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Supporting Information for

Planetary Commons for the Anthropocene

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Glossary of Key Terms

Abrupt change (based on ref. 1): A change in a system that is substantially faster than the typical rate of the changes in the system's history and/or the typical rate of change in external forcing of the system. See also *Abrupt climate change* and *Tipping point*.

Abrupt climate change (based on ref. 1): A large-scale *abrupt change* in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades and causes substantial impacts on human and/or natural systems. See also *Tipping point*.

Anthropocene (based on ref. 1): The proposed new geological epoch resulting from significant human-driven changes to the structure and functioning of the *Earth system*, including the climate system. Originally suggested in the Earth system science community in 2000, the proposed new epoch is undergoing a formalization process within the geological community[*] based on the stratigraphic evidence that human activities have changed the Earth system to the extent of forming geological deposits with a signature that is distinct from those of the *Holocene*, and which will remain in the geological record. Both the stratigraphic and Earth system approaches to defining the Anthropocene consider the mid-20th century to be the most appropriate starting date, although others have been proposed and continue to be discussed. The Anthropocene concept has already been informally adopted by diverse disciplines and public discourse to denote the influence of humans on the Earth system.

Climate feedback (based on ref. 1): An interaction in which a perturbation in one climate quantity causes a change in a second, and the change in the second quantity ultimately leads to an additional change in the first. Negative feedback is one in which the initial perturbation is weakened by the changes it causes; positive feedback is one in which the initial perturbation is enhanced.

Earth's biophysical systems: The Earth's large biological, chemical, and physical systems or sub-systems, from critical biomes (like boreal and tropical forests) to ice sheets, and oceanic and atmospheric circulation systems.

Earth system (based on ref. 3): A single, self-regulating system comprised of interacting physical, chemical, biological and human components.

Earth system governance (based on ref. 4): A new paradigm in sustainability science that integrates insights from *Earth system* science with analytical, normative and transformative research on governance, institutions, and politics. Earth system governance is defined as the sum of the formal and informal rule systems and actor-networks at all levels of human society that are set up to influence the co-evolution of socio-ecological systems at planetary scale in a way that secures sustainable development – that is, a development that meets the needs of present generations without compromising the ability of future generations to meet their own needs.

Earth system resilience (based on refs. 5, 6): The capacity of the biogeophysical Earth system to absorb anthropogenic stressors, such that the system persists in, or recovers to, a *Holocene*-like interglacial regime, encompassing the essential regulating structures and functions that are the foundation for a habitable planet and sustainability. See also *Habitability/livability of the Earth*.

[*] The process is led by the Anthropocene Working Group of the International Commission on Stratigraphy (2).

Functions of the Earth's biophysical systems: Processes that enable the *habitability/livability of the Earth*. Some examples include carbon sequestration via ocean carbon pump (combination of physical, chemical and biological drawdown of carbon from the atmosphere), distribution of heat between low and high latitudes via ocean circulation, reflection of incoming solar radiation, regulation of sea levels by ice-sheets and glaciers, moisture recycling by forests, and absorption of ultraviolet radiation by stratospheric ozone.

Global commons: Large areas lying outside of national jurisdictions that have been recognized by states and that are regulated under international law. Understood broadly, these encompass the high seas and deep seabed, outer space, Antarctica, and the atmosphere (including the climate system).

Habitability/livability of the Earth: The ability of the *Earth system* to sustain life in general in its *Holocene*-like abundance, diversity and ecological integrity, and to support the entire human population in the current and projected size indefinitely, while also enabling achievement/maintenance of a decent living standard for all.

Holocene (based on ref. 1): The current interglacial geological epoch, spanning the interval from 11,700 years ago to the present day. The early part of the Holocene is marked by the late stages of deglaciation of Pleistocene (Ice Age) land ice, sea level rise, and the occurrence of warm phases that affected different regions at different times, often referred to as the 'Holocene Thermal Maximum'. In addition, the epoch includes the post-glacial interval, which began approximately 7,000 years ago when the fundamental features of the modern climate system were essentially in place, as the influence of remnant Pleistocene ice sheets waned.

Irreversibility (based on ref. 1): A perturbed state of a dynamical system (including the *Earth system* and the climate system) is defined as irreversible on a given time scale if the recovery from this state due to natural processes takes substantially longer than the time scale of interest.

Nested governance (based on ref. 7, p. 560): A nested governance system is one that distributes decision-making among a wide range of institutions, where key governance functions are organized into multiple, reinforcing layers of governance, and where governance units operate under an overarching set of broadly agreed principles.

Planetary boundaries (based on refs. 8, 9): Values of nine dimensions of *Earth system* change, indicating the level of human-driven planetary change in respective nine key biophysical processes (namely, biosphere integrity change, climate change, stratospheric ozone depletion, ocean acidification, interference with biogeochemical cycles of nitrogen and phosphorus, land-system change, freshwater use, atmospheric aerosol loading, and introduction of novel entities) that should not be transgressed if we are to avoid unacceptable global environmental change, related to the risks humanity faces in the transition of the planet from the *Holocene* to the *Anthropocene*.

Planetary commons: The planetary commons include the main Earth-regulating components, subsystems and their functions, irrespective of where they are located, because they are essential to sustain all life across the planet. Key elements of the planetary commons include all major Earth system domains, such as the atmosphere, the oceans, land and the cryosphere, with which the biosphere, humans included, interact. They also include all large sub-systems of the Earth that determine the overall structure, functioning and stability of the Earth system, and that provide the vital conditions in which just livelihoods for present and future humans and non-humans are possible. These include the tipping elements, but also systems such as the Congo and Southeast Asian rainforests, temperate forests, wetlands, and coastal blue carbon ecosystems, because they also contribute to regulate the state of the Earth system, even though they might not have documented evidence of non-linear and irreversible change behavior. Not allowing these biophysical systems to drift away from their Holocene conditions, or to drift away further, will ensure that the Earth system can continue to support life. See also *Earth system resilience* and *Habitability/livability of the Earth*.

Tipping element (based on refs. 1, 10): A large-scale component of the *Earth system* (of the order of at least ~1,000 km in length, i.e., ~1 million km^2) that is susceptible to a *tipping point* with far-reaching potential impacts on human societies and the biophysical systems.

Tipping point (based on refs. 1, 10, 11): A point at which a small perturbation can qualitatively alter the state or development of a system, i.e., a critical forcing threshold beyond which a system reorganizes, often abruptly and/or irreversibly. This qualitative change may occur immediately after the cause, but in the context of the *Anthropocene* the tipping dynamics may also unfold over long timescales (centuries to millennia). This has implications for the governance time horizon, including time over which policies and political decisions can determine whether a tipping point is reached ("political time horizon", up to ∼100 years) and additional time over which the subsequent qualitative changes in the *Earth's biophysical systems* (e.g., disintegrating ice sheets) proceed to have ethically problematic consequences, such as adverse impacts on future generations ("ethical time horizon", approximated to ∼1,000-10,000 years). In the Anthropocene context, the qualitative change in an *Earth system*'s *tipping element* relates to the severity and scale of impacts unleashed by transgressing the tipping point, such as a change in the overall mode of operation of the Earth system or significant and widespread harm to human welfare (e.g., as caused by rising sea levels, collapsing biomes or increasing frequency of extreme events due to shifting weather patterns). See also *Irreversibility* and *Abrupt change*.

Table S1. Tipping elements as a subset of the planetary commons, with some key characteristics relevant for developing their governance, including functions by which they regulate habitability/livability of the Earth, main anthropogenic pressures that put them at risk of tipping with associated spatial and temporal scales, and subnational, national and international spheres that currently play, or could play, a role in governing these planetary commons.

Tipping element	Service/function provided by the tipping element	Timescale to avoid tipping	Timescale of change manifestation	Current governance	Main anthropogenic drivers of change (e.g., GHG emissions, deforestation, aerosols)	Scale of influence on anthropogenic drivers of change (local/global)	Spatial scale at which impacts of anthropogenic change in the tipping element occur
Greenland Ice Sheet	albedo, cooling the planet, avoiding catastrophic sea-level rise	decades	centuries to millennia (but with some major impacts occurring on the timescale of decades)	Denmark, local communities	GHG emissions / climate change	global	sea-level rises globally, but substantially more in the Southern Hemisphere (as shown by sea-level fingerprinting work)
Arctic Winter Sea Ice	regulation of regional and global climate	decades?	decades	member states of the Arctic Council (Russia, Canada, USA, Nordic countries), local communities	GHG emissions / climate change	global	additive impact on warming both regionally and globally
Barents Sea Ice	regulation of regional atmospheric circulation and European climate, and potentially of the AMOC (another tipping element)	decades?	decades?	Norway, Russia, local communities	GHG emissions / climate change	global	regional impacts on atmospheric circulation and European climate, and potentially on the AMOC
Extrapolar mountain glaciers	water source (including agricultural use), energy source, avoiding sea-level rise	years	decades	many different nations (each with its own governance scheme)	GHG emissions / climate change	global + individual countries	global (sea-level rise, albedo), local (water scarcity & in certain cases flooding, impacts on agri-food system, extending via supply chains to all parts of the world)
West Antarctic Ice Sheet	albedo, cooling the planet, avoiding catastrophic sea-level rise	decades	centuries to millennia (but with some major impacts occurring on the timescale of decades)	global community of states under the Antarctic Treaty	GHG emissions / climate change	global	sea-level rises globally, but substantially more in the Northern Hemisphere (as shown by sea-level fingerprinting work)
East Antarctic Ice Sheet	albedo, cooling the planet, avoiding catastrophic sea-level rise	decades	centuries to millennia (but with some major impacts occurring on the timescale of decades)	global community of states under the Antarctic Treaty	GHG emissions / climate change	global	sea-level rises globally, but substantially more in the Northern Hemisphere (as shown by sea-level fingerprinting work)
East Antarctic Subglacial Basins	avoiding catastrophic sea-level rise	decades?	centuries to millennia	global community of states under the Antarctic Treaty	GHG emissions / climate change	global	global sea-level rise
Boreal Permafrost	slow carbon sink, cooling the planet	decades	centuries to millennia	member states of the Arctic Council (Russia, Canada, USA, Nordic countries), local communities	GHG emissions / climate change, land use	global + Arctic countries	global (CO_2, CH_4 emissions), teleconnections via hydrology changes, local (infrastructure)
Amazon Rainforest	carbon storage, biodiversity, moisture recycling	decades	decades	8 South American countries in the Amazon Basin and French Guyana (France), local communities	land use / climate change	Amazon countries + global (via GHG emissions, and demand for agricultural products and minerals)	regional and global
Boreal Forest	carbon storage, biodiversity, moisture recycling	decades	decades to centuries	boreal zone countries (North America and Eurasia)	land use / climate change	global + boreal zone countries	regional and global
Atlantic Meridional Overturning Circulation (AMOC)	regulation of climate in Europe and globally, avoidance of substantial sea-level rise along the East coast of North America	decades?	decades to centuries	global community of states under the UN Convention on the Law of the Sea (UNCLOS)?	GHG emissions / climate change	global	global impacts on temperature and precipitation patterns (including North Atlantic cooling, Southern Hemisphere warming, southward shift of Intertropical Convergence Zone, changes in monsoons) and related reduction in natural carbon sinks, strong regional sea-level rise along the East coast of North America
Labrador Sea / North Atlantic Subpolar Gyre Convection	regulation of climate in Europe and globally	years to decades?	years to decades	Canada, Nordic countries	GHG emissions / climate change	global	regional cooling (~2 to 3°C) in the North Atlantic, possibly global cooling (up to ~0.5°C), a northward shift in jet stream, weather extremes in Europe, and southward shift of the Intertropical Convergence Zone
Low-latitude Coral Reefs	biodiversity, fisheries, provision of habitat for juvenile stages of many species from different marine ecosystems, regulation of water quality, biogeochemical cycling, protection of coasts from waves and extreme weather, support for tourism	years	a decade	many different nations (each with its own governance scheme)	GHG emissions - climate change and ocean acidification, chemical water pollution, overfishing, sediment loading, introduction of invasive species	global and local/regional	wide-spread impacts on marine food web (e.g., tropical coral reefs support almost 30% of the world's marine fish species), with severe implications for biodiversity, livelihoods and lives of people who depend on the reefs for work, food and protection from waves, storms and floods
West African Monsoon	regulation of regional climate in the Sahel	decades?	decades to centuries	many different nations (each with its own governance scheme)	GHG emissions / climate change, aerosols?	global	regional (some, but not all, climate models predict wetting and greening of the Sahel)

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