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Re-defining Sustainability: Living in Harmony with Life on Earth

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The increasing frequency of extreme weather events, urban air pollution, and contamination of oceans by plastic waste have dramatically increased awareness that human civilization faces an existential environmental crisis. Here, we argue that the way humankind views its place on planet Earth is the cause of this crisis and of the reluctance to take meaningful and urgent action. This view gives humans the right to exploit everything on Earth for their own benefit and a belief that sustainability can be delivered through exploiting nature in a smarter way and controlling it better. We propose that humankind rejects this view and instead learns to live in harmony with life on Earth by respecting the land, the oceans, and the atmosphere from which everything derives. We show how knowledge, creativity, and innovation can drive transformation in all sectors of society to enable this new relationship to develop, re-defining sustainability in terms of all life on Earth.

Introduction: A Brief History of Life on Earth

For over a billion years, life on Earth existed in harmony with the physical and chemical properties of the planet—the atmosphere, the oceans, and the land (Figure 1A). Major shifts due to volcanic eruptions, climate and sea-level change, and upheavals from asteroid collisions resulted in consequential biological shifts as life on Earth adapted through genetic evolution to new circumstances. Many species disappeared, and new ones appeared. In turn, biology exerted influence on these physical and chemical properties, changing the composition of the atmosphere and the structure of the land's surface. Over time, the forces of natural selection resulted in a vast array of species of microbes, plants, and animals existing together in dynamic but stable ecosystems: the biosphere. Even the evolution of large animals, which are potentially destructive and dominant, was kept in check by predator-prey interactions and the availability of food. Thus, the forces of nature keep everything in balance. Indeed, the idea of planet Earth as an organism-like self-regulating entity (Gaia hypothesis), though perhaps not factually correct, is nevertheless a fair description.[5]

But around 200,000 years ago, the emergence of *Homo sapiens* changed everything. The mental capabilities of these hunter gatherers to communicate within family and social groups enabled task sharing and collective action that brought success way beyond individual capability. Language and the use of tools led eventually to the harnessing of plants and animals, giving rise to agriculture and settlement and, around 10,000 years ago, the birth of human civilization (Figure 1B). Increasingly complex communities were built upon controlling the impact of the environment—food supply without worrying about natural spatial variation of plants and animals or seasonal availability, shelter from adverse weather, clothing to keep warm in winter, and so on. Humankind was hence engaged in a relentless battle to control the forces of nature. At the same time, increasingly ingenious ways to exploit the environment were found—the control of fire, quarrying of stone, digging of wells, felling of trees, mining of metal ores, and clearing of land for agriculture, buildings, and transportation. All of this was enabled by a remarkably stable and warm climate for the past 10,000 years, unlike previous interglacial periods.[6]

The Tragedy of the Commons

For many centuries, this level of human activity was in practical terms sustainable. As described in the classic article "The Tragedy of the Commons," this was only because the human population was small.[7] Estimates place the human population at 150–200 million at 0 CE and 300 million at 1,000 CE. At the beginning of the Industrial Revolution in the mid-1700s, it had grown to 700 million. The embryonic exploitative society in pre-industrial times had little impact on the environment because of scale. Population was limited by the availability of food, water, and energy and a lack of knowledge and was kept in check mainly by high rates of infant mortality through illness and disease. Civilizations were destroyed when these counterforces got the upper hand—the Black Death reduced the European population by about 50 million in the mid-1300s. In time, social and cultural evolution occurred—a series of transitions (European expansion and the Industrial Revolution), each associated with more people, more resource use, more energy, and more environmental impact, eventually leading to manifestations of capitalism (Figure 1B). The step change occurred after the 1700s and had its seeds in three changes. First, the discovery of fossil fuels (initially coal but later oil and gas) removed the reliance on wind, water, and wood (used primarily for the manufacture of textiles and iron making) and provided a denser and more transportable energy source. Second, enabled by the new energy sources, rapid advances in science and technology drove new inventions that transformed agriculture, buildings, transportation, and the way of life. Third, the increased understanding of microbiology and human physiology together with technological innovations in

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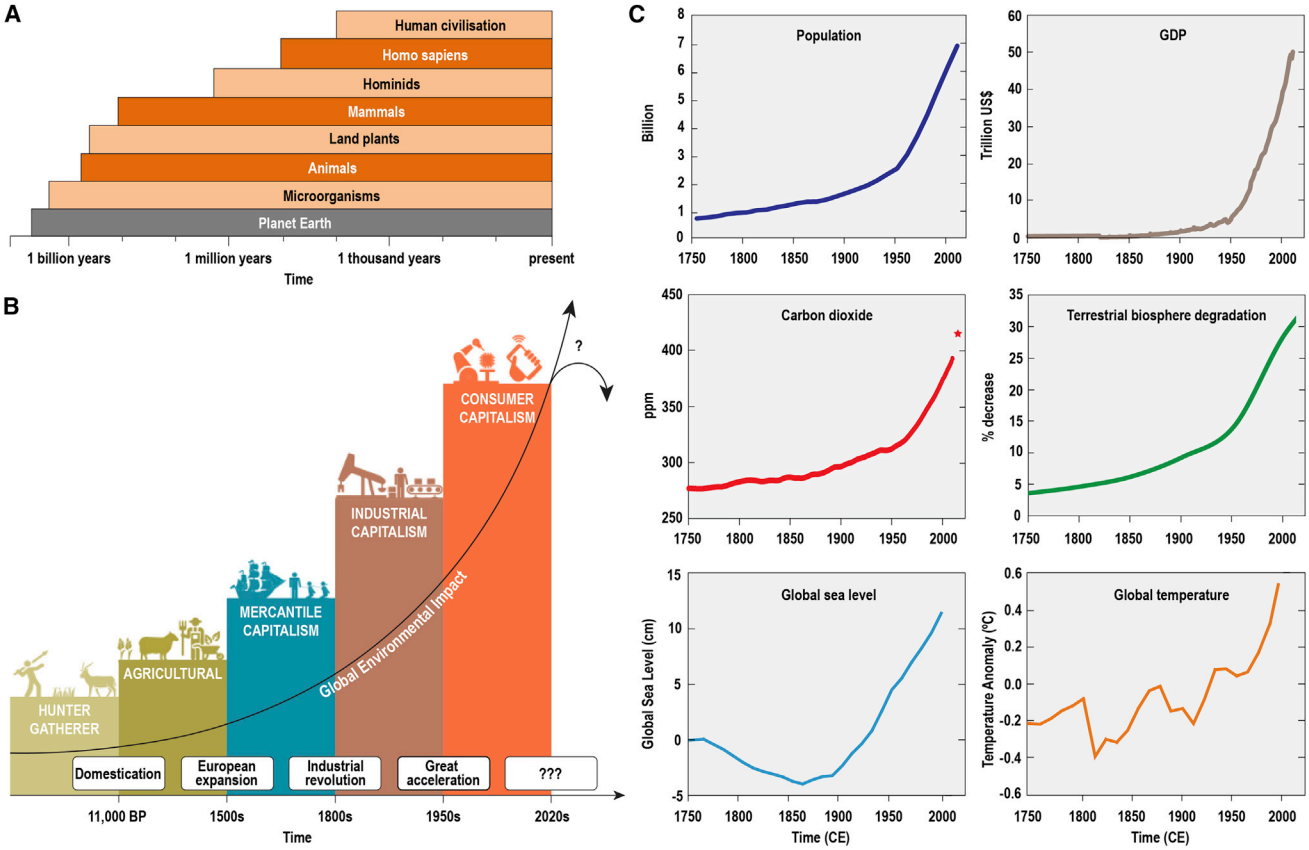

Figure 1. History of Planet Earth and Human Civilization

(A) Timelines for the evolution of life on Earth.

(B) Development of human civilization, a period commonly referred to as the Anthropocene.[1] Each stage shows more energy use and more people. This image was modified from one kindly supplied by Professors Lewis and Maslin at University College London, UK.

(C) Trends from 1750 to 2010 in globally aggregated indicators for socio-economic development and environmental impact for the Great Acceleration. Units are as follows: population, billions; GDP, trillion USD normalized to 2005 value; carbon dioxide, ppm; terrestrial biosphere degradation, percent decrease (data from Steffen et al.[1] are available from IGBP [http://www.igbp.net/globalchange/greatacceleration.4.1b8ae20512db692f2a680001630.html] except for the June 2019 CO_2 data point[2]); global sea level, cm relative to 1750; global temperature, °C relative to the 1850–2000 mean (data from Kopp et al.[3] and Mann et al.[4]).

sanitation and water supply led to the development of practices that prevented and cured diseases.

These technological inventions and innovations gave many benefits to humankind—eradicating previously incurable disease, reducing infant mortality, providing security from invasion, reducing poverty, and securing resources such as water, energy, and minerals. The Green Revolution, the transformation in plant breeding coupled with the development of agrochemicals and the mechanization of agronomic practice, brought about massive increases in the yield of the major cereal crops, saving millions of lives. Life became healthier, happier, and more secure. The human population grew rapidly to 1.6 billion by 1900 and to 6 billion by the end of the 20th century (Figure 1C). Large cities grew as the population increased, and people moved away from agriculture into industry, commerce, and the institutions that supported an increasingly complicated society. By any measure, whether it is lifespan, infant mortality, death rates, or wealth, human progress was astounding and continuous.[8] Until the latter part of the 20th century, technology-based progress and economic growth were rapid and unabated, but they were largely confined to a small number of nations, often at the expense of the rest of the world. However, the 21st century has seen accelerated development in India, Brazil, and China as a result of the globalization of markets, finance, and labor, and development in Africa has also resurged. The world population grew at an accelerated rate in association with a relentless increase in gross domestic product (GDP) and is projected to reach 10 billion by the middle of the 21st century (Figure 1C).

The period of growth since around 1950 is known as the Great Acceleration (Figure 1C) by virtue of the sharp increase in the rate of change in almost every metric of socio-economic activity and the resulting environmental impact.[1] It has coincided with the realization that the burning of fossil fuel, the linchpin of all of this development, was increasing the level of CO_2 in the atmosphere, which had the potential to dramatically change the world's climate. In the short term, it was predicted that this would cause disruption to food supplies and severe environmental damage, affecting millions of people, and in the long term, it could destroy human civilization itself. We are already seeing many of these predictions, for example, the disappearance of glaciers, sea-level rise, the melting of Artic sea ice, and the increasing frequency of extreme weather events, such as record summer temperatures in both northern and

southern hemispheres, unprecedented wild fires in the Arctic circle, and catastrophic floods in South East Asia. At the same time, limits to the production of food and the availability of water have sometimes been approached, causing economic, political, and social upheavals throughout the world.

The Emergence of the Sustainability Problem

Hence, in the latter part of the 20th century, concerns over the sustainability of human activity grew, and questions were raised as to whether and when the planet's finite capacity to support human civilization would be reached—there is a limit to how much resource the planet can provide, how quickly it can renew itself, and how much human impact it can absorb before it starts to fail. Rachel Carson described the cause and effect of human outgrowth from the Industrial Revolution in her acclaimed 1962 book *Silent Spring*.[9] The Club of Rome's 1972 report, *Limits to Growth*, concluded that "given business as usual, the limits to growth on earth would become evident by 2072, leading to sudden and uncontrollable decline in both population and industrial capacity."[10] These precipitated the emergence of various environmental movements, national and international government bodies, agencies, and non-governmental organizations, but it was a further 50 years until the idea of "planetary boundaries" was introduced, a landmark change in the definition of human impact on planet Earth.[11] These boundaries, which include not only land area but also water availability and quality, air quality, biodiversity, deforestation, nitrogen and phosphorus cycling, and climate change, have been estimated, and the results are alarming—three of these boundaries (climate change, nitrogen, and biodiversity loss) have already been exceeded, and others are predicted to follow. A recent analysis indicates that universal achievement of the lifestyle of high-income countries (HICs) would exceed these boundaries by two to six times.[12]

Sustainability means staying within the planetary boundaries. It was initially defined by the Brundtland Commission as meeting the needs of the present without compromising those of the future generations and was later extended to include the ideas of economic sustainability and social equity;[13] in addition to planetary boundaries, social boundaries should also not be crossed.[14] The idea of sustainable development was formalized by the United Nations with their Sustainable Development Goals (SDGs).[15] The 17 goals set out 169 targets and objectives covering all aspects of human life—people, planet, prosperity, peace, and partnership. Most importantly, the SDGs apply to all countries, from the low- and middle-income countries (LICs and LMICs, respectively) of Africa and Asia to the HICs of Europe and North America. The targets in effect can be used for constructing road maps to deliver human health, prosperity, and well-being for all the people of the world within the planetary boundaries that define the quality of the land, oceans, and air and the finite resources they provide. There are many synergies between these targets, but there are sometimes trade-offs and conflicts between them. There is no doubt that the SDGs represent a laudable aspiration. But are they deliverable? Will humankind make the changes necessary for them to be realized?

Routes to Sustainable Development

Generally two routes to sustainability are discussed (Figure 2). In the first, the idea is one of reduction and/or restriction in the form of "degrowth" or "green growth," embedded in SDG12 (Responsible Consumption and Production). But, a key question is who is responsible for bringing about change? A recent trend is to put the onus on individuals to change their behavior. Individual action coalescing into larger movements clearly indicates the desire for change, but there are restrictions on what action can be taken, as imposed by the surrounding infrastructure or by socio-economic circumstances. It is difficult to make sacrifices, change habits, reduce consumption, and make do with less. As a result, rather superficial changes often take place; these seemingly satisfy the consumer's desire to act but in a way that does not drastically change his or her lifestyle and/or does not have a significant effect on the major sustainability issues. Furthermore, from a global perspective, it is clearly unfair to ask individuals in LICs and LMICs to share the burden of problems created by HICs. Only governments co-operating at the international level can deliver the SDGs equitably. Only the large international corporations whose practices are exceeding planetary boundaries can make the changes necessary to implement the SDGs. Citizen pressure is essential but on its own insufficient—leadership is required.[16] But what form will such leadership take? Will governments be able to break the "iron law" and convince voters that sacrificing economic growth (and therefore income growth) is necessary to preserve the environment?[17] Will the implied (taxation-induced) reduction in consumption happen given the likely exaggeration of societal divisions that would result? Will corporations sacrifice shareholder profits for environmental reasons? At present, the answer to these questions is no, which offers a bleak future scenario if this route is followed. Despite overwhelming evidence of ecological crisis, the pursuit of technological development and economic growth continues largely unabated and is now spread more widely across the world with the expansion of urban infrastructure and ever-increasing consumption in the Western model. The massive infrastructural development in the Belt and Road project and the recent multinational discussions about exploiting the "opportunities" arising from the Arctic ice melt are graphic examples of where we are.[18,19]

The second route to sustainability assumes that technological advancement will bring solutions through, for example, limitless renewable energy, geoengineering fixes to the greenhouse gas (GHG) problem, new clean materials, zero resource consumption through recycling and reuse, improvement in agritechnology that delivers food sustainably to all, different more fulfilling community- and social-based activities rather than consumption, and so on. This optimistic technological view imagines sustainable prosperity and well-being throughout the world. Again, one has to ask whether this is achievable. An analysis of the progress made by humankind over the last century concludes that the answer is yes.[8] But there are risks: will there be sufficient resources (e.g., rare-earth elements, sand, or water); will these new technologies emerge given the apparent fantastical nature of some, such as reflecting sunlight away from the Earth with mirrors or refreezing the Antarctic; will they emerge in time given the estimates of just 11 years to prevent runaway climate change; what will drive (and who will pay for) their development; and will they be sustainable or just lead to another unforeseen environmental crisis?

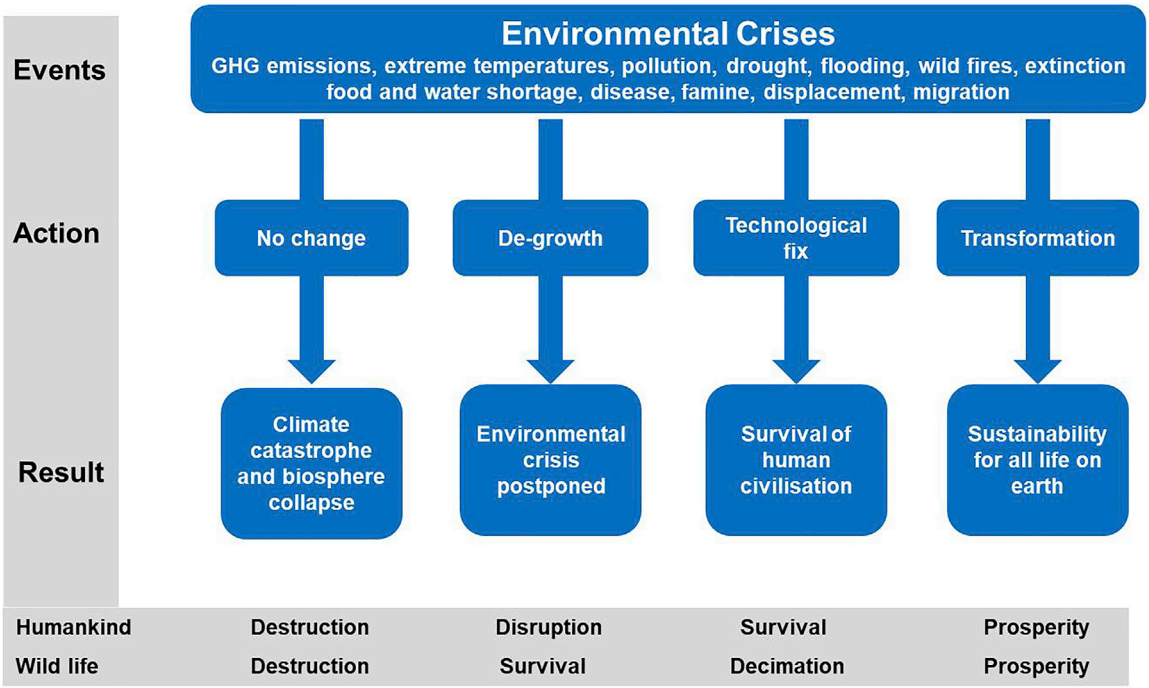

Figure 2. Responses to the Environmental Crises

Four actions in response to the events identified as symptoms of multiple environmental crises (no change, degrowth, technological fix, and transformation) have differing results for the biosphere (biosphere collapses, crises postponed, civilization survives, and true sustainability, respectively) with implications for both humankind and wildlife. Degrowth disrupts society as a result of exaggerated inequality and conserves wildlife, whereas a technological fix ensures survival of human society but further decimates wildlife. We argue that only the transformative pathway advocated in this paper leads to prosperity for both.

What these two routes to sustainable development have in common is the continued exploitation of the Earth's resources. In the former, we try to reduce the level of resource use just enough to allow a maximum level of human civilization and economic development to continue. In the latter, it is imagined that technology and innovation will produce various fixes, which will allow unabated growth in human activity. Both invoke a relentless domination of the natural world, which is viewed only as a resource to be exploited, as "natural capital" and a source of "ecosystem services" to meet our needs. To solve the sustainability problem, the biosphere continues to be changed for our benefit, perhaps even allowing non-critical planetary boundaries to be exceeded and managed. In both models, "non-essential" biodiversity is sacrificed—new knowledge could allow ecosystem services to be maintained and nature reserves to be conserved so we can still view and marvel at the beauty of a (partly decimated) natural world. In this way, the SDGs would be delivered. But is that really true—what do we mean by the word "life" in SDG14 (Life on Land) and SDG15 (Life beneath Water)? Perhaps herein lies the fatal flaw—the reason both routes to sustainability may fail. Does this expose a moral bankruptcy in the SDGs themselves? The SDGs are for humans only, and sustainability as currently defined does not include conserving any aspect of the natural world unless it is for our benefit. Clearly, "no change" will lead to environmental catastrophe and the collapse of human civilization and much of the biosphere (Figure 2). So, is there an alternative to "degrowth" and a "technological fix"?

Human Supremacy, the Cause of the Sustainability Crisis

In a recent essay, this human-centric worldview was incisively analyzed, introducing the term "human supremacy."[20] It is explained how the pervasive attitude of human supremacy leads to an extractivist mentality and the consequent environmental degradation and decline in biodiversity. It shows how modern society has hijacked, manipulated, and exploited intrinsic human drivers for survival, leading to excessive consumption and development without limits. Aspects of cultural development and religion have fostered and cemented the idea that everything on Earth is a resource for humans to use. These ideas could also suggest that it is impossible for such human activity to lead to its own annihilation or even that annihilation could be pre-ordained and therefore not be resisted. Thus, human supremacy is not only the cause of the environmental crises we face but also a significant barrier to the changes needed to overcome them.

If human supremacy is the inevitable cause of the sustainability crisis, how can this change? Can we imagine a society in which actions are responsible in a planetary context and not only in a human social context? Can we build a society that is on an equal footing with nature and in which *Homo sapiens* is just one species among many? Can we take actions not only "for our children and grandchildren" but also because of an awareness of our position in the biosphere? Our intelligence has given us huge power but also the knowledge of the consequences of our actions. Thus, we should not drive another species to extinction just to satisfy our own needs because, unlike

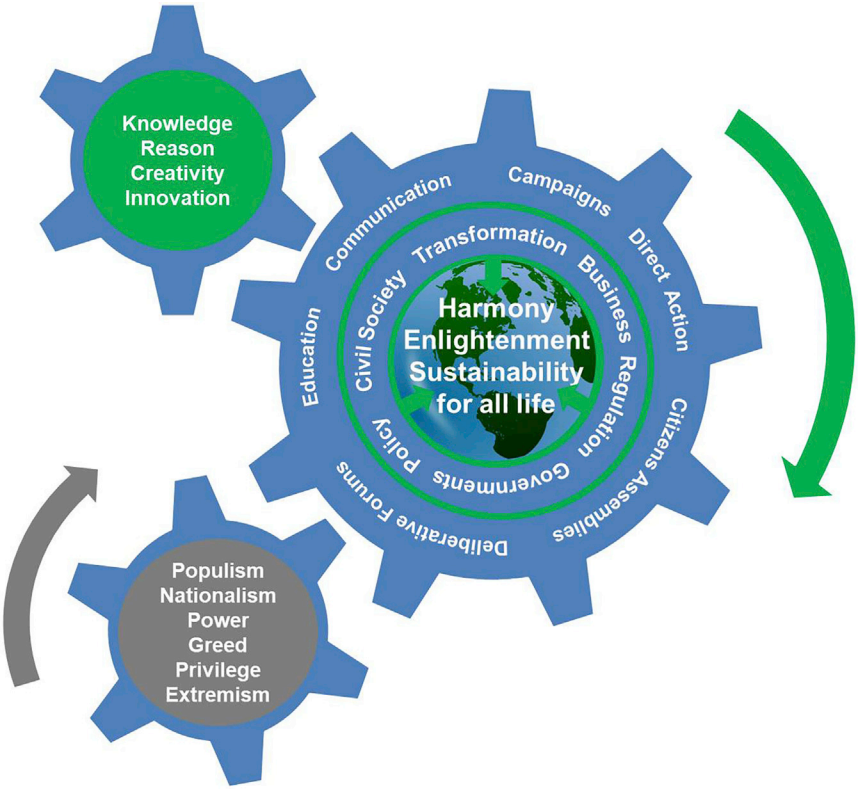

Figure 3. How a Transition to Sustainability for All Life on Earth Could Happen

The transformation pathway shown in Figure 2 is driven by knowledge, reason, creativity, and innovation, fueling changes in civil society, business regulation, and government policy via a number of processes, including education, communication, campaigns, and citizen's assemblies. These changes lead to enlightenment for humankind, harmony with nature, and sustainability for all life on Earth (green arrows). The negative forces of populism, nationalism, power, greed, privilege, and extremism oppose this pathway (brown arrow).

any other species, we are *aware* of our actions and now have the knowledge of the consequences. This moral responsibility has to be the reason for conservation of the environment and protection of biodiversity. Of course, there are other factors—appreciation of the beauty of nature and the idea that the natural environment and human well-being are intertwined. But these human-centric emotions are not sufficient. That is not to say that there cannot be a spiritual dimension to this issue: knowing our place in the context of the biosphere and feeling a responsibility to it could become fundamental aspects of human morality. Indeed, in some societies that are alien to the predominant world cultures, these form the basis of cultural practice and religious beliefs (see below).

Fundamental changes in perception and definition flow from the rejection of human supremacy.[21] The question that the SDGs should pose is, can we promote global development that is in harmony with the natural world of which human beings are just a part? Sustainability has to be redefined—meeting the needs of humanity both now and in the future while respecting the existence of the other species inhabiting planet Earth. Moreover, a profound change in the way we live is required, and this change has to happen within a couple of decades. Although this change will combine aspects of "degrowth" and a "technological fix," it is a new direction, a transformation that leads to prosperity not only for humans but also the whole biosphere (Figure 2).

How Change Could Happen

Two hypotheses can be put forward for how such a profound change in human society could be precipitated. In the first, one imagines a global catastrophe or series of catastrophes so massive that all societies and governments unite and push forward the required changes. This might well also involve revolution—uprising from the millions of people directly affected by such events. A second scenario imagines a new "age of enlightenment," when evidence is assimilated, human failings are recognized, and democratic change ensues. Is this "pie in the sky"? Will all the vested and selfish interests outlined above somehow subside and allow transformative transition to take place? Will cultural belief and practice transform in line with such enlightenment? Below, we set out seven prerequisites for this to happen (Figure 3).

New Knowledge

An age of enlightenment is based upon knowledge. Knowledge creates awareness that underpins changes in attitude and lifestyle and provides the evidence for new policies. Academia has a key role to play. Just as it was mainly academia that predicted and documented the emerging environmental crisis, so it can similarly provide the road map for the way forward. This effort will be interdisciplinary and integrate areas not often considered together. A unified view of the natural world combines sociology and engineering, economics and ecology, and philosophy and architecture to create a new societal model that incorporates human beings and other species in equality and in harmony. This new scenario requires radical change not only in the priorities for academic research but also in the way in which it is carried out. A change in outlook, motivation, and philosophy—a renewed community of researchers striving toward the common goals of prosperity and security for *all of* humankind—is needed. Although there is still a place for competition between individuals and institutions to help drive the pursuit of excellence, its worst excesses based on ego and greed will be replaced by humility and altruism. Along with this reform is a rejection of exclusiveness and elitism; new knowledge needs to be uncovered through collaboration where non-academics of diverse backgrounds engage with business and civil society. Academic institutions need to develop new mechanisms to establish interdisciplinary research to meet this new challenge and new training programs for all graduate students and early-career researchers, whatever their specialty, to give the required level of global perspective.[22]

Hand in hand with such institutional changes must go radical change within the research funding bodies. There are already encouraging signs. Universities across the globe are setting up multidisciplinary institutes dedicated to sustainability research. New funding schemes are appearing, for instance, in the UK through its Global Challenges Research Fund and in Singapore through its Research Centres of Excellence, such as the Earth Observatory of Singapore. At the global level, Future Earth is integrating a range of research activities relating to climate change, agriculture, and sustainability.[23] Philanthropic funding is also increasing in these areas, for example, from the Bill and Melinda Gates Foundation, the Grantham Foundation for the Protection of the Environment, and many others. At the 2018 Climate Action Summit, nine of the world's largest foundations pledged $4 billion to fund efforts to limit GHG emissions and to transition to clean energy.[24] Philanthropy could give the long-term funding necessary to unite engineers, natural scientists, and social scientists and enable the required knowledge transformation. However, whether this activity is truly transformative remains to be seen. For instance, the narrative for philanthropic funding is usually set in the context that climate change is primarily an environmental pollution problem solvable, for example, by setting a price on carbon and by deploying other market forces.[24]

New Technology

Although some see technology as part of the problem, it is essential that it be part of the solution. Reducing the impact of 10 billion people on the natural world requires new technology—improved transportation, carbon-neutral energy supply, more efficient resource use, and so on. But, we also need to re-think how we can use technology to help enable a new relationship with the biosphere: in harmony with it but still fulfilling the ambitions and advancements that are the essence of humanity and its achievements. This is not going back to the past but to a new and better future. Again, the prerequisite is that the development of new technologies be a partnership with producers and consumers. But action is needed urgently—imperative is the requirement for reducing GHG emissions through eliminating fossil fuels from our energy supply and sequestering CO_2 from the atmosphere, both of which are needed if the target temperature of less than 2°C warming above pre-industrial levels is to be met.[25] Can this be done without further harm to the natural world given the required scale of solar installations, wind farms, carbon capture and storage, and tree planting? Undoubtedly, new approaches to the production, distribution, and use of energy will be needed (e.g., see Service[26]).

Another crisis point is how to feed a growing population without further destroying natural habitats while reducing the 30% contribution to global GHG emissions.[27] For this we need to radically change how we produce food by using a range of new agritechnologies to change where and how agriculture takes place.[28] Some of these changes might seem to be incompatible with living in harmony with nature, but there are unpalatable truths; for example, agriculture might need to be abandoned in areas where the soil is degraded and the climate is increasingly hostile, and genetically modified crops will be essential to increasing yield per unit land area and increasing the efficiency of resource use. However, the hope is that by changing diets away from meat and dairy, we can reduce the pressure on land use to free up land areas for other purposes while combining the principles of organic farming with these new technologies.[27–29] But again, creative innovation is needed, perhaps to produce more food under artificial conditions, underground, or in vertical farms.[30] The beauty of these reforms to our food system is that they also help combat malnutrition and promote good health.[27,28]

New approaches to restoring biodiversity could emerge from approaches borrowed from technology.[31] Microsoft's Artificial Intelligence (AI) for Earth program supports projects that use advanced computational methods to map and model biodiversity changes and climate impacts.[32] Digital technologies present opportunities to see the world differently. Virtual reality enables the observation of nature in remote parts of the world and an appreciation of its functioning (and its destruction). AI, rather than being a technology that takes us even further from interaction with the real world, could offer new ways to understand and appreciate it.[33] Seeing how animals, plants, and microbes communicate, how different kinds of "brains" enable an organism to function successfully, and how complex ecosystems work could all be aided by AI. Learning that intelligence is not the preserve of the superior human but exists not only artificially in machines but also throughout nature could be a massive counter to the human-supremacy view of life.

New Education and Communication

New knowledge and new technologies have to be communicated—that is, first visualized and then shared.[34] Education plays a crucial part from the earliest age through to adulthood. The new way of thinking about the role of humankind has to be ingrained and be a part of every action. A prerequisite for this to happen is gender equity in all cultures and all countries: equal access for girls and women first to education and then to healthcare, training, resources, and finance; and equal rights, status, and opportunities. This is a powerful catalyst for change, which could drive the transformation we envisage.[35]

Communication not just through mainstream media but also through art, music, and literature has to capture and radiate the new ideals. Already we are seeing activities to communicate sustainability: the Royal Society for the Encouragement of Arts, Manufactures and Commerce's Sustainability Network,[36] the Grantham Art Prize,[37] an International Institute for Applied Systems Analysis art and science project to convey the effects of climate change in the Arctic through a series of plays,[38] and the Land Art Generator, which brings forward solutions for sustainable energy infrastructures as works of public art.[39] Sustainability issues are also pervading popular culture, even into the 2018 box-office-hit movie Marvel's *Avengers Infinity War*.

Social media and the digital world also have a major part to play, and their importance in starting up and promoting campaigns, action groups, protests, and lifestyle changes cannot be underestimated, as evidenced from the impact of Greta Thunberg. In August 2018, she started a school "strike for the climate" outside the Swedish Parliament, and it has since spread all over the world and now involves over 100,000 schoolchildren with over 800,000 Twitter followers. Also of significance are informed and experienced advocates of environmental issues, such as Sir David Attenborough, Brian Cox, Silvia Earle, Michael Mann, and Vandana Shiva. Attenborough's success in raising awareness about ocean pollution showed the power of such

communication and leadership, as evidenced by the rapid change in the public perception of plastic use and plastic waste and new government policies outlawing single-use plastics. We need more public figures, outside of academia and politics and from a diverse range of backgrounds, countries, and cultures, to do the same. But such advocates need to "walk the walk" and not "talk the talk": research shows that people are much more likely to follow advice if it is given by people who practice what they preach;[40] note the media uproar about the recent Google Camp where celebrities arrived via private jets, super yachts, and helicopters to discuss climate change.[41]

New Politics and Policies

Governments will determine whether this transformation takes place. They will need to show leadership because there is no escape from the fact that the societal transformation will involve people changing the way they live—giving up some things that they desire or have worked for. Studies indicate that people are prepared to sacrifice on two conditions: (1) that they are convinced of the necessity to do so and (2) that everyone makes the same sacrifice.[42] The latter is problematic; how can policies to disincentivize air travel or meat consumption be acceptable if the better off are able to continue undeterred? We have to move toward a condition in which it is socially unacceptable to act in a way that is detrimental to nature. Governments have to smooth the transition through systems of tax rebates, for example,[43] or offsetting the rising food prices that would result from a properly sustainable agriculture.[28] Governments also have a major role to play in changing their spending priorities. Raising taxes, in a progressive way in a system that works fairly and efficiently, not only deters and directs consumption but also allows government spending on those things that are compatible with a nature-focused society: green space, re-wilding the countryside, transforming agriculture, better public transport, a holistic education, community activities, and so on. Perhaps such tax reforms will come from transformative change in how democracy works—through citizens' assemblies and deliberative forums[34,44]—to break the likely polarization and log jam in navigating the way forward.

New Global Regulations and Interventions

Global agreements, usually through the UN, have dominated moves to combat environmental problems. The Intergovernmental Panel on Climate Change remains the most powerful voice for climate-change policy, and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services is similarly prominent in driving moves to combat biodiversity loss. Despite the fact that recommendations are continually resisted by governments (for the reasons described above), they provide models for how new regulations and interventions can be driven. Specific problematic sectors (the dominance of agriculture on the planet, fish harvesting that drives species to near extinction and destroys natural ocean habitats, the pollution of the oceans, the excessive use of water, urbanization, travel, and so on) need to be addressed through new global agreements. Many interesting initiatives, such as giving a bill of rights for nature and non-human species, are emerging.[45] Aspirations of the scale of the action required to restore nature are eloquently put forward in the idea of "Half-Earth"—setting aside half of the Earth's land mass for nature.[46] This would form part of a climate-change-mitigation strategy by sequestration of CO_2 into plant biomass, "a natural climate solution."[47] This could be implemented on a regional level by collectives of nations and be funded through the UN perhaps with private-sector involvement.[48] Government contribution would be determined according to GDP, whereas obligatory corporate contribution would be set according to their value—a new global sustainability levy. Another solution relies upon creating new types of urban communities that fully integrate natural environments. Forest cities, as being built in China, offer the prospect of a totally different urban experience that could form part of the desired holistic lifestyle.[49] Many other such innovations will result from the new knowledge and new technologies once it is accepted what the objective is.

New Ethics in the Business Sector

It is undeniable that the sustainability crisis has been created by our economic system, a system that depends upon every increasing production of goods at the lowest possible costs. Already there have been substantial reforms in terms of environmental protection, health and safety, equality, and so on, but the power structure always pushes back and finds new ways to progress the free-market model. Despite decades of awareness of the danger of fossil fuel emissions and plans to reduce them, CO_2 levels have continued to rise and have this year reached 415 ppm,[2] the highest for 2.5 million years. Voluntary change is the preferred route, and many companies value their corporate image and responsibility, but often such voluntary changes are superficial "green wash," false claims of sustainability. Therefore, it seems inevitable that the new regulations will be legally enforceable so that business has to comply; the environmental impact of production has to be controlled, and the use of the planet's resources has to be drastically curtained.

New Values in Society

A sustainable future requires that 10 billion humans live within planetary boundaries in harmony with millions of other species of animals, microbes, and plants. It is clear that this is incompatible with the lifestyle enjoyed in HICs in the last two decades.[12] All of the above—the knowledge, the technology, the education, the policies, and the global agreements—have to lead to a new way of being. In this new way, priorities in life shift from the aspirations of the Western lifestyle (relying on the transient satisfaction derived from consumption) to a sense of well-being based on community and harmony with nature. However, it is insufficient to debate such utopian ideals because the problems we face require urgent action. We need to set guidelines for this action after first answering some awkward questions. What are acceptable limits for the amount of meat we eat, the amount of water we consume, the amount of air travel, or the temperature of our homes? What is an acceptable extent of inequality of wealth within and between nations in terms of economic development as we transition to the new way of being (when such inequalities will, by definition, disappear)?

Perhaps the most significant, important, and profound question is when is it legitimate for humans to exploit, harm, and destroy living things and the environment that every species depends upon? There are many paradoxes to unravel and unpalatable truths to confront—the killing of horses or dogs is despised in many Western societies that would nevertheless slaughter millions of cattle, sheep, and pigs; we marvel at our natural forests

yet harvest great swathes for timber or for releasing land for our own use; we identify endangered species and outlaw their killing but do nothing to stop the destruction of their habitats; and we marvel at the beauty of landscapes but scar the Earth with mines, industrial wastelands, and pollution. In searching for a new society and a new definition of the good life, perhaps we should begin by looking to other cultures. There is no better example of such a culture that that of the Navaho,[50] who "were taught to live in harmony with Mother Earth, Father Sky and the many other elements such as man, animals, plants, and insects" and see that "living in harmony with the universe and all living creatures on Earth gives a clean soul."

Conclusions

The premise of this article is that the only way environmental catastrophe can be avoided is by a profound change in the goals, motivations, and ambitions of our civilization such that we recognize our place in nature as one species among millions and act accordingly. It is argued that the SDGs, laudable as they are, are essentially unachievable unless we redefine what sustainability means in light of this change. Some would argue that this is utopian nonsense and that we just have to develop the new technologies to cope with whatever is thrown up. Such negativity should be rejected. Although accepting that urgent action is needed to address the environmental crises, principal of which is climate change, we argue that these actions have to be set in the context of the bigger picture and the need for revolutionary and profound change. Already signs of change indicate the green shoots of this revolution. The knowledge of ocean pollution by plastics has elicited enormous response and awakening. There is a rise in climate-change activism, mainly driven by young people. We see the powerful outcry from politicians and all sectors of civil society in response to the accelerated destruction of the Amazon rain forest. The Great Green Wall project, aimed at reversing or halting desertification in Africa by planting millions of trees across an 8,000 km corridor, is an example of the scale of the interventions needed.[51] There is already a rejection of some aspects of the consumer society; enterprises based on sharing or reusing are growing, and there is increasing rejection of some aspects of the "throwaway" society. Perhaps this is evidence of movement toward a system where we purchase a function rather than the device to do it[52] so that perhaps we are past "peak stuff." Awareness of the environmental impact of the Western diet is widespread,[27–29] and there is evidence of change to eating more plant-based food in HICs (unfortunately, the opposite is true for LMICs). Both national governments and even small local councils[53] are declaring climate emergencies. Of course, one could point to other changes in the opposite direction—the negative forces of populism, nationalism, privilege, greed, and extremism—that oppose the influence of knowledge, reason, creativity, and innovation. These are invariably peddled by self-serving authoritarian (or would-be authoritarian) politicians who ignore evidence and brand the environmental crises as fake news. But there is resistance to such negative forces at the local level and in civil society. It seems that politicians and governments are a step behind what an increasing majority of people know and want to change. That is the hope: that further empowered by new knowledge and aided by new technologies, these shoots will grow and humankind will save both itself and the natural world it lives in.

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AUTHOR CONTRIBUTIONS

P.H. developed the concept of the paper and wrote the first draft. B.P.H. helped develop the paper further, and both worked on the final version.

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