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Phronesis at the Human-Earth Nexus: Managed Retreat

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This study explores how experiences from the current pandemic can inform societal responses to future climate change. To that end, an established philosophical concept of geoscientific insights (geoethics) is utilized to advice on governance under systemic uncertainty that, in turn, is a critical feature of complex-adaptive dynamics. Illustrative examples are the Covid-19 health pandemic and the impact of the global sea-level rise to threatening heights in the early 22nd Century. The term "geoethics" labels an emergent geo-philosophical school of thought rooted in geoscience expertise. When combined with contemporary political philosophies, geoethics leads to a geo-philosophical framework that can support adaptation to complex-adaptive dynamics by favoring multi-agent and context-depending processes (e.g., learning-by-doing). The proposed geo-philosophical framework merges geoethics with the political philosophies of H. Jonas (1903–1993), L. Kohlberg (1927–1987), and M. Bunge (1919–2020). These contemporary philosophies emphasize as relevant for achieving a modern caretaking society, respectively, "the hierarchy of societal coordination processes," "the intergenerational responsibility of agents of change," and "the balancing of individual wellbeing (happiness) and duties." When these philosophies are combined with geoethics, a logical approach can be derived for policy design and decision-making. It emphasizes the "autonomy" (of the human agent) combined with a civic culture that favors "trustworthiness," "scientific culture." and a "culture of inclusive justice." We argue that governance of adaptation to complex-adaptive dynamics (e.g., climate change impact) can be informed by the geo- and society-centric perspectives of the proposed geo-philosophical framework. It can address "Human Earth Nexus" governance issues using the knowledge of both natural and social sciences and applying the lens of geoethical thinking.

Keywords: managed retreat, sea level rise, COVID-19, socio-ecological systems, Human-Earth Nexus

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INTRODUCTION

The problems accumulating around global change have created a new form of the Human-Earth Nexus. A geo-philosophical framework is proposed for how to act at this nexus (Plenge, 2020). The framework combines "responsible Earth-sciences" (Bohle and Ellis, 2016), e.g., geoethics (Peppoloni et al., 2019), with political philosophies addressing some essentials of caretaking societies. As an illustration, this essay looks at experiences from the Covid-19 health pandemic and the expected impacts of a rising mean sea level. The relationship between these two different events can be traced, given that both unfold in complex-adaptive social-ecological systems. The

commonalities between a pandemic disease and the impacts of anthropogenic global change are apparent when considering culture or sociological features.

Adaptation to impacts of global change will involve retreat in various forms (Hanna et al., 2021; Siders and Ajibade, 2021). The notion of "managed retreat" is more than a managerial or technical task. It concerns social and cultural adaptation (Dachary-Bernard et al., 2019). The cause for the retreat will be that local (physical) living conditions are unbearable, for example, because of heat, drought, or floods. The example discussed in this essay is the rising global mean sea-level in the next century and beyond. Other threatening impacts of anthropogenic global change are expected sooner (Robinson et al., 2021), and what will be discussed in this essay will apply to them likewise.

While there is still a long way to go, and regarding the sea-level of the 22nd Century, the Intergovernmental Panel on Climate Change (IPCC) was able to present in 2021 robust scenarios on the sea-level rise beyond the next century (Masson-Delmotte et al., 2021). Still, in 2014, the IPCC, an intergovernmental consultation mechanism with the support of scientific expertise, could not agree on a physically plausible upper limit bound for sea-level rise by 2100 and beyond. Seven years later, the situation evolved. Governments agreed sea-level rise poses a challenge having a 100-year-plus time horizon.

We argue that two distinct phenomena can be put into mutual perspective: first, the COVID-19 health pandemic of 2020 onward and, second, the global mean sea-level rise to threatening levels due to global warming. Despite evolving on different time scales, the current COVID-19 health pandemic and the future global mean sea-level are comparable phenomena because they show similar systemic features. To relate them with governance issues, this essay explores how "geoethics" (Peppoloni et al., 2019) combined with contemporary political philosophies could support a cultural environment appropriate to tackle the impacts of anthropogenic global change.

We hypothesize that an appropriate cultural environment could be anchored in a double imperative, namely to act driven by (i) scientific insights (into the Earth System) and (ii) concerns for caretaking societies. Subsequently, four pivots for policy-design are proposed for acting at the Human-Earth Nexus, namely "autonomy," "trustworthiness," "scientific culture." and a "culture of inclusive justice," which are underpinned by emphasizing: processes for reproducible knowledge-building; Earth science literacy; the quality of societal coordination processes; the responsibility of agents of change; and the balance between individual wellbeing and duties.

Following this introduction, this essay is structured into three sections. The Matters and Methods section illustrates the study's concept; the examples (COVID-19 pandemic and sea-level rise) seen through the lens of this concept; the geoethics approach, including how it can inform governance when combined with political philosophies. The Results section derives key features for designing policies. The concluding section, Discussion, argues why these pivots empower human agents and are suitable for a caretaking, learning, and participatory society informed by scientific insights. Regarding nomenclature, (i) the notion "human agents" should be read as individual, collective or institutional human agents/agency; (ii) the notion "scientific insights" should be read as best available scientific understanding including related uncertainties; (iii) the expression "geoethical logic approach" is used to name a particular manner to structure geoethical thinking, (iv) the term "systemic uncertainty" is used to label the intrinsic non-deterministic behavior of complex-adaptive systems; for a discussion, see (Bohle, 2020, 2021).

MATTERS AND METHODS

This section is divided into five parts. The first and second parts outline the background of the study and the theory of complex-adaptive social-ecological systems (Biggs et al., 2021). The third part describes the COVID-19 pandemic emphasizing how human agents perceive the pandemic. From these perspectives, we can deduce how to approach governance of impacts of global change. The fourth part describes what we know about the incoming sea-level rise because of global warming, emphasizing how human agents likely perceive global sea-level rise. The fifth part describes geoethics and the derived "geoethical logic approach."

Background to the Study

The specific research question of this essay is how geoscience-informed philosophies may support designing policies for adaptation to anthropogenic global change. To approach the question, we start from what we – as geoscientists in the broader sense – have in hand, that is, a bulk of corroborated empirical evidence and recent developments in geo-philosophical concepts (Peppoloni et al., 2019; Bohle and Marone, 2021; Marone and Bouzo, 2021).

The argumentation outlined in the essay applies a geo-philosophical approach. It combines modern concepts (Mogk, 2018; Peppoloni et al., 2019) of 'responsible Earth Sciences' (Geological Society of America, 1997; United Nations, 2013; Bohle and Ellis, 2016; Vasconcelos and Orion, 2021) with three political philosophies formulated in the last century. These philosophies address essential elements of a caretaking society, namely "societal coordination" (Kohlberg, 1981), "intergenerational responsibility" (Jonas, 1979), and "balance of wellbeing (happiness) and duties" (Bunge, 1989).

As a description of a specific knowledge domain, "Earth Sciences," in a restricted connotation "Geosciences," are the natural sciences studying the Earth, mainly abiotic processes, although without neglecting biological and social processes (Phillips, 2012; Bohle et al., 2019). Because of the study subjects of Earth Sciences (Geosciences), controlled experiments are rarely possible (e.g., sediment flux), and hypothesis testing is constrained due to the limited reproducibility of natural/social phenomena (e.g., river floods). Insights are gained from subsequent observations of recurrent phenomena (e.g., volcanic eruptions) and, in some cases their mathematical simulation (e.g., Meteorology, Oceanography). Input information is often incomplete, insufficiently precise or not standardized.

Many hypotheses about natural/social phenomena cannot be tested by "reproducing" them in *stricto sensu*. In this

sense, Earth Sciences are constantly confronted with a sort of "reproducibility crisis" (Kleinhans et al., 2010; Marone et al., 2019) Therefore, the knowledge-building process of Earth Sciences applies a "synthetic thesis of truth" (Bunge, 2006), which helps combine empirical evidence, stochasticity (combination of deterministic and probabilistic approaches), mental experiments, or computer modeling. Synthetic thesis of truth *"requires considering a hypothesis corroborated both by purely empirical confirmation and external consistency or compatibility with the bulk of existing background knowledge (systemicity).… Pattern consistency (empirical control) together with an understanding of causal relations (rational together with empirical control) make confirmed hypotheses robust and more reliable"* (Marone et al., 2019, p 363).

A few words are added to contextualize the subjects of this essay. The challenges of climate adaptation are demanding and they include both risk assessment associated with ongoing change or threshold-depending events and risk perception, for example, depending on local culture and individual experiences (Stewart and Lewis, 2017). Options to handle risks might be hard to implement or pose additional threats. While non-human systems are complex, i.e., non-linear in nature, an additional complexity of modern societies is related to 'technologies' or the "technosphere" (Haff, 2017; Trischler and Will, 2017; Kranzberg, 2019). Tibaldeo, *"For several reasons our present-day civilization has become increasingly complex. Indeed, complexity seems to be one of the most eloquent characteristics which unifies several aspects of today's world, such as epistemology, science, technology, politics, economy, culture, society, and so on"* (Tibaldeo, 2015, p. 225). Hans Jonas suspected in his essay 'The Heuristic of Fear', that technology places the future of humanity in jeopardy (Jonas, 1980). Bunge pledged *"the scale and complexity of modern technological impacts requires that experts be in charge of social action — although they must be answerable to the public. Technologists, instead of being shackled by others, must tackle their own moral problems and take a hand in overhauling ethics"* (Bunge, 1980, p. 139).

Contextualizing the Examples

Throughout the next century, the world will experience, unevenly though fully developed, the distress of social-environmental systems due to the consequences of anthropogenic global change. These circumstances require a philosophy to support governance, for example, in building adaptive strategies such as Bayesian methods (recurrent updating of probable scenarios) or "relational heuristics" (Biggs, 2008; Preiser et al., 2021).

The COVID-19 (SARs-CoV-2) pandemic, declared by the World Health Organization in March 2020, offers qualitative lessons on governance (see, for example Cardoso et al., 2020; Marone and Bohle, 2020; Santos-Carrillo et al., 2020).

Regional climates and living conditions shift (Robinson et al., 2021). They will have changed substantially by mid-century. People will have to migrate. Notions like "climate refugees" are part of the political vocabulary, arguing for a "compassionate retreat" (Brown and Schmidt, 2014). The future rise of the global sea-level and the current COVID-19 health pandemic can be compared because of systemic similarities. Both phenomena are (1) pandemic/global and rapidly evolving, (2) certainly occurring and scientifically defined, (3) less known regarding local manifestations blurred by shifting baselines, (4) on everyone's mind because of massive media reports, (5) happening globally but punctuated by local disasters, and (6) causing people's reactions ranging from fear to denial. The given experiences with modest (local) sea-level rise already illustrate these features (Pilkey and Pilkey, 2019).

These systemic similarities arise because complex-adaptive dynamics characterize both phenomena. Complex-adaptive dynamics are typical of (many) social-ecological systems (Biggs et al., 2021). Mutatis mutandis, the systemic lessons from the COVID-19 health pandemic (see, for example Angeli and Montefusco, 2020; Merriam, 2020; Robie, 2021), can inform on distant events like the impacts of global change phenomena (e.g., high sea-levels) in the next century.

Complex-Adaptive Social-Ecological Systems

Complex systems, or non-linear and threshold-depending dynamical systems with multiple non-separable cause-effect pathways, are challenging. The resulting complex-adaptive system dynamics lead to systemic uncertainty. Determinism, the dominant (engineering) paradigm in (linear) systems theory, is failing when it comes to complex systems (Beven et al., 2018). A classic example in physics is the study of turbulent flows, relevant, for example, in boundary layers of lakes (Bohle-Carbonell and van Senden, 1990; Cimatoribus et al., 2018). Learning that the behavior of a given phenomenon cannot be predicted or controlled can be perceived as faulting data and knowledge. Subsequently, the search for a "blueprint" or "master plan" may continue, often motivated by the available mathematical tools and computational methods (Hansson, 2015). However, with a better understanding of the dynamics of non-linear systems, scientists deal with them (e.g., turbulent flows) in a stochastic way, which ultimately enables the modeling of climate systems[1].

Beyond non-linearity, natural dynamics exhibit links, feedbacks, cascading reactions, unexpected turning points, irreversibility and multifaceted properties, making dynamics a complex-adaptive reality of systemic uncertainty (**Table 1**) to be dealt with (Biggs et al., 2021). In the mid-18th Century, Thomas Bayes formulated a theorem stating that probability statements can describe unknown parameters. The Bayesian approach is a conceptual paradigm to search for approximate solutions (in a probabilistic sense). Examples are various practices: learning by doing; updating (probable) scenarios successively as more evidence or information becomes available, or stepwise constraining systemic uncertainties (see, for example Fuerth and Faber, 2012; Barash et al., 2019; Muiderman et al., 2020; Biggs et al., 2021; Lo and Zhang, 2021; Preiser et al., 2021).

Like any complex-adaptive dynamical system, the social-ecological one presents systemic uncertainty. Instead of pursuing fully informed choices, Bayesian approaches offer remedies (Biggs, 2008; Kato and Ahern, 2008; Koppes and King, 2020), which are helpful when the rate of change outpaces the speed

[1] As acknowledged by the 2021 Nobel prize in Physics.

TABLE 1 | Dynamic characteristics of complex adaptive systems (adapted from Woermann et al., 2018).

Feature	Description	Effect
Networked causes	multiple, parallel cause-and-effect pathways	local and system-wide behavioral patterns
In-put/out-put relation	not proportionally related	minor changes in a controlling driver can cause rapid, system-wide behavior/significant changes in the controlling driver may cause slow and limited system-wide response
Structure	structural parts are multifunctional	different structural parts may perform the same function/the same structure can perform various functions
Non-linearity	amplifying dynamic interactions.	Minor inputs may trigger cascades of significant effects that cause surprise, and uncertainty/local interventions may modulate system-wide organization

of decision-making and implementation (Berta et al., 2020; Tiggeloven et al., 2021).

A Complex-Adaptive Earth System

The concepts of complex-adaptive dynamics and social-ecological systems are a powerful description of the (natural and societal) features of the Earth System (Preiser et al., 2018). Complex-adaptive systems are hard to handle and may behave contrary to the observer's expectations. Such counterintuitive system behavior, which can be perceived as "wicked" (Head and Xiang, 2016), includes, for example (see **Table 1**), multiplexed cause-and-effect paths, not proportional output-input relations, amplifying interactions, and multifunctional structures.

As part of the Earth System, humankind operates a globalized network to supply food, commodities, and goods. It is tightly knotted with multiple process loops (Walker et al., 2020). They create an intimate social and ecological dynamic entangling World and Nature (Donges et al., 2017; Behrendt, 2018; Dyer-Witheford, 2018; Bennett et al., 2019; Schlüter et al., 2019).

As part of the Earth System, human practices also encompass the governance arrangements of public bodies or corporations (Biermann, 2014). For example, governance arrangements determine how to design technologies, production systems, and consumption patterns. The societal processes (e.g., administrative, political, cultural) and related infrastructures (e.g., parliaments, ministries, foundations, think tanks) have a dual nature; namely, they combine a cognitive function (sensemaking) and a material foundation (to enable the sensemaking process). In social-ecological systems, people's attitudes and behaviors have mental and material forms. The latter (institutions, technologies, interactions) mirror cognitive processes.

Such "soft sub-systems" of the Earth system co-shape its dynamics and, hence, influence the entire system behavior. They are essential, like technical artifacts or natural processes. They contribute to complex-adaptive dynamics of the Earth System given that *"humans are actors whose actions are not just determined by their natural, social, and cultural environments, by their economic, political, or religious interests, or by their drives and passions, but also by their thinking, and in particular by what they actually know about the world and themselves, and by how they know and share it, as well as by the way in which they make use of their knowledge"* (Renn, 2020, p.10f).

Lessons, the COVID-19 Pandemic

On the day of writing[2] and about 21 months since the WHO declared a health pandemic, the number of infected people cumulated to 248 million, the death total to 5.0 million, and the administrated vaccine doses to 7.1 billion. Hence, the reservoir of infectible humans is about half of the global population, assuming two vaccination doses are required to protect an individual.

The COVID-19 health pandemic reached threatening levels, that is, the risk of the health system collapsing at different times in different regions (Reddy, 2020; Daghriri and Ozmen, 2021; Kuhlmann et al., 2021; Coccia, 2022). Likewise, news about events and actions in one region informed authorities and people in other regions unevenly, leading to a patchwork of responses. Although robust and valid information was available, the levels of rumors, fake news, and misinformation were disorienting for many. Subsequently, the regional threats and impacts differed enormously; (see, for example Reicher and Stott, 2020; Shaw et al., 2020; Lindholt et al., 2021).

The COVID-19 health pandemic has hit many sectors of the economy and society including health systems. Examples are food production and supply chains (Chowdhury et al., 2020; Fernandes, 2020; Bassett et al., 2021). Beyond studies in such fields and leaving aside studies comparing countries' strategies (Chowdhury et al., 2020), other works researched issues like terrorism (Marone, 2021), ethics for health system operators (Robert et al., 2020), or ethics of management issues, including sociological perspectives (Schröder-Bäck et al., 2020).

The Covid-19 health pandemic is a collective experience of cognitive uncertainties (Sarry et al., 2021), both for individuals and institutional agents (Janssen and van der Voort, 2020; Shu and Wang, 2021). The pandemic is profoundly influencing daily lives, although, for many, the disease is not experienced "hands on" but is communicated through mass and social media. People collectively experienced how usual ways of doing got scattered. The pandemic challenged the lifestyles of many people and weakened communities in many developing countries; (see, for example Cardoso et al., 2020; Bassett et al., 2021; Egger et al., 2021). Although the coerced temporary changes of lifestyles (social distancing, lockdowns) were not physically threatening for most, the perceived loss of autonomy, security, and liberty was collectively unknown for many (Anicich et al., 2020).

The features of the pandemic also challenged the sensemaking capabilities of many, triggered defensive reactions (fear, denial), and encountered dispersed and less-than-adequate responses, also from governments. Most societies (states) initially implemented various containment measures without much intergovernmental coordination (Capriglione, 2020). Intergovernmental cooperation emerged stepwise and erratically.

[2]https://coronavirus.jhu.edu/map.html (5th November 2021).

Given these experiences and referring to COVID-19, Angeli and Montefusco (2020, p. 1) stated that *"just as complex adaptive systems, societies affected by the pandemic and by the subsequent containment policies present non-linear and unpredictable outcomes, which highly depend on the social systems' initial states and on the behavioral rules governing the actions and interactions of the agents composing the systems."*

The COVID-19 health pandemic illustrates what is reported as systemic for complex-adaptive socio-ecological systems (Termeer et al., 2015, 2016; Huang and London, 2016; Preiser et al., 2017). Also, the COVID-19 pandemic taught those in charge of decision-making to be aware of unexpected disproportionate consequences of management actions, while at the same time decision-making must be flexible, highly adaptive, fast, and frugal; (see for example Fuerth and Faber, 2012; Munene et al., 2018; Kool et al., 2020).

Teachings, the Rising Sea-Level

Introduction

The science of global sea-level rise is robust. The global mean sea-level has risen more rapidly since 1900 than in any previous century. Likewise, like many other climate changes, it is now irreversible for centuries to millennia, even if climate change mitigation strategies are implemented (Clark et al., 2016; Christodoulou et al., 2019; Frederikse et al., 2020; Horton et al., 2020).

The global mean sea-level will rise to threatening heights in the early 22nd Century (Kulp and Strauss, 2019). The threats are multiple, including flooding, rising mean water table, shoreline erosion, saltwater intrusion into coastal aquifer, loss of coastal wetlands, or hampered the operation of ports. The threats vary depending on the local topography, such as cliffs, lowlands, or anthropogenic coasts (Sterr, 2008; Leuven et al., 2019). How to handle them depends, for example, on geomorphology, hydrology, climate, economy, population density, socio-political systems, and culture (Tol et al., 2008). Subsequently, people will retreat from the actual shorelines (Mees et al., 2014; Anurag Danda et al., 2019; Piguet, 2019; Siders, 2019; Doberstein et al., 2020). Even under optimistic climate change mitigation scenarios, the global mean sea-level will continue to rise for several 100 years. Hence, a reasonable societal goal should be to retreat, when needed repeatedly, from the shoreline in an anticipated and coordinated manner before disasters strike (Hanna et al., 2021).

A Narrative – Global Mean Sea-Level

Referring to the IPCC[3], it is sure that the global mean sea-level will continue to rise over the entire 21st and 22nd Centuries. Compared to 1995–2014, by 2150, it could increase to 0.37–0.86 m (very low emission scenario) and 0.98–1.88 m (very high emission scenario). In the longer term, the rise (by about 2–3 m) will continue because the deeper layers of the world ocean will warm (and expand). Some ice sheets will melt even if the warming is limited to 1.5°C. With high confidence, the sea-level will remain elevated for thousands of years. Even if global CO_2 emissions were negative, it would take several centuries to millennia for the rise to reverse. Hence, even under the most optimistic climate change mitigation scenarios, the rising sea-level rise threatens the world's coastal zones. Caused by local mean sea-level rise, extreme sea-level events occurring locally once per century in the recent past are projected to happen at least once a year in most places. Subsequently, the frequency and severity of coastal flooding and impact on operations of harbors will increase (Christodoulou et al., 2019).

Global warming will cause flooding of productive coastal areas within the next 100 years involving substantial uncertainties and neither easy nor inexpensive solutions (Anderson et al., 2020; Lincke and Hinkel, 2021). The "shifting baseline syndrome" will mark the events (Pauly, 1995; Jones et al., 2020; Thomas, 2020), and regional differences within and beyond national jurisdictions will characterize them. Initially, bothersome hazards (e.g., saltwater intrusions) and deadly threats (e.g., flooding) will be local, and responses (e.g., migration, either due to personal health and safety concerns or by economic considerations) may be spontaneous and individual (Pilkey and Pilkey, 2019). The retreat process will be a media-reported experience (of 'the others' lives'), one of the several similarities of the COVID-19 pandemics and climate change. Rising seas will probably force millions of coastal people to relocate (Hauer et al., 2020), triggering a climate refugee crisis (Leardini, 2017; Simonelli, 2021) like no other; including the disappearance of some island countries or estuarine regions (Nunn et al., 2017; Anurag Danda et al., 2019).

Regional Patterns, an Example

Although caused by global warming, the rising mean sea-level is not a uniform steric phenomenon (Horton et al., 2020) because of ocean dynamics and mass distribution (ice). Significant regional differences will occur (Grinsted et al., 2015), including shifts of extreme events wherever the mean sea-level is subject to substantial changes (Witze, 2018). For example, water levels in Hamburg or London (Western Europe) may rise by 0.8 m and drop in Oulu (Northern Europe, Bay of Bothnia) by 0.1 m. Related to the mean sea-level changes, the likelihood of the combined height of astronomical tides and storm surges [extreme sea-levels (ESL)] shifts. For example, in the Elbe estuary (Germany, North Sea), *"the 500 year ESL is projected to become as or more frequent than the historical 100 year ESL"* (Rasmussen et al., 2018, p. 9). Threats increase further when extreme sea-level combines with strong river discharge (Hofstede, 2019a, p. 289).

Like their peers in the Netherlands (de Graaf et al., 2009), public authorities in Northern Germany plan for mean sea-level rise and increased likelihood of extreme sea levels by the end of the 21st Century (Sterr, 2008; Hofstede, 2019a). Also, the option of a managed retreat is mentioned. However, it is a sensitive topic because, for example, in *"the Schleswig-Holstein sector of the Wadden Sea, more than 1,000 years of land reclamation through embankments has led to the detachment of about 2,400 km² of coastal marshes from marine influences.... Today, the mainland coastline is almost completely occupied by 190 km of primary embankments in the responsibility of the State. The 8 to 9.5 m high and up to 80 m broad embankments protect*

[3]https://www.ipcc.ch/assessment-report/ar6/

about 130,000 inhabitants and 19 billion € of capital assets.… Due to the long history of land reclamation, in many places, several embankments and polders exist behind each other; the oldest ones lying the farthest from the sea. In result, more than half of the coastal lowlands are protected by a so-called second embankment-line" (Hofstede, 2019b, p. 1069). This century-long cultural path of defending shorelines (and claiming land from the sea) will be challenging to reverse. Hence, as we have the better part of a century to prepare, the question is how a developed industrial society of deeply rooted engineering prowess prepares to implement a "retreat" when former societies did not "give up" and sanctioned those who did. In the history of German coastal communities, individuals were expropriated when they did not participate in the maintenance of shore defenses (Gierke, 1907).

To date, it would be mere speculation as to how a policy change for shore defense could evolve in Germany under given cultural, historical, and economic circumstances. Nevertheless, it seems inevitable for the 22nd Century. One may wonder what kind of disasters must strike, whether they would be politically viable, and whether they would remind of the historical past (*Grote Mandränke* 1362 and 1634)[4] that was overcome since the 19th Century (Hansen, 1894).

Finally, we would like to recall that the situation at German coasts is by no means unique. Subsequently, "managed retreat" is discussed in many places (van Staveren and van Tatenhove, 2016; Dachary-Bernard et al., 2019; Anderson et al., 2020; Dundon and Abkowitz, 2021; Hanna et al., 2021; Siders and Ajibade, 2021). It is vital to develop a culture that treats removal policies as managed, coordinated, and anticipated.

Geo-Philosophical Insights

Within Earth Sciences, geoethics investigates societal contexts and professional obligations (Peppoloni and Di Capua, 2012; Peppoloni et al., 2019). Distinct from Gaian ethics or alike, geoethics is a Western geo-philosophical school of thought. It is rooted in geoscientific knowledge (to understand Earth), emphasizes practical wisdom (*phronesis*), and tackles issues relating to responsible geosciences. Subsequently, geoethics can be structured for various application contexts and with different philosophical embedding (Bohle, 2021; Peppoloni and Di Capua, 2021).

The variants of geoethical thinking share the insight *"that choices that are taken in a specific social and cultural setting, that respect the ethical norms of this setting, may appear unethical elsewhere*" (Peppoloni et al., 2019, p. 30). This "degree of freedom" or "option of normative pluralism" is an intentional feature, which gives geoethics plasticity to operate in different contexts. Still, geoethical thinking implicitly incorporates formal ethical frameworks (see Hourdequin, 2015, p.55): *"utilitarianism directs our attention to consequences; Kant's ethics to respect and autonomy; Aristotle's virtue ethics to character and its connection to living well."* In geoethical thinking, Kantian and Aristotelian thinking is vital. Utilitarian views are expressed, for example, in the Cape Town Statement on Geoethics, asserting that geoscientists are *"primarily at the service of society. This is the deeper purpose of their activity*" (Di Capua et al., 2017, p. 6). Furthermore, (Bohle and Di Capua, 2019; Mogk, 2020) discuss issues of justice, diversity, and equality; although without exploring ethics of justice.

The variant of geoethical thinking that is used in the following sections merges geo-philosophical insights with the contemporary (political) philosophies of Kohlberg (1981), Jonas (1979), and Bunge (1989). These philosophies provide additional framing, incorporating thinking regarding "a hierarchy of societal coordination processes"; "an intergenerational responsibility of agents of change"; and "a balance of individual wellbeing (happiness) and duty." The embedding of geoethical thinking in these political philosophies leads to the "geoethical logic approach" (**Table 2**).

This approach was suggested in recent years (using various terms to name it, e.g., geoethical rational, thesis). It targets to apply geoethical thinking in a broader context than professional geosciences; (see Bohle, 2020, 2021; Bohle and Marone, 2021). The 2-fold foundation of this approach ensures that [geo]ethical decision-making is guided by insight into the functioning of the Earth System and concerns about the functioning of the society, both under the imperative of "caretaking" for the entire social-environmental system. The descriptions of the geoethical logic approach would require a scrutiny beyond what is possible in this essay. Applying a "folk meaning" or "practitioner's wisdom" seems sufficient in the given context (Bardach, 1987). However, given the following arguments, how we use the term "reproducibility" is sketched in the following paragraph.

Reproducibility means that the relation between the object of a study, the method, and the finding is invariant; e.g., *"genuine science is impersonal"* (p. 461) or *"every research project… should be impersonal, and therefore replicable by others employing the same methods"* (Bunge, 2017, p. 467). Hence, reproducibility implies that knowledge (e.g., scientific finding) should not depend on investigators' philosophical, cultural, social or political ideas[5]. Furthermore, reproducibility means that the same piece of knowledge can be established by applying different methods to the same object of study. Finally, the reproducibility of knowledge (e.g., a scientific finding), can be supported by a theoretical framework, which may take a mathematical form.

RESULTS

The future rise of the mean sea level and the ongoing COVID-19 health pandemic show systemic similarities; as listed above: they are (1) pandemic/global and rapidly evolving, (2) certainly occurring and scientifically definite, (3) less known regarding local manifestations blurred by shifting baselines, (4) on everyone's mind because of massive media reports, (5)

[4]https://www.ndr.de/geschichte/chronologie/Die-Grote-Mandraenke-Schicksalhafte-Fluten-1362-und-1634,grotemandraenke101.html

[5]It is a different debate how philosophical, cultural, social or political views of investigators influence, for example, the choice of the research question, object of the study, or study method. Also, the object of a study, method and finding can be described only with finite accuracy. Hence, reproducibility is given 'within error margins'. Finally, scientific knowledge systems constrain the thinkable and evolve (Renn, 2020).

TABLE 2 | The tenets (of the geoethical logic approach) and their expressions as socio-political preferences to shape governance arrangements in complex-adaptive social-ecological systems (adapted from Bohle, 2021).

Tenet of geoethical logic approach focusing on	Meaning	Implying governance & caretaking societies
1. Agency	A framework that invests human agents [#] in acting to their best understanding, balancing (individual) happiness and (individual) duties, and considering the given circumstances, opportunities and purposes;	Societal/cultural/political preferences for a distributed human agency; governance structures that encourage human agents to act in a context-depending manner;
2. Virtue	A corpus of traits (e.g., honesty, integrity, transparency, reliability, a spirit of sharing, cooperation, reciprocity) of a human agent, which furthers operational (handling of things) and social (handling of people) capabilities of the individual/group;	Societal/cultural/political practices (e.g., public and private educational frameworks and modes of cooperation), which (a) favor traits of human agents such as honesty, integrity, transparency, reliability, etc., and (b) suchlike, enhance skills of agents for effective and efficient operational and interpersonal dealings;
3. Responsibility	The outcome of a normative call (internal, external) on a human agent, which frames decisions/acts in terms of accountability for the intended effects, the unintended consequences, and the implications for future generations;	Societal/cultural/political practices (e.g., public and private educational frameworks and modes of cooperation) foster political and social behaviors that value accountability, foresight, and intergenerational justice and caretaking.
4. Knowledgebase	(a) As a foremost instance, knowledge [*] that is acquired by scientific methods; (b) experience-based knowledge [**] is a secondary instance; (c) reproducibility of knowledge by third parties [***] supports trustworthiness rather than an allusion to faith or 'authorities'; [*] any domain of human scientific & scholarly knowledge; Earth system literacy (including geosciences) as *primus inter pares* within STEM; [**] indigenous/traditional/local [***] core of the scientific method, see Bunge's 'synthetic thesis of truth' (Bunge, 2006)	Societal/cultural/political practices (e.g., public and private educational frameworks and modes of decision making), which emphasize 'scientific methods' and 'reproducible knowledge' with particular emphasis on 'Earth science literacy' and dynamics of complex systems;
5. Inclusivity	Achieve a participatory practice (e.g., *'shared social license to operate'*) between various agents by mitigating differentials of power, voice etc. using capacity building;	Societal/cultural/political practices of inclusive political/societal processes and modes of cooperation allow human agents to participate in decision-making and implementation.
6. Universal-rights	Guide affective and rational sensemaking and cooperation of human agents by furthering adherence to human rights (life, liberty, justice) and by strengthening derived norms such as utilitarian, sustainability, precautionary principles or rights of non-human sentient beings and nature;	Societal/cultural/political practices (e.g., public and private educational frameworks and modes of cooperation) that care about governance practices emphasize sensemaking based on human rights.
Comments:	[#] understood as individual, collective, or institutional agent	

happening globally but punctuated by local disasters, and (6) causing people's reactions ranging from fear to denial. It is expected that most of the impacts of anthropogenic global change will share these similarities.

Complex-adaptive dynamics of social-ecological systems, be they featured by the COVID-19 health pandemic or the rise in global mean sea-level, are characterized by a systemic uncertainty about "what happens next" or newly emergent system features. Subsequently, the capabilities to forecast change are limited. The handling of problems is iterative. Solutions are adapted regularly to adjust them to path-dependent and irreversible developments. In the same vein, irregular variability in time and space and difficult-to-discern patterns disorient people and cause frustrations that elites and authorities 'are not getting it right'. Subsequently, decision-makers and managers are challenged for both: making decisions and communicating them. Therefore, maintaining mutual trust is a very high societal value. Experts' culture cannot nourish it. Instead, trust must root in other qualities (Rochira and Salvatore, 2021) and may comprise, for example, an extensive interaction of scientists and citizens (Resnik et al., 2015). Therefore, the geoethical logic approach suggests "virtue," "responsibility," "inclusivity," and "universal-rights" as tenets that guide the human agent to preserve trustworthiness. Hence, trust is not an outcome of proven expertise. Instead, the behavioral traits of the human agent and the manner how expertise is put into practice are building trust.

Being aware of shifting baselines is knowing the *status quo* and *status quo ante*. Humans have difficulties keeping track of baselines (Pauly, 1995; Moore et al., 2019). The slow rise in mains sea-level is a perfect example, e.g., flooding during king-tides in Miami becomes normal (Wdowinski et al., 2016). Subsequently, a sense of urgency and need-for-change is lost, and the public and coordinated response is hampered. In the same vein, when lacking direct (own) experiences of upcoming threats while experiencing insights and behaviors being socially communicated (or coerced) and media-driven, then ample opportunities for distortion, fakes, and active misinformation arise (Salvaore et al., 2019). Therefore, the geoethical logic approach postulates "reproducible knowledge," which might be scientific or scholarly (although it may have other sources) as a vital tenet. It aims to prevent misjudgment by shifting baselines and passive or active misinformation. The tenet enshrines the

reproducibility of knowledge as an essential feature of any critical process of knowledge consolidation.

When understanding local particularities and global patterns, human agents may learn to handle dynamics exhibiting context-dependency and lacking uniformity. In the same vein, shifting baselines and irregular variations trigger spontaneous reactions and, hence, hamper coordinated responses. Also, as said above, the trust in agents handling complex-adaptive dynamics is not rooted in the experience "they got it right last time" because it was no last time to compare with. Any such feature questions the delegation of agency to "authorities." Instead, they call to acquire capability (agency) for local action. Therefore, the geoethical logic suggests investing in the empowerment of human agents, calling for inclusiveness and human rights to shift from a "spontaneous" to a "coordinated" response.

Given a governance perspective, these findings can be aggregated into four pivots for policy-design: "autonomy" and "trustworthiness" of the human agent living in a society with a "scientific culture" and a "culture of inclusive justice."

Schematically:

- Tenet "1" (agency) of the geoethical logic approach indicates to accentuate the "autonomy" (of the human agent), namely to act on own initiative to face (diverse) local circumstances. Subsequently, a culture and governance policy encouraging citizens' emancipation to act must be advocated.
- Tenets "2, 3" and "5" (virtue, responsibility, human rights) of the geoethical logic approach indicates to accentuate "trustworthiness" (of the human agent) despite volatile circumstances. Subsequently, a culture and governance policy encouraging civism/*res publica*/*citoyenneté*/*Bürgersinn* must be advocated.
- Tenet "4" (knowledge) of the geoethical logic approach indicates to accentuate a "scientific culture" with reproducibility of knowledge (e.g., scientific findings) at its core. Subsequently, a culture and governance policy encouraging scientific literacy must be advocated.
- Tenet "5, 6" (inclusivity, human rights) of the geoethical logic approach indicates accentuating a "culture of inclusive justice." Subsequently, a culture and governance policy encouraging systemic citizens' empowerment, caring for all members of society and future generations must be advocated.

Reflecting the design of geoethics, respectively, of the geoethical logic approach, these pivots are a bundle without an internal hierarchy. They set out a sole framework for governance, which shall nurture the "autonomy of trustworthy human agents acting within a society having a scientific culture and a culture of inclusive justice." The agent's trustworthiness is rooted in traits like "virtue" and "responsibility" and practices like "inclusivity" and "universal-rights." The essence of scientific culture emphasizes the reproducibility of findings, which also applies to knowledge systems other than science *per se* (Renn, 2020).

To situate the above within geoethical thinking: Emphasizing autonomy, trustworthiness, and scientific culture encapsulates the conceptual core of geoethics (Peppoloni et al., 2019). Geoethics started as a deontological approach within Earth Sciences. Its subsequent development, including framing by political philosophies, led to more comprehensive application scopes. The geoethical logic is another application-oriented development of geoethics, which does not alter much the underpinning design.

DISCUSSION

Dystopic visions of future worlds are numerous (Cook and Balayannis, 2015; Yusoff, 2018). This essay sketches a concept of governance inspired by geoethical thinking to find alternatives. The vehicle is a specific geo-philosophical framework' (the "geoethical logic approach"), which draws on a variant of philosophy of science, of "responsible Earth-sciences" (geoethics), and three contemporary political philosophies, which address the needs of caretaking societies. Subsequently, societal practices seem possible, which inform human agents how to tackle the impacts of anthropogenic global change. The empowerment of human agents is founded on inter-generational perspectives, concerns for caretaking, learning, participatory practices, and scientifically informed insights into the functioning of the world and nature.

Why "Geo?"

The prefix "geo" of the notions geoethical and geo-philosophical has various connotations. First, it specifies that Earth System literacy is a knowledge domain *primus inter pares* because of the vital expertise in times of anthropogenic global change. Second, the prefix points to the specific knowledge-building process in geo- or Earth-System sciences, determined by dependence on context and path, a multiplicity of methods, and scarce opportunities for controlled experiments. As a philosophy of sciences, this knowledge-building process implements Bunge's "synthetic thesis of truth." Third, the prefix relates to the governance of adaptation to the impacts of anthropogenic global change (e.g., sea-level rise), which should be informed by an ethic of perspectives concerned with Earth and society (geoethics), which applies adaptive, iterative, and synthetic scenario building of possible configurations of the Human-Earth Nexus.

As a word of caution, while emphasizing why the prefix "geo" is used in this essay, the geoethical logic approach implies a comprehensive scientific and scholarly knowledge base extending beyond Earth-/Geosciences. Furthermore, centering on the agency of humans is about unique duties as an intrinsic part of the Earth system. Humans are the species answerable for mismanaging the planet.

Conventional, Innovative, and Incomplete?

The proposed pivots for policy-design might appear conventional, given they are founded on known political philosophies and the concept of responsible sciences. However, innovation is 2-fold.

First, the pivots for policy-design are not hierarchically ordered to shape societal culture(s), public policies, and human agents' actions. Instead, they jointly inform culture, policies,

and action. The goals of "autonomy" and "trustworthiness" (of the human agent) and "scientific culture" and "culture of inclusive justice" (of the society) apply without a pre-established ranking. This feature implies mutatis mutandis, that (cherished Western) concepts like "universal" are to be taken *cum grano salis*. Instead, an aggregating approach of comparative Justice is favored (Sen, 2010) and unbound individual agency is questioned.

Second, the combination of insights, which underpins the pivots, is vital. These are: (1) the reproducibility of knowledge (e.g., scientific), (2) Earth science literacy (essential knowledge domain), (3) the quality of societal coordination (favoring the distribution of power), (4) the responsibility of change agents (favoring intergenerational accountability), and (5) the balance of individual wellbeing and duties (the key-virtues of the human agent).

Despite the substantial sociopolitical embedding, the proposed geoethical logic approach seems incomplete because it is not informed by socioeconomic constraints, which, for example, limit the freedom of human agents. A remedy can be found interpreting Hannah Arendt's political philosophy of the "Human Condition" (Arendt, 1958) for times of anthropogenic global change. Her notions of labor (for subsistence), work (of agents of technological change), and act (political agency) indicate how to complement the geoethical logic approach with insights into what social stratification and differential power might imply for "autonomy" and "inclusivity."

Such amendment of the geoethical logic approach deems needed because inequalities in socio-ecological systems are a critical issue. The preparedness, reactions, mitigation capacities, adaptation capabilities, and decision-making processes will suffer from the inequalities as much as from the hazards. The problem is well-known (McMichael et al., 2004). J. Timmons Roberts asserted that *"Global warming is all about inequality, both in who will suffer most its effects and in who created the problem in the first place"* (Roberts, 2001, p. 501). Beyond sea-level rise and flooding, climate change may affect human health and mortality due to extreme heat and cold waves, climate disasters and changes, the lessening of air and water quality, and changes in the ecology of infectious diseases.

A further open research question is the decision making process, e.g., whether, for example, the human agent needs to make decisions standing behind the Rawls veil (Huang et al., 2019). Recently (Markkanen and Anger-Kraavi, 2019), policymakers were alerted again of the indirect and often complex social and inequality impacts that their decision may have. They suggest that, in all stages of policymaking, the potential impacts inequalities can produce or enhance must be taken into consideration to get better results. In the same vein, *"[p]rojections of the global health effects due to the global climate changes signal a massive impact on the less favored parts of the world"* (Sunyer and Grimalt, 2006, p. 216). In 2021, Brazilian researchers (Rocha et al., 2021) showed, using a Social Vulnerability Index, that in Brazil, the leading risk factor related to COVID-19 are socioeconomic inequalities, rather than age, health status, and other risk factors.

On Divergent Practices and Practical Wisdom

When applying the pivots for policy-design to inform culture and governance, the resulting practices will diverge. This specific feature, different valid approaches, stems from the initial design of geoethics. It arises because of divergent insights and judgements of human agents who handle a non-hierarchical set of guiding principles.

Geoethics and, hence, the pivots for policy-design are not designed to lead to a single or uniform application case. Instead, different valid approaches, which each respects the four pivots, should be plausible. This multitude is essential because it is unlikely that a "best" approach (scenario) exists (and can be found) in contexts determined by complex-adaptive dynamics. Hence, it is the desired design feature to encounter divergent practices or approaches when applying the proposed pivots because *"[t]here may not indeed exist any identifiable perfectly just social arrangement on which impartial agreement would emerge"* (Sen, 2010, p.15).

A plurality of approaches seems favorable when handling complex-adaptive dynamics, although the risk of inconsistent (e.g., arbitrary) choices is inherent, which, in turn, may lead to irreversible developments. Handling complex-adaptive dynamics requires Bayesian-like approaches to operate context-dependent and path-dependent, as well as iteratively; (see for example Fuerth and Faber, 2012; Sharma-Wallace et al., 2018; Janssen and van der Voort, 2020). The combination of framing and plasticity that the geoethical logic approach offers should facilitate handling systemic uncertainty and shifting baselines of complex-adaptive dynamics and, likewise, intermittent and recurrent phenomena. Building the capability to tackle such features (Arroyo, 2017; Stewart and Lewis, 2017; Marone and Bouzo, 2021) is essential to counter attitudes of denial of facts and evidence.

Being able, that is, "having the wisdom," to cope with divergent practices is the essence of cultural/political processes at the Human-Earth Nexus. Therefore, the requirement to meet the pivots for policy-design at any time should frame cultural/political processes while also providing plasticity to adjust practices consistently to different regional impacts and non-uniqueness of adaptation options. Also, media-mediated experiences of the public should be addressed because the pivots for policy-design can nourish a consistent discourse, including persistent debunking of fake news. Finally, considering the overall context of anthropogenic global change (and the specific illustration of "the rise of the main sea-level"), advancing from spontaneous to managed responses should be possible giving the "autonomy" of a trustworthy human agent, who has a "scientific culture" and adheres to a "culture of inclusive justice."

Concluding

When perceived through complex-adaptive dynamics and geo-philosophical concepts, experiences gained in the COVID-19 health pandemic can inform the governance of (some) climate change impacts in the next century. Evolving in the same global, complex-adaptive social-ecological system, the COVID-19 health

pandemic and the rising global mean sea-level have similar systemic features. Hence, the Human-Earth Nexus of challenges and policy options is similar. Therefore, comparable approaches may address the respective global, regional, and local problems.

The proposed geo-philosophical framework merges [geo]science-based insights with the contemporary (political) philosophies of Kohlberg (hierarchy of societal coordination processes), Jonas (intergenerational responsibility of agents of change), and Bunge (balancing individual wellbeing (happiness) and duties). Using them is a choice reflecting our view of what ought to be (morally) valued and what kind of political philosophy can be amalgamated with a [geo]scientific philosophy (geoethics) initially emerging from insights into the functioning of the (physical) Earth System. Other choices would lead to a different geo-philosophical framework. The given choice use an established (best) practice in political philosophy and Earth sciences. Combing both should be of practical wisdom (*phronesis*) to tackle the self-inflicted impacts of anthropogenic global change. The essence of "be practical" is founded on the reproducibility of knowledge (e.g., scientific method), Earth science literacy (knowledge domain), quality of societal coordination (distribution of power), the responsibility of agents of change (intergenerational accountability), and balance of individual wellbeing and duties (virtues of the human agent).

Some may consider the proposed pivots for policy-design to be not more than a "pious" wish in view of open resistance in contemporary societies to evidence and facts. However, it is a proposal (from a geoscience perspective) to counter dystopian visions of future worlds and call to adjust societies' scientific culture (Nagy and Bohle, 2021) and education system (Marone and Bouzo, 2021). It seems appropriate, also drawing on other experiences (Arroyo, 2017), that the successful governance of adaptation to the anthropogenic global change shall emphasize the "autonomy" and "trustworthiness" of the human agent and call for a society with a "scientific culture" and "culture of inclusive justice." Such a geo-philosophical orientation may serve "*[w]hen Humans formed an independent relation with Earth [to be] left to choose between a path of care and a path of neglect*" (Hamilton, 2017, p. 150).

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

MB conceptualized the study. MB and EM developed the matter and wrote the paper. Both authors contributed to the article and approved the submitted version.

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