoethical thinking. Thus this book exhibits the tension between expanding or focusing geoethics.

5.2 Expanding Versus Focusing?

Aligned with reflections in many scientific communities, inquiring 'what is meant by acting in an ethical manner' is ongoing in geosciences. These inquiries can be located within wider efforts that have been undertaken under the label 'responsible science' since the turn of the last century (United Nations 2013). In this context, some geosciences constituencies, initially addressing matters relating only to geology rather than to geoscience more widely, aggregated inquiries into ethical matters under the label ‘geoethics’. They started studying geoethics from various angles. Furthermore, ‘acting ethically in geosciences’ is found to be inspired by a wide range of concerns.

Notwithstanding the considerable efforts undertaken in the last decade by the geoethics community, the list of geoscience subjects for which geoethical inquiries are partly or entirely lacking is a long one; it includes, for example, geoengineering, climate change, artisanal mining, deep-sea mining and differential mortality in geo-hazards depending on social status. Likewise, exploring the grounding of geoethics in different ethical norms is missing from the published literature and will need cooperation with scholars outside geoscience communities. Hence, the current development path of geoethics seems to be about expanding. When considering the matters presented in this book, it is apparent that the development of geoethics has not yet even reached an inflection point. In this context, limiting the expansion of the application scope of geoethics would seem to be an act of unjustified intellectual coercion. In its current configuration, geoethics, as an emerging subject, is driven by the necessity to create a conceptual and practical framework for the work of geoscientists in the context of the complexity of the interactions between humans and the Earth system. Its promoters, mainly applied geoscientists, have progressively framed suitable ethical orientations for their professions. On many occasions, their inspiration has come from practices within chartered geoscience professions, which frame the interaction of geoscientists and clients, geoscientists and public institutions, geoscientists and mass-media, citizens or decision-makers through codes, guidelines and established practices. Resting on these foundations, geoethics as it currently stands has been designed to guide the conduct of scientific and professional work, to facilitate the civic involvement of geoscientists and to build the credibility and legitimacy of geosciences within the fabric of society. As outlined in this book, these professional matters have a broad and diverse scope, that will increase as the economic and societal applications of geosciences grow further. In this sense too, the development path of geoethics is about expanding.

In light of the case for extending the scope of geoethics, potentially across multiple dimensions, like those outlined above, it may be helpful to debate how geoethics could be framed in such a way that it retains its identity (and therefore its operational usefulness) without constraining its expansion and development.

One line of thought for opening these debates might be to consider a notion like 'geoethics proper'. The term itself is a little awkward, but could be coined to relate to the research, studies and practices of professional geoscientists who study the abiotic (inanimate) natural world and professional intervention into it (mainly by geoscientists). Although such a limitation of scope may sound practical and would distinguish geoethics from environmental ethics, it would obscure the fact that interactions of the biosphere and geosphere shape Earth system dynamics. Furthermore, human thinking about 'appropriate interventions' often treats as a continuum the abiotic (inanimate) and biotic (living) world, including any possible impact on people. Hence, an attempt to focus geoethics only on the abiotic natural world, and human interventions into it, seems unsatisfactory.

To take another attempt to explore limits to the application scope of geoethics, the fact could be considered that geoethics has been designed to focus on the agent, its deeds and the virtue ethics pertaining to these deeds. The focus on the agent immediately begs the question 'who is an agent'? An obvious agent in the case of human–geosphere interactions is the geoscientist acting in a professional capacity. However, the agent may be any professional that uses geoscience expertise in an explicit manner or any citizen who is benefiting implicitly from geoscience expertise when acting as a member of civil society or as a consumer. The idea of constraining geoethics in terms of specifying the agent therefore looks problematic too.

Moreover, if, as a hypothesis, geoethics were understood to be a tool for the 'geoscientist acting in a professional capacity', then a description would be needed of the disciplines that geosciences include. When undertaking this quest, it becomes evident that, at best, one may identify a nucleus of disciplines to which many may agree; and to which additions could be made as felt suitable according to individual preferences. Early studies of the Earth could broadly be sketched as having had two primary configurations—geography and geology—with geography describing the surface of the Earth including human activity and geology describing features below the Earth's surface. This sketch is somewhat incomplete because other expertise, such as that relating to minerals, mining or civil engineering, was part of the picture from the outset. With the emergence of modern natural sciences, geosciences became more clearly differentiated from geography, and while the human dimensions of geography remained at its heart, those relating to geoscience have tended to be seen as peripheral matters arising from the application of science rather than being a fundamental part of it. However, interactions with social processes are vitally important in both geography and geosciences, including through commercial and industrial applications, human health and wellbeing, and social development. Examples include hazard mitigation or urban planning when studying the supply of water and power or urban climate. It is a matter of choice, also driven by personal preferences, where to locate any border zone between geosciences and related fields. Cutting through the entangled geo-disciplines, it may be stated that geosciences refer to a range of applied and fundamental research fields, as well as related engineering disciplines and commercial undertakings. Together, they address the functioning of the Earth, the intersections of Earth and human systems as well as the extraction and use of (abiotic) natural resources. Given this application case, scholarly inquiry into the interfaces between geosciences and social sciences and humanities is germane, including into geoethical thinking. However, the difficulty of drawing an effective and objective boundary around the geosciences for this purpose would make it difficult to limit the scope of geoethics on this basis.

Drawing on the above, conceptually limiting the application scope of geoethics in terms of 'natural domain' (i.e., the geosphere), 'agent' (i.e., professional geoscientists) or 'intellectual domain' (i.e., geosciences) does not deliver a clear specification. Having discussed the prospects of limiting the scope for geoethics, an explicit programme of its expansion is an alternative option. The choice of embracing such a programme of expansion would build on the insights arising from attempts at limiting the scope of geoethics explored above.

The application of geosciences expertise may happen explicitly through the activities of professional geoscientists, implicitly in other professions or public governance, or embedded in the daily actions of any citizen. All these actions are part of how human activities and the geosphere intersect, and these are entangled with the biosphere too. The production systems and consumption patterns that sustain the human population are complex adaptive socio-ecological systems that give rise to the broad and diverse range of applications of geoethics, from natural hazards to mining, construction, the shaping of landscapes and geoengineering. By the same token, geosciences are entangled with other disciplines, including natural sciences, social sciences and humanities.

Understood in this manner, the possible application range of geoethics goes well beyond providing a framework for geo-professionals only. Thinking geoethically may provide a framework for many professions and organisations across a wide range of societal challenges, and offer a means of orientation for other citizens, all of whom are agents whose daily activities intersect with the geosphere in numerous ways. Geoethical thinking framed in this broad sense has the potential to be a fundamental public good, woven into the fabric of civil society, the literacy of citizens and our conceptions of democratic citizenry. However, an emphasis only on 'ethics' in such a framing may be too narrow, and a further notion may therefore be needed that can be used alongside geoethics.

5.3 Geoethics and Geosophy

Seeking a notion that is complementary to geoethics, bibliographic research suggests terms such as 'geo-humanities', 'humanistic geosciences' or 'geosophy' (Wright 1947; Mouchang 2011; Sörlin 2012; Castree et al. 2014; Hawkins et al. 2015; Holm et al. 2015; Blankenship 2018; Shaw 2017). When considering the meaning of 'geo-humanities' or 'humanistic geosciences', for example, it seems evident that they could refer to a composite body of expertise composed from natural sciences, engineering, social sciences and humanities. But the notion 'geo-humanities' is already used by geographers with specific meanings and purposes. The notion 'geosophy' seems to offer an appropriate meaning, by the construction of the term, to refer to knowledge about Earth. On first sight, without further analysis, for example, of its etymological roots, the notion 'geosophy' seems convenient for the present context. Although conceived in 1947 by Wright, as discussed in the previous chapter, the term has not been taken up into the scholarly vocabulary. Therefore the notions 'geosophy' and 'geoethics' might be an appropriate pair to encompass together the societal context, implications and obligations of geosciences, leaving open for exploration what is the middle ground between them, depending on the role of the human agent for a given issue.

In view of whether to expand or focus the application scope of geoethics, it should be explored whether the notions 'geoethics' and 'geosophy' together may describe comprehensively insights into the human–Earth system, and hence the building of a planetary human niche. In such a framework, the core of geoethics would be an 'an actor-centric and enriched geo-professional ethics', in the sense described by the Cape Town Statement on Geoethics (Di Capua et al. 2017):

> Geoscientists have know-how that is essential to orientate societies towards more sustainable practices in our conscious interactions with the Earth system. When applying a wider knowledge-base than natural sciences, then geoscientists need to take multidisciplinary approaches to economic and environmental problems, embracing (geo)ethical and social perspectives. Geoscientists are primarily at the service of society. This is the deeper purpose of their activity.

When reaching out beyond its initial core, geoethics would encompass matters that are relevant for the human–Earth system and address any human agent who is explicitly or implicitly using geoscience knowledge in its actions. As a complement, the notion 'geosophy' would encompass matters that are relevant for the understanding of the human–Earth system but that relax the focus on the human agent. Hence, geosophical and geoethical thinking would embark on inquiries into the human condition in contemporary times of anthropogenic global change. Geosophical thinking would focus on the relevant knowledge base, compared with geoethical thinking that has its focus on the actions of the human agent and the consequences of them. The balance between both notions provides for exploring the mutual limitation of their respective operational scopes, within which the tension between expanding or focusing of geoethics could be handled. As an example, geoscience literacy as a knowledge base would be part of geosophy. However, development and application of geoscience literacy jointly with other knowledge bases would be part of geoethics, *"wherever human activities interact with the Earth System"* (Peppoloni and Di Capua 2017, p. 2). That is, geoethics is designed with clear operational criteria that it is about the deeds and values of the human agent as part of the Earth system.

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