REFLECTION; What will you say when you are asked, 'What did you do once you knew?'

April 2024, Arie Voorburg

Without setting the stage for where we actually are, how can we truly understand where to allocate our energy? By observing the major issues of our time we get to witness what the opportunities are for impactful and useful innovation and design.

To start with an apology. Unintentionally this reflection became longer than intended. But halfway through writing I realized that it is a big story we have to tell and came to terms with it. Impossible and absolutely not intended to be complete, this overview unveils the harsh reality of the state we are in. And it has become a sobering story. Based on personal narratives, experience and expert insights, exposing a serious global crisis and the lack of responsibility and accountability, which include a growing disparity between power and competence.

This REFLECTION aims a to start raw and truthful conversation with students and young professionals about how we feel about the state of the world, our current system and its symptomatic expressions of dominant thought patterns.

Earth's exploitation has accumulated financial capital – sometimes to absurd levels – for investors and shareholders, and generated manufactured capital ('human made mass') that now exceeds the biomass of all living things on Earth. Significantly manipulated by the marketing industry these behaviours have now brought humanity to the point where their sheer scale – through our numbers, appetites and technologies – is driving ecological overshoot and threatening the fabric of complex life on earth.

The anthropogenic ecological overshoot can been identified as a fundamental cause of the myriad symptoms we see around the globe today from biodiversity loss and ocean acidification to the disturbing rise in novel entities and climate change. The need to explore the behavioural drivers of overshoot, and understanding that this overshoot is itself a symptom of a deeper, more subversive modern crisis of human behaviour. This crisis must be recognised globally as a critical intervention point for tackling ecological overshoot. Current interventions are largely physical, resource intensive, slow-moving and focused on addressing the symptoms of ecological overshoot rather than the distal cause (maladaptive behaviours). Even in the best-case scenarios, symptom level interventions are unlikely to avoid catastrophe or achieve more than ephemeral progress.

Even though humans as well as nature itself are in a stressful situation, few of us are aware of the order of magnitude of what is happening. Fewer still have any adequate understanding of its causes or the capacity to initiate any effective program for the revitalization of these communities upon which everything depends. An increasing number of organisms are subjected to abiotic (e.g., air, water, and soil quality, temperature), but also biotic (e.g., new pathogens) stressors. These stressors may disturb the chemical and physiological homeostasis of living systems, and thus impact their ecology and evolution. Disruption of the life process has led also to disruption of the more limited human community itself. If social turmoil and inter-nation rivalries have evoked significant concern, the disruption earth's life systems remains only a vague awareness in the human mind. This is strange indeed when we consider that the disruption of our bioregional communities is leading to a poisoning of the air we breathe, the water we drink, the soil and the seas that provide our food. We seek to remedy our social ills by industrial processes that only lead to further ecological devastation. Indeed our sensitivity to human conflict over the sharing of earth's resources has distracted us from the imperiled condition of these resources themselves, a period associated with the loss of topsoil, the destruction of forests, the desertification of fruitful areas, the elimination of wetlands and spawning areas, the exhaustion of aquifers, the salinization of irrigated areas, the damaging of coral reefs.

SEE THE WORLD. IT'S MORE FANTASTIC THAN ANY DREAM.

Earth is, to our knowledge, the only life-bearing body in the Solar System (part of our galaxy, the Milky Way, a hazy band of light formed from 100 to 400 billon stars. The universe contains perhaps more than 2 trillion galaxies). This extraordinary characteristic dates back almost 4 billion years. Earth is teeming with organisms and that this has lasted for so long.

Our living planet, the dynamic web of organisms and ecosystems, between organisms and several unique aspects of Earth - atmosphere, hospitable environment, long-term climate variations, liquid water, gravitation, natural greenhouse effect, plate tectonics, and magnetic field - is connected with the Solar System and the whole Universe. For example, the conditions that make the Earth temperature generally suitable for organisms, thus determining the planet's thermal habitability are connected with the Earth's distant and motion around the Sun, which governs the seasons. The formation of the Earth-Moon system 4.5 billion years ago and the resulting presence of the Moon favored climatic conditions suitable for organisms as well as the effects on organisms of latitudinal, diurnal and seasonal variations in the solar radiation flux reaching the Earth's surface. The combined effects of the atmospheric and oceanic circulations on the redistribution of heat on the planet. Most of the Earth water, which is essential to organisms, may have been brought from far away in the Solar System, by impacts between protoplanets during the formation of Earth, and/or later by asteroids and comets. Also, chemical elements such as carbon were forged in faraway stars billions of years before the formation of the Sun and Earth.

The history of the Earth atmosphere began shortly after the formation of the Earth-Moon system, and the composition of the atmosphere underwent profound changes during the following 4.5 billion years. Planet Earth and other astronomical bodies in the Solar System, notably the Sun, have magnetic fields. Interactions between the magnetic fields of Earth and the Sun contribute to protect the Earth's atmosphere, and the latter shields the liquid water from loss to space. In addition, organisms on continents are largely protected from direct hits by cosmic rays because the magnetic field both shields the atmosphere from most cosmic rays, and protects the atmosphere whose thickness absorbs most of the cosmic radiation that passes the shield.

HABITABILITY

Overall habitability is connected with geological and astronomical events and processes. The extent of the habitable environments of Earth varied during the planet's history, but never threatened the presence of organisms. However, there were periods when lower habitability caused mass mortality of species, witnessed by the five mass extinctions of the last 500 million years.

The habitability of a planet is its capacity to allow the emergence of organisms. Astronomical and geological conditions concurred to make Earth habitable 4 billion years ago. The respective roles of non-biological and biological characteristics, the non-living and living components of the planet and the roles of organisms and ecosystems maintained the habitability of Earth. Organisms have progressively occupied all the habitats of the planet, diversifying into countless life forms and developing enormous biomasses over the past 3.6 billion years. In this way, organisms and ecosystems took over the Earth System, and thus became major agents in its regulation and global evolution. There was co-evolution of the different components of the Earth System, leading to a number of feedback mechanisms that regulated long-term Earth conditions.

LIFE, ORGANISMS

Organisms are made of chemical elements assembled into increasingly complex organic molecules, and the connections between life’s building blocks (amino acids) of organisms and gravitation. The latter had major roles in the availability of key biogenic elements in the Universe and the Earth’s environment, and has largely controlled the distribution of chemical elements on the planet since its early history. Gravitation also favors the circulation of chemical elements between different layers of Earth, thus ensuring their long-term availability for ecosystems.

One major component of organisms is their chemical constituents and physical structures, which includes molecules ranging from very simple (a few atoms) to highly complex DNA (more than one billion atoms). Another major component is the genetic information, which is carried by DNA and other nucleic acids. Gravity contributed to the creation of biological this hardware and software by contributing to the formation of chemical elements in the Universe and controlling their distribution on Earth.

The creation of first life was facilitated by processes such as self-organization and autocatalysis as well as synergistic and symbiotic processes, providing ever growing, novel, information. Further complexity and sophistication was partly realized by genetic mutation, and chromosomal reorganization, combined with the selection pressure of the environment. It should be realized here that classical Darwinism did not take into account a number of crucial factors in evolution: cooperation and symbioses (not only with regard to species but also being essential in cellular functions), horizontal gene transfer between species (for instance by viral elements), the role of quantum processes in evolutionary information processing, empathy as a crucial factor in individual and group survival and, last but not least, epigenetic influences on gene expression through interaction with the environment. The complexity of ecosystems, the symbiotic and symphonic process by which life creates conditions conducive to life, include the biotic and abiotic components in forests and oceans to deserts and grasslands, and provide a variety of essential services that are critical to the survival, support and evolution of life.

The Anthropocene is a remarkable result of human cultural evolution. Its deep cultural evolutionary roots can be seen through its connections to past human evolutionary transitions, including the evolution of symbolic language, cognition and social institutions and practices, such as agriculture and Industrial Revolution. These transitions have set in motion new trajectories through processes, such as multilevel selection and human niche construction, that can be self-reinforcing and have played important roles in the growing scale of human activities. While this growth has delivered large increases in standard of living in many parts of the World, it also comes with its own new set of problems.

Earth, society is facing a unprecedented number of existential threats due to anthropogenic impacts exceeding our planet's boundaries. We are in dangerous territory with instability in the known realms of biosphere integrity, land system change and novel entities such as plastics and synthetic toxins, climate change, freshwater change and biogeochemical flows. Considering the dynamic, closed and interconnected nature of Earth's systems together, these threats pose an increasingly catastrophic risk to all complex life on Earth. Beyond climate change, biodiversity loss, disrupted nutrient cycles, there is evidence of 'fast forward driven' overshoot including insect extinctions, the impact of climate change on microorganisms, the freshwater biodiversity crisis, endangered food webs, invasive alien species, the degradation of large lakes, the illegal/unsustainable wildlife trade, the role of affluence, tree extinctions, an imperilled oceans and population growth as a specific driver.

A BEWILDERING WORLD.

Today's globally connected systems are characterized by multiple interacting crises spanning the ecological, social, economic and technological domains. The interconnected, global challenges of the Anthropocene lead to the question of whether we as humans could be on the verge of being, or already have become, locked into some form of undesirable trajectory with persistent crises and growing negative impacts on human well-being. For millennia, and especially since the Industrial Revolution nearly 300 years ago, humans have gradually transformed the Earth System. Technological developments combined with the large increase in human population have led, in recent decades, to major changes in the Earth's climate, soils, biodiversity and quality of air and water. After some successes in the 20th century at preventing internationally environmental disasters, human societies are now facing major challenges arising from climate change. Some of these challenges are short-term and others concern the thousand-year evolution of the Earth's climate. Humans should become the stewards of Earth.

Today's dominant neoliberal economics conceives of the economy as a selfgenerating 'circular-flow of exchange (monetary) value' that operates separately from, and essentially independent of, the natural environment.36 We generally measure the scale of economic activity in terms of gross national product, i.e. the abstract monetary value of final goods and services produced in a country in a specified time period. Physical natural resources (i.e. 'the environment') are seen as merely one of several interchangeable 'factors of production;' should a particular resource become scarce, we need only increase the input of other factors (capital, labour, knowledge) or depend on rising prices to stimulate some engineer to find a substitute.The same simplistic thinking conceives of humans as self-interested utility maximisers (i.e. 'consumers') with unlimited material demands and no attachment to family or community. It was easy for modern techno-industrial society to make the leap from believing that the economy is untethered from nature, people essentially insatiable and human ingenuity unbounded, to accepting the notion of unlimited economic growth fostered by continuous technological progress.

The international system seems directionless, chaotic, and volatile as international values, rules and institutions are largely ignored. Many countries are plagued by slower economic growth, widening societal divisions, and political paralysis. Prioritizing economic growth and a robust trading relationship created an economic interdependence alongside competition over political influence, governance models, technological dominance, and strategic advantage. Several global economic trends, including rising national debt, a more complex and fragmented trading environment, the global spread of trade in services, new employment disruptions, and the continued rise of powerful firms, are shaping conditions within and between states. The world is fragmented into several economic and security blocs of varying size and strength, centered on the United States, China, the EU, Russia and a few regional powers and focused on self-sufficiency, resiliency, and defense. Information flows within separate cyber-sovereign enclaves, supply chains are reoriented, and international trade is disrupted. Vulnerable developing countries are caught in the middle.

The current economy is characterized by a second phenomenon: a divergence between the real gross domestic product—the monetary market value of goods and services produced—and any reasonable measure of societal progress. This divergence signals that the production of goods and services is increasingly reliant on the depletion of natural capital. Consequently, our prosperity is eroding the very natural capital it depends on. This results in a concurrent increase in poverty and inequity.

In this brave new world of unchecked business growth, multinationals were no longer marketing hygienic toothpaste, but a mint-flavoured confidence boost – a maintenance purchase was suddenly something that could make you feel more attractive. Cars were no longer being sold based on their functional superiority (i.e. space, speed, comfort, price), but by what they suggested about you as a person (i.e. status, sexiness, rebelliousness, appetite for adventure).

The current emphasis for overshoot intervention is resource intensive (e.g. the global transition to renewable energy) and single-symptom focused. Indeed, most mainstream attention and investment is directed towards mitigating and adapting to climate change. Even if this narrow intervention is successful, it will not resolve the meta-crisis of ecological overshoot, in fact, with many of the current resource-intensive interventions, it is likely to make matters wors. Interventions at the symptom-level often do more to maintain the status quo than to address the drivers of ecological overshoot. Accepted approaches are generally technological interventions requiring immense amounts of raw materials and generating proportional ecological damage. For example, the much-hyped wholesale transition of our energy systems from fossil fuels to renewables would require daunting levels of raw material and fossil fuels in a futile struggle to meet humanity's ever-growing demands.

Erosion of social cohesion and societal polarization has been climbing in the ranks of perceived severity in recent years. Defined as the loss of social capital and fracturing of communities leading to declining social stability, individual and collective wellbeing and economic productivity. A widening gap in values and equality is posing an existential challenge to democratic systems, as economic and social divides are translated into political ones. Polarization on issues such as immigration, gender, reproductive rights, ethnicity, religion, climate and even secession have characterized recent elections, referendums and protests. The risk of being left behind and preclude the full participation is growing. The extent of exclusion and its outcomes depend on the economic, social, political and environmental context, including national and local institutions, norms and attitudes as well as laws and policies in place. Differences in access to education, health care, infrastructure and employment as well as inequalities in political participation are pervasive and symptomatic of social-economic exclusion.

The wealth gap has increased by the widened inflation and interest rates leading to an ongoing uncertainty for people living from month to month, and the prospect of a recession is causing additional anxiety. People are grappling with these inequalities and uncertainties, both short-term and longer-term, in myriad ways. Geopolitical conflicts such as Russia's war on Ukraine, and the resulting energy crisis, have added to the uncertainty, as have worsening climate / ecological related disasters.

IF HUMANITY IS TO CONTINUE FOR ANOTHER MILLION YEARS, OUR FUTURE LIES IN BOLDLY GOING WHERE NO ONE ELSE HAS GONE BEFORE.
I HOPE FOR THE BEST. I HAVE TO. WE HAVE NO OTHER OPTION.

— **Stephen Hawking, Brief Answers to the Big Questions**

The world has entered a new era of rapid and major change. Significant shifts are occurring in global economic power, technology, urban growth and through -global- environmental changes that pose existential threats to humanity, such as climate change and the destabilization of the ecosystems on which human life depends. Given current trajectories, transformation of human societies in some form is inevitable. It is, however, not clear whether global transformations can be navigated to avoid catastrophic environmental change and ensure more desirable trajectories of human and non-human life on our planet. Such navigation requires active stewarding of systemic societal, economic and technological change across diverse sectors of society and challenging deeply held assumptions underpinning unequal and environmentally degenerative patterns. Financing transformations, for example, requires transformations in financial systems, while narratives to support transformations require transformations in the way narratives are conceptualized, produced and applied.

With its unprecedented changes in the earth's geo-and biosphere, the fundamental and irreversible human imprint and impact on natural systems and processes has turned humankind into a geological agent, which has led to term this epoch and state of affairs, the 'Anthropocene'. Under the techno human condition, anthropogenic-induced environmental change and the domination of the Earth's ecosystems have reached a global scope and a permanent geological time-scale. Conceptual disconnection and practical alienation from nature, life, the appropriation of (capitalist) desires, and fantasies of constant growth and repeatable progress have gained increasingly ideological traction and power. The earth bio-spherical and socio-ecological metabolism cannot 'digest' human interferences, interventions and outputs.

SO SIMPLE A BEGINNING..

The living world is a realm of dazzling variety, yet a shared set of physical principles shapes the forms and behaviours of every creature in it. How four basic principles-self-assembly, regulatory circuits, predictable randomness, and scaling-shape the machinery of life on scales ranging from the microscopic world of molecules and cells to large organisms and ecosystems. The key features of DNA -ingredients of life- and the processes by which it is rendered into proteins, including a high-level transcriptional control, the nature of cell membranes, the role of the extracellular matrix and mechanical stimuli in cell differentiation.

Earth's organisms comprise of four essential features; 1) the 'software', namely the genetic information encoded in nucleic acids (DNA, RNA, Genes), 2) the 'hardware', consisting of the biochemical compounds (carbohydrates, lipids, proteins) and the membranes of the cell, and the components (tissues and organs) and structure (body systems) of the bodies of multicellular organisms, 3) the flux of energy, organisms maintain their high level of organization through a continual intake and dissipation of energy. And in addition, 4) organisms are capable of replication or reproduction. Reproduction leads to development of large biomasses of organism that are subject to biological evolution, which results in the massive and diverse ecosystems that progressively occupied the planet.

Life, in all its infinite and exquisite complexity, for the most part derives from a mere 20 amino acids that, strung together in myriad ways, make the proteins that make us go.

THE ART OF LIVING TOGETHER

Symbiosis is exceedingly common in nature. Symbiotic relationships modify the physiology and influence the ecological dynamics and evolutionary processes of interacting partners, ultimately altering the distribution of species across the planet. This is particularly true with microbial symbiosis. Microbial symbioses are ubiquitous interactions in nature. As such, they play key roles in structuring and modulating ecological communities. Symbionts play a pivotal role in shaping biodiversity at ecological and evolutionary scales. However, many facets of the relationship between symbiosis and the generation and maintenance of biodiversity remain unexplored. In the face of unprecedented climatic changes, biodiversity studies incorporating symbiotic relationships will be key to understanding how species will endure changing environmental conditions. Symbiotic relationships between hosts and microbes alter biodiversity patterns at ecological and evolutionary scales and as a result of environmental change.

Symbiosis gives substance to the nature of the interactions between different organisms living in close physical association. In ecosystems all over the world, there are immense, mutually beneficial associations of macro fungi with flowering plants in complex, positive, metabolic, symbiotic relationship to each other. Findings such as these have scientifically overturned the view that evolution and life are solely founded on competitive struggle between species.

A new era of symbiosis is characterized by human intelligence that replicates the symbiotic and mutually reinforcing life-reproducing forms and processes found in living systems. Given that we have evolved as a species within the pre-existing evolutionary matrix, such intelligence lies within us as latent potential. The elements include full recyclability of all inputs and outputs, the elimination of toxic waste in all aspects of human enterprise, safe and socially just renewable energy, and full and harmonious integration of human industry and technology with physical and living systems at all scales.

The meaning of symbiosis implies living together for mutual benefit as a core aspect of ecological thinking, symbiosis affirms the interconnectedness of life and all living things. Such interconnection and interaction puts a human worldview back into the community of life.

LET'S TALK ABOUT …..

Earth system science is motivated by concern over human impact on Earth and life processes. Its main focus has been investigating how the different components of the Earth system – including the atmosphere, hydrosphere, biosphere and lithosphere – interact. A key theme is the way complex physical systems are able to absorb stresses or pressures for change – up to a limit. Once this critical threshold is breached, stabilizing reactions in the system – `negative feedbacks' - give way to self-amplifying reactions – or `positive feedbacks', which can result in rapid transition to a whole new regime or operating state.

This kind of nonlinear variability at every temporal or spatial scale, especially systemic change at the planetary scale. Possible tipping points in global climate, leading to abrupt and irreversible climate change, are a now well-known example. But increasingly climate is viewed as just one aspect of a more encompassing set of possibilities for cascading, interconnected change in the Earth system.

The Earth System is usually defined as a single, planetary-level complex system, with a multitude of interacting biotic and abiotic components, evolved over 4.54 billion years and which has existed in well-defined, planetary-level states with transitions between them. About 3.8 billion years ago, life appeared on Earth, opening a new chapter in the story of the universe. Biological evolution has been a wondrous adventure of tenacity and inventiveness through titanic episodes of extinction and proliferation. Modern humans (Homo sapiens) have effectively been around in the biosphere for some 250 000 years.

The Earth System is driven primarily by solar radiation and is influenced by other extrinsic factors, including changes in orbital parameters and by its own internal dynamics in which the biosphere is a critical component. The earth System is a dynamic integrated system comprised of geosphere, atmosphere, hydrosphere, cryosphere as well as biosphere components and humansphere and Technosphere forcing with nonlinear interactions and feedback loops between and within them. These components can be also regarded as self-regulating systems in their own right, and further broken down into more specialized subsystems. Organisms progressively occupied most environments of the planet, diversifying into countless life forms and developing enormous biomasses. In this way, organisms and ecosystems and became major agents in its regulation and global evolution.

Across the ocean and the continents, the biosphere integrates all living beings, their diversity, and their relationships. There is a dynamic connection between the living biosphere and the broader Earth system, with, as aforementioned, the atmosphere, the hydrosphere, the lithosphere, the cryosphere, and the climate system. Life in the biosphere is shaped by the global atmospheric circulation, jet streams, atmospheric rivers, water vapor and precipitation patterns, the spread of ice sheets and glaciers, soil formation, upwelling currents of coastlines, the ocean's global conveyer belt, the distribution of the ozone layer, movements of the tectonic plates, earthquakes, and volcanic eruptions. Water serves as the bloodstream of the biosphere, and the carbon, nitrogen, and other biogeochemical cycles are essential for all life on Earth. The Earth system contains several biophysical sub-systems that can exist in multiple states and which contribute to the regulation of the state of the planet as a whole. In ecosystems, diverse life forms interact in complex ways that can contribute to the conditions necessary for sustaining life, although these systems are dynamic and subject to change.

THE ANTHROPOSPHERE HAS BECOME AN ADDITIONAL FUNCTIONAL COMPONENT OF EARTH SYSTEM, CAPABLE OF ALTERING EARTH SYSTEM STATE.

Earth's biophysical systems, ranging from critical biomes (e.g., tropical forests) to ice sheets, and oceanic and atmospheric circulation systems are particularly at risk. Many of these systems show evidence of having multiple stable states, separated by tipping points with feedback dynamics and interactions (within and between systems) that deter-mine what state they reside in Human societies influence some the large-scale processes of geological, biological, and anthropogenic forcing factors, the climate and biological evolution of the Earth System. Contrary to biological evolution, which has influenced Earth System processes over tens to hundreds of millions of years, the current anthropogenic perturbations have timescales of at most a few hundred years but their effects may last thousands of years. Major external and internal abiotic processes affect the evolution of the planet, the main steps of biological evolution and the emergence of negative feedback loops in the Earth System.

Anthropogenic perturbations of the global environment are primarily addressed as if they were separate issues, e.g., climate change, biodiversity loss, or pollution, zoonotic events, etc. This approach ignores these perturbations' nonlinear interactions and resulting aggregate effects on the overall state of Earth system. Understanding how biosphere, anthroposphere, and geosphere processes interact with one another is a prerequisite for developing reliable projections of possible future Earth system trajectories. A fully process-based understanding of the interactions between these domains is, however, still only partially available and calls for more deeply integrated modeling of Earth system by bringing together currently available evidence for the relevant processes and their interactions from different disciplines and sources.

RADIATIVE EQUILIBRIUM

Earth's mean temperature is determined primarily by its energy balance, including the key variables of solar insolation (increasing during Earth history), greenhouse gas forcing (broadly decreasing during Earth history) and albedo. The distribution of heat at the Earth's surface is modified by orbital variations (shape of Earth's orbit, Earth's axis is tilt, Earth's axis of) and paleogeographic patterns driven by tectonics, which in turn can drive feedbacks that lead to whole-Earth changes in albedo or greenhouse gas forcing. Thus, over multi-million-year timescales, Earth's climate shifts in response to gradual changes in continental configuration, the opening or closing of ocean gateways, and the plate tectonic, which, together, drive long-term changes to the carbon cycle and the biosphere. These long, slow changes modify the effects of solar forcing, not least by changing the balance between sources of CO2 (from volcanic activity) and its sinks (starting with chemical weathering and progressing through sequestration in sediments).

Earth's heat engine does more than simply move heat from one part of the surface to another; it also moves heat from the Earth's surface and lower atmosphere back to space. This flow of incoming and outgoing energy is Earth's energy budget. For Earth's temperature to be stable over long periods of time, incoming energy and outgoing energy have to be equal. In other words, the energy budget at the top of the atmosphere must balance.

The climate system is integral to all other components of the Earth system, through heat exchange in the ocean, albedo dynamics of the ice sheets, carbon sinks in terrestrial ecosystems, cycles of nutrients and pollutants, and climate forcing through evapotranspiration flows in the hydrological cycle and greenhouse pollutants. Together these interactions in the Earth system interplay with the heat exchange from the sun and the return flow back to space, but also in significant ways with biosphere-climate feedbacks that either mitigate or amplify global warming. These global dynamics interact with regional environmental systems (like El Niño–Southern Oscillation or the monsoon system) that have innate patterns of climate variability and also interact with one another via teleconnections. The living organisms of the planet's ecosystems play a significant role in these complex dynamics.

Also neglected is the Tibetan Plateau -3th Pole- which plays a substantial role in the global climate system by affecting atmospheric circulation and driving weather patterns, such as the Asian summer monsoon, around the planet. And in turn, climate crucially influences the plateau. A projected warmer and wetter climate will affect the region's glaciers, snow cover, permafrost, runoff, and vegetation, affecting ecosystems locally and globally. The plateau feeds a vast network of rivers, which together make up Asia's 'water tower providing water to nearly 40% of the world's population.

The natural greenhouse effect has kept the Earth temperature suitable for organisms since their appearance on the planet. The suitable temperatures allowed biomasses to build up, and organisms to progressively take over the Earth System. The natural greenhouse effect is connected with the Earth geological activity. Plate tectonics is a very special characteristic of Earth, which has major effects on the long-term functioning of the Earth System. It affects the recycling and sequestration (long-term storage in natural reservoirs) of carbon and other chemical elements used by organisms. A wide range of organisms help to cycle carbon back to the atmosphere. Plants stabilize the land and limit physical weathering (erosion) from wind and water and simultaneously contribute to chemical weathering of rocks by changing the acidity of the soil. The chemical alteration of continental and seafloor silicate rocks is a key process that controls the concentration of atmospheric carbon dioxide in the long-term, and thus the global climate. The latter is also affected by volcanic activity at different timescales. Earth's habitability depends on the long-term natural greenhouse effect.

UNNOTICED, UNSEEN

Special attention is needed for the most abused ecosystem of the planet, used as a global garbage dump. The ocean is a vast three-dimensional environment that is constantly in motion, creating and maintaining differences at different scales. The physical and chemical characteristics of the ocean, specifically the importance of temperature and salinity, but also the influence of Earth's rotation, which affects ocean circulation carrying heat energy to different parts of the globe and transferring energy to the atmosphere, play an extremely large role in global and respective regional climates. Not to misunderstand the intrinsic value of biodiversity and various biological and physical processes that transfer carbon to the deep ocean where it can be stored. At the surface and beneath these currents, gyres and eddies play a crucial role in physically shaping the coasts and ocean bottom; in transporting and mixing energy, chemicals and other materials within and among ocean basins; and in sustaining countless plants and animals that rely on the oceans for life—including humans.

In an unstressed ocean ecosystem, currents, wind, and tides mix the layers, creating smoothed temperature and salinity transitions between them. Ocean stratification is a hydrographical feature due to differences in density, with warmer, lighter, less salty water layering on top of heavier, colder, saltier water. Mixing between layers occurs as heat slowly seeps deeper into the ocean and by the action of current, winds, and tides. But the greater the difference in density between the layers, the slower and more difficult the mixing and the more stable the ocean becomes.

A warming climate increases ocean stability by making the surface ocean less dense, first by warming the water itself, which expands its volume, and also by melting ice, which adds freshwater into the ocean and decreases surface salinity. The resulting increase in stratification further drives global warming. Warmer water on the surface can absorb less carbon dioxide from the atmosphere, which increases the atmospheric concentration of carbon dioxide and in turn further warms the Earth's surface, including the upper layer of the ocean. Increasing the temperature of the upper ocean has a number of other negative effects. Warmer water can absorb less oxygen, and the oxygen that is absorbed cannot mix as easily with the cooler ocean waters below, making it difficult for marine life to thrive. Warmer ocean water also leads to increased bleaching of coral reefs and more favourable conditions for intense long-lasting hurricanes to develop. Globally, ocean stratification has increased 5.8% when looking from the surface down to 2,000 meters, and 7.3% when looking at just the top 200 meters. Stratification, however, has not increased uniformly across ocean basins. The largest increase has been in the Southern Ocean (9.6%), followed by the Pacific Ocean (5.9%), the Atlantic Ocean (4.6%), and the Indian Ocean (4.2%).

Water stratification also characterises estuaries. Moreover, in terms of its importance in the general dynamics of the estuaries, water stratification has a great influence on estuarine chemistry and biology. In contrast to coastal and oceanic waters, where stratification is controlled mainly by vertical gradients in temperature, stratification in estuaries is related mainly to changes in salinity: freshwater from the rivers flows at the surface because of its lower density, whilst marine water entering from the coastal adjacent areas flows within the sub-surface and bottom layers.

Soil is the top layer of the Earth's crust and is composed of a mixture of water, gases, minerals and organic matter. It is where 95% of the planet's food is grown yet it has historically been left out of wider debates about nature protections. Soil organisms mediate unique functions we rely on: It recycles nutrients, sequesters carbon, is fundamental to biodiversity, helps keep our ecosystems in balance and is an essential part for the production of food, fiber, and human and planetary health. Soil is likely home to 59% ± 15% of life including everything from microbes to mammals, making it the singular most biodiverse habitat on Earth. although soil represents the difference between survival and extinction for most terrestrial life, human activities have caused it harm leading to compaction, loss of structure, nutrient degradation, increasing salinity and denuding landscapes. 33% of soil is already degraded around the world, about 3.2 billion people worldwide are currently suffering from degraded soils.

There is more to soil; trees in a forest might look solitary but they are connected underground by a complex network of thread-like strands of fungi. Mycorrhizas are fungi associated with the root systems of many plants including trees, shrubs, groundcovers and grasses. These relationships are mutually symbiotic. The resulting system of interconnected tree roots is called a common mycorrhizal network. Among other things, the fungi can take up from the soil, and transfer to the tree, nutrients that roots could not otherwise access. In return, fungi receive from the roots sugars they need to grow. As fungal filaments spread out through -forest- soil, they will often physically connect and these relationships extend beyond individual trees etc to form a complex network of underground communication and cooperation.

Animal populations and whole species are declining across the tree of life, making the Anthropocene defaunation crisis one of the most alarming syndromes of human impacts on environments globally. Biological annihilation, a mass extinction at the genus level with massive potential harms to human society. Interest -public and scientific- has focused on extinctions of species but recent studies found entire genera (the plural of genus) are vanishing as well, a mutilation of the tree of life putting a big dent in the evolution of life on the planet. When a species dies out, other species in its genus can often fill at least part of its role in the ecosystem. And because those species carry much of their extinct cousin's genetic material, they also retain much of its evolutionary potential. But when entire genera goes extinct it is a loss of biodiversity that can take tens of millions of years to regrow through the evolutionary process of speciation. Climate disruption is accelerating extinction, and extinction is interacting with the climate, because the nature of the plants, animals, and microbes on the planet is one of the big determinants of what kind of climate we have.

Whether species and their populations can survive the Anthropocene defaunation will depend on their intrinsic traits, their adaptive potential, and also the research and management we dedicate towards preventing their disappearance. Based on the signals of the current biodiversity crisis, the time to recognize this phenomenon as occurring has already passed, and now is the pivotal time to protect the future integrity of biodiversity, and thereby the persistence of humanity.

CRITICAL THRESSHOLDS

For more than 3 billion years, interactions between the geosphere (energy flow and nonliving materials in Earth and atmosphere) and biosphere (all living organisms/ecosystems) have controlled global environmental conditions. As the Earth system's state changed in response to forcings generated by external perturbations (e.g., solar energy input and bolide strikes) or internal processes in the geosphere (e.g., plate tectonics and volcanism) or biosphere (e.g., evolution of photosynthesis and rise of vascular plants). These forcings were processed through interactions and feedbacks among processes and systems within Earth system, shaping its often complex overall response. The Earth system components have a critical threshold beyond which a system reorganizes (tipping elements) are critical in maintaining the planet in favorable Holocene-like conditions. To stay within biophysical limits there are the non-negotiable planetary preconditions that humanity needs to respect in order to avoid the risk of deleterious or even catastrophic environmental change at continental to global scales. These thresholds are defined as non-linear transitions in the functioning of coupled human–environmental systems and are intrinsic features of those systems and are often defined by a position along one or more control variables. These are now challenged, threatening to trigger self-reinforcing feedbacks and cascading effects, beyond which changes become self-sustaining — ultimately causing the whole Earth system to shift into a new state possibly hostile to life in its current forms. By example, deforestation in the Amazon Rainforest may have knock-on effects for the climate in distant regions, potentially pushing key elements of the global climate system — on the Tibetan Plateau and the West Antarctic Ice Sheet — closer to climatic tipping points that could be catastrophic for humanity and our planet's biodiversity.

BOUNDARIES AND TIPPING POINTS

The relatively stable, 11,700-year-long Holocene epoch is the only state of the Earth System that we know for certain can support contemporary human societies. Anthropogenic pressures on the Earth System have reached a scale where abrupt global environmental change can no longer be excluded. Despite some natural environmental fluctuations over the past 10 000 years (e.g., rainfall patterns, vegetation distribution, nitrogen cycling), Earth has remained within the Holocene stability domain. The resilience of the planet has kept it within the range of variation associated with the Holocene state, with key biogeochemical and atmospheric parameters fluctuating within a relatively narrow range. At the same time, marked changes in regional system dynamics have occurred over that period. Although the imprint of early human activities can sometimes be seen at the regional scale (e.g., altered fire regimes, megafauna extinctions), there is no clear evidence that humans have affected the functioning of the Earth System at the global scale until very recently. However, since the industrial revolution (the advent of the Anthropocene), humans are effectively pushing the planet outside the Holocene range of variability for many key Earth System processes.

There are the non-negotiable planetary preconditions that humanity needs to respect in order to avoid the risk of deleterious or even catastrophic environmental change at continental to global scales. These boundaries / thresholds are defined as non-linear transitions in the functioning of coupled human–environmental systems and are intrinsic features of those systems and are often defined by a position along one or more control variables.

Boundaries define the safe operating space identified by. Apart from the climate system, there is scant evidence to support the view that global aggregates like biodiversity, chemical cycles, or resource extraction have planetary thresholds that define the boundaries of a global safe operating space and define the bio-chemophysical realities of critical natural thresholds that need to be respected.

There are planetary boundaries identified that cover the global biogeochemical cycles of nitrogen, phosphorus, carbon and water; the major physical circulation systems of the planet (climate change, stratosphere, ocean systems); the biophysical features of Earth that contribute to the underlying resilience of its self-regulatory capacity (marine and terrestrial biodiversity, land systems, genetic diversity, functional integrity); and critical features associated with anthropogenic global change (aerosol loading, Interhemispheric difference; novel entities chemical pollution).

Tipping points exist across the Earth including the cryosphere (ice-bound domains), biosphere (the living world), ocean and atmosphere. Pressure beyond a threshold causes them to shift to a very different state, often abruptly or irreversibly, as a result of self-sustaining feedbacks – they pass a tipping point. Tipping points occur when components of a system change rapidly due an initial forcing that is amplified by positive feedbacks, resulting in a regime shift. This threshold behavior is often based on self-reinforcing processes which, once tipped, can continue without further external forcing. The transition resulting from the exceedance of a system-specific tipping point can be either abrupt or gradual. Crossing single tipping points has severe impacts on the environment and threatens the livelihood of many people. There is also the risk that, through feedback loops, further tipping points in the Earth System are reached and a domino-like chain reaction is initiated.

Complex co-drivers, interactions, and feedbacks are destabilizing tipping points, including climate change for most as well as habitat loss (e.g. deforestation), nutrient pollution and air pollution for some.

Tipping points represent critical thresholds that divide the desirable and undesirable regimes in the Earth system and undermine critical life-support systems with significant societal impact already felt. tipping points. Several tipping points are likely in the cryosphere, at a large scale in ice sheets and on a more local scale in permafrost and glaciers. In the biosphere, evidence for regime shifts and tipping points exist in many ecosystems such as in tropical forests, savannas, drylands, lakes, coral reefs and fisheries, and are often spatially complex. Tipping points in ocean circulation and monsoons are also likely to exist, but the proximity of their thresholds are subject to high uncertainty.

- In the cryosphere, six Earth system tipping points are identified, including large-scale tipping points for the Greenland and Antarctic ice sheets. Localized tipping points likely exist for glaciers and permafrost thaw. Evidence for large-scale tipping dynamics in sea ice and permafrost is limited.
- In the biosphere, 16 Earth system tipping points are identified, including forest dieback (e.g. in the Amazon), savanna and dryland degradation, lake eutrophication, die-off of coral reefs, mangroves, and seagrass meadows, and fishery collapse.
- In ocean and atmosphere circulations, four Earth system tipping points are identified, in the Atlantic Meridional Overturning Circulation (AMOC), the North Atlantic Subpolar Gyre (SPG), the Southern Ocean Overturning Circulation and the West African monsoon.

Some Earth system tipping points could be very close already. Major tipping systems are already at risk of crossing tipping points at the current levels of global warming: the Greenland and West Antarctic Ice Sheets, the North Atlantic subpolar gyre circulation, warm-water coral reefs and some permafrost regions. Boreal forests, mangroves and seagrass meadows are three additional systems that could be at risk of tipping in the 2030s. Coral reefs and some ice sheets could tip at current warming levels, and other systems' thresholds will soon be reached on current warming trends.

All are presently heavily perturbed by human activities and the majority of boundaries are transgressed.

PAST ITS EXPIRATION DATE

The concepts of sustainability and resilience have been appropriated by forces committed to the status quo and has been pulled into the gravitational influence of toxic industrial society on a globalized scale. These approaches typically focus on reducing anthropogenic harm to acceptable levels, such as through improving efficiency (e.g., net zero carbon targets), which is deemed too incremental and superficial given that we have already transgressed planetary thresholds. Moreover, sustainability often fails to challenge the underlying drivers of current crises, such as capitalism, commodification, and worldviews where humans are viewed as separate from nature.

Instead of a rebound into configurations of successful models of living after disturbance, we are now seeing resilience being used to justify the ongoing existence of processes and activities. This form of resilience occurs where pathological social relationships that are oppressive and exploitative of humans and ecosystems (life) are rendered resistant to change by economic and political interests and vested interests.

In order to counter all these negative trends within the Anthropocene we clearly need, within popular politics and culture, visions and memes of a different future. We also will need more novel conceptual development, since the foundation on which we are building right now is seriously flawed and conducive of nothing but great waves of ecological, social-cultural, economic distress.

As sustainability and resilience pasted there expiration date we have to strive for encouraging rapid and deep change; regenerative dynamics and systems. Broadly speaking, regenerative social-ecological systems can be defined as those that maintain positive reinforcing cycles of within and beyond themselves, especially between humans and wider nature. Regenerative systems have a capacity to exist or be created again. A regenerative dynamic can also been summarized as life creates conditions conducive to life, in which humans are participating as nature to support continued co-evolution of the biosphere. Regeneration is positioned not only as the antithesis of contemporary societies' extractive and exploitative activities but also as going well beyond mainstream solutions in terms of the depth of change advocated, including transformation of worldview.

To be considered regenerative, a system would maximize the ability of Earth's biosphere to build, maintain, repair, and reproduce itself, as well as adapt and evolve, such that it retains its integrity over time. This ability might be called the lifeness of life and is underpinned by living systems' distinctive thermodynamic behavior. Furthermore, living organisms maintain some structural consistency over time thanks to the information preserved in DNA or RNA, enabling them to regenerate parts or all of themselves following damage, decay, and reproduction.

IMPORTANCE OF PLACE

Earth is not an uniform global reality but as a complex of highly differentiated regions caught up in the comprehensive unity of the planet itself. There are arctic and tropical, coastal and inland regions, mountains and plains, river valleys and deserts. Each of these has its distinctive geological formation, climatic conditions, and living forms. A wide variety of life communities that may be referred as biome' (or ecozones) -- a broad community of plants and animals adapted to specific climatic conditions found across a range of continents. Bioregions are major subdivisions of Earth's biomes, contained within established realms and delineated by a process of intersecting biomes with large-scale geological structures -- mountain ranges, plains, plateaus, and basins – as well as commonly used climate zones. A bioregion is defined by physical properties or boundaries like coastline and mountain ranges that contain a similar mix of biota, or plant and animal species throughout, and interdependent hydrological patterns of flow that unites the region. The bioregions incorporate adjoining freshwater and marine areas. A bioregion is large enough to encompass all the biological activity and ecological processes necessary for life to sustain itself, and for local habitats and ecosystems to preserve their biological integrity. A bioregion is larger than an ecosystem, and is in fact usually host to several. Ecologically, a bioregion is a specific geographic area that is distinct from others by the characteristics of its natural environment. While a single bioregion may include numerous different habitats and ecosystems, bioregionalism emphasizes that each place is profoundly interconnected with one another.

By valorizing nature and elevating the cultural component to bioregions, bioregionalism attempts to describe an economic and governance model that is based on community, attachment to land and a sustainable relationship between man and nature. Bioregionalism emphasizes that this sense of community and shared culture stems from the local geography and ecological traits of the bioregion, which are ultimately what bind the society together. The bioregion is understood as the scale at which we live our lives, and therefore the scale at which regenerative communities can develop.

Everything is interconnected beyond our myopic, linear way of human-thinking, and once able to see this, it affects our values and thus the choices we make. From big to small, every choice we make and actions we take impacts those around us. Bioregionally allows us to realize that many of the issues we talk about in silos are not limited to one little region or community, that they have bigger cross-border implications that impact the quality of lives we all live. Development at bioregional scale helps contain and quantify the impact one has as a stepping stone to thinking about our global impact.

FUNDAMENTAL STAGE

Regarding the biosphere the Earth may be approaching a fundamental stage of evolution because of a wide range of human pressures. The contemporary biosphere differs significantly from previous stages of evolution due to many anthropogenic modifications and perturbations. These include global homogenization of flora and fauna; human appropriation of 25–40% of net primary production (likely to increase along with population growth); extensive use of fossil fuels to break through photosynthetic energy barriers; human-directed evolution of other species; and increasing interaction of the biosphere with technological systems.

RECAP, A VOLATILE RISK LANDSCAPE IN A LOW COOPERATION WORLD

The world is undergoing multiple long-term structural transformations: the rise of technological convergencies, the aforementioned weakened and vulnerable Earth Systems, a shift in the geopolitical distribution of power, and demographic transitions. Weakened systems only require the smallest shock to edge past the tipping point of resilience.

Current climate change and biosphere degradation could cause fundamental changes in key elements of the Earth system, with far-reaching impacts for billions of people around the world. These impacts include accelerated sea-level rise, changing weather patterns and reduced agricultural yields, with the potential to trigger negative social tipping points leading to violent conflict or the collapse of political institutions. Tipping elements are, as aforementioned, not separate entities, they are closely linked: triggering one tipping point in the Earth system or in human societies could in turn destabilize another tipping system, making tipping cascades possible.

Collectively overshooting the planetary boundaries, protecting Earth's life-supporting systems effects the minimum social foundation necessary to ensure that no one is deprived of life's essentials represented by: physiological needs water, food, shelter, energy, clean air. Safety and security represented by: personal health, education, income & work, peace & justice, political voice, social equity, gender equality, networks and therefore a just distribution of resources. Global tension and corrosive socioeconomic vulnerabilities can (will) be amplified in the near term, with looming concerns about an economic downturn resurgent risks such as inner and interstate armed conflicts. Resource stress, economic hardship and weakened state capacity will likely grow and, in turn, fuel conflict as well. High-stakes hotspots undermine global security, and may fuel a combustible environment in which new and existing hostilities are more likely to ignite. The internationalization of conflicts by a wider set of alternate powers will accelerate multipolarity and the risk of inadvertent escalation.

There are tipping points that transcend business-as-usual thinking within its infinite growth paradigm, mechanistic and reductionistic methods, techno-solutionist approaches riddled with hubris and greenwashing & myopic, disconnected narratives that are lacking contextual and collective relevance.

To even try to comprehend the (near) future it's vital to consider the complex interplay between the various factors -key elements- that influence the trajectory of our global society. Focused on primary variables, it's important to remember that these factors don't operate in isolation. Instead, they are profoundly interconnected and can create feedback loops that amplify or mitigate specific outcomes and must acknowledge the inherent uncertainty in forecasting the future, as unforeseen technological advancements, policy changes, and shifts in global cooperation could significantly alter the outcome. By maintaining a holistic perspective and acknowledging the dynamic nature of our world, we can better appreciate the potential risks and opportunities that these predictions present, ultimately empowering world leaders to make informed decisions for a more sustainable and resilient future.

NOW WHAT?

The coming decades will witness a fundamental transformation of the human presence and impact on Earth. We are at a bi-furcation point in our species evolutionary trajectory. It we continue on the path we are on we will create an increasingly technologically dependent species that aims to solve the problems of its own making by doing more of the same, thereby only exacerbating them until we hit the bio-physical limits of rising energy and materials demand.

While this disruption is inevitable only by transforming our very core way of seeing and understanding the world will we navigate a transition in a way that elevates humanity to new heights while avoiding societal breakdown. This era can also be characterized by a tightly interconnected world operating at high speeds with hyper-efficiency in several dimensions confronts us with a deep structural crisis induced by its contradictions and limitations: perpetual growth on a finite planet, political fragmentation in an interdependent world, widening chasms between the privileged and the excluded, and a stifling culture of consumerism. Feedbacks are everywhere: environmental stress exacerbates poverty and incites conflict, thereby threatening economic stability; economic instability weakens efforts to protect nature and reduce poverty; desperate underclasses degrade the environment and seek access to affluent countries, exciting backlash that undercuts geoeconomics cooperation. Multiple interweaving threads of connectivity lengthen, strengthen, and thicken, forming the ligature of an integrated social-ecological system. A macro-shift in the human condition is underway with implications as far-reaching as those of previous great transformations.

Achieving sustainability often requires balancing competing priorities and making trade-offs between economic, social, and environmental goals. This can be challenging, as different stakeholders may have conflicting interests, making it difficult to find comprehensive and universally acceptable solutions. While sustainable development set a good precedent, it is evident that it is not enough anymore. Resilience focuses on the capacity to withstand and recover from shocks and stress, prioritizing short-to medium-term responses and recovery of mainstream economic interests.

Does the monumental global task to restore degraded ecosystems need to include sophisticated technologies to understand and support the regeneration and evolution of complex biospheres?

A new and symbiotic relationship between nature, technology and society. Symbiosis as an interdisciplinary social- nature / ecological-technology (Deep Tech) framework to understand and guide the development of regenerative future.

FINALLY, SUMMERY AND CLOSING REMARKS

Ontologically, epistemologically and practically, the Anthropocene challenges the traditional distinctions that are separating nature from culture that is from cultural structures, and the order of approaches and knowledge about the world and social practices. Nature has been and is domesticated, technologized and capitalized in a way that it even cannot any longer be considered as what was used to be called ‘natural’. Whereas nature is ‘humanized’ in the sense of anthropo- and socio-genic practices, these same practices are normalized or ‘naturalized’ and thus understood as part of ‘natural’ occurrences. Realizing humanity’s material dependence, embodiment, and the fragility of beings including human ones calls for rethinking and reimagining those traditional assumptions and myth about the autonomy-based self-contained and rational subject that commences and terminates with itself. The challenge will be developing a different alternative approach. This would be one that processes differences sensitively, and simultaneously is more inclusive concerning the very status of the entangled material-based and the human-mediated spheres seen in a newly understood and enacted continuum of the natural and cultural life and its worlds. The degree of stabilization of biospheric change equivalent to that needed to stabilize the climate system would require ecosystem restoration and careful stewardship, a rapid reduction in the extinction rate, innovative approaches to agricultural production, full recycling of nutrients such as nitrogen and phosphorus and other materials, the spread of living (green) infrastructure in urban areas, and so on.

Humankind and nature each indisputably possess agency, and clearly the evolution of technology for several millennia has greatly enhanced human agency. Technology has become more than just an instrument used by humans in their relationship with nature. Humanity's embrace of the market economy and its evolution into corporate capitalism has resulted in immensely complex technological artifacts and systems that, to those who do not have any way to exert control or power in its face, may well seem beyond human control.

Society is confronted by rapidly rising risks of triggering irreversible and increasingly unmanageable Earth system–wide impacts and persistent shifts in life support systems. This requires a new approach to safeguard Earth's critical bio-physical systems that contribute to regulate planetary resilience and livability on Earth. This approach must be fully in sync with Anthropocene dynamics and the most recent scientific evidence of eroding planetary resilience. It must simultaneously recognize the integrated nature of the Earth system and the importance of its functions to sustain planetary resilience, while creating obligations for planetary stewardship and addressing injustices

Consequently, the existential human challenge is to cultivate a regenerative world, not simply to fix what we have broken. Humanity's erratic response to the current crisis does not offer a hopeful sign that we can resolve much larger crises such as climate change. Humanity must imagine and work toward futures that do not solely rely on technological fixes. If we cannot cultivate a sustainable world, our future portends more crises for humanity as well as for nature.

It requires a fundamental change in the nature of the anthroposphere, so that its dynamics become more synergistic with those of the biosphere. Yet even this dramatic shift could not undo the past alteration of the biosphere relative to the Holocene, an alteration that already represents a regime shift in the Earth System.