A Global Anthropocene Earth Science Take on Avoidable Deaths

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Purpose of this Article

The purpose of this article, written specifically for the *Avoidable Deaths Network* is to: 1) present a discourse founded in some of the greatest contributions of Earth Science to human thinking; 2) fuse these Earth Science contributions with aspects of demography, consumption, inequality, and planetary environmental limits theory; and, 3) offer rationales and solutions for global level challenges with respect to the Avoidable Deaths Network paradigm (defined here as deaths, injuries, and damage caused, in part, through systems failure and discriminatory practices resulting from inequality, and skewed social values, with a disaster focus), that offer future scenarios which can increase or decrease *Avoidable Deaths* at all scales.

The article will propose that the impact of > 8 billion humans, together with their cumulative consumption, and gross levels of inequality, is the main cause of *Avoidable Deaths*, alongside an inability to share resources equitably. The article will also demonstrate that Earth and life (as a whole system) has nothing to fear from human activities, including Climate Change: Geological Time teaches us that Earth and life are resilient, powerful, and sustainable, and have weathered aeons of extreme Earth environments.

The conclusions and interpretations are my own, rooted in evidence and solid science, rather than roaming too far into self-indulgent speculation.

Avoidable Deaths and Armitya Sen

One of the inspirations of the Avoidable Deaths Network is the work and philosophy of Armitya Sen, a polymath, who mastered Economics and Philosophy, amongst other subjects, and a Nobel prize winner. Professor Ray Bennett quotes from Sen in her book [1]*Avoidable Deaths: A Systems Failure Approach to Disaster Risk Management* articulating a key principle that 'most deaths that occur during natural disasters are avoidable' based in part on Sen's work relating to '*event violence*' and '*social choice theory*'. These theses state that avoidable deaths are a matter of justice and occur because of systems failures which impact disproportionately on the poorest and least empowered. Some of Sen's most famous quotes include: 1) *'famines are rarely due to a lack of food and do not occur in well-run democracies*'; and 2) '*being poor does not mean living below a theoretical imaginary poverty level…but have an income level that does not allow individuals to cover the basic necessities… within the requirements of the environment (in which they live)*'. We either have or don't have social choices, freedoms, and 'unfreedoms', Sen argues, depending on our 'entitlement levels' or our ability to economically transact and exchange through our inheritance, labour, goods, services, and other options. Sen's 'Failure of Exchange Entitlement' theory predicts that it is the poor, less connected, and less powerful who are the most adversely affected by famine, poverty…and disasters. (for further reading please see Sen's books [2]*Poverty and Famines: an Essay on Entitlement and Deprivation* (1982); [3]*Development as Freedom* (1999); [4]*The Idea of Justice* (2010))

The Avoidable Deaths Network challenges the world to rethink its approaches in disaster management, and to use the socio-economic-philosophical theories of Sen, and numerous other workers empathetic to this way of thinking, to redress the iniquitous skewed societal balance that leads to 'avoidable deaths'. The network undertakes work on local to global levels, working with people in partnership, in collaboration, and in-country, to address the priority themes they wish to address, be that hazards linked to snakebites, swimming accidents, floods, health, earthquakes, and so on.

In this article I would like to address and widen the 'Avoidable Deaths' scope to non-humans, to ALL sentient beings, who, as I will present, are greatly-struggling at this moment in earth history.

The Anthropocene

Geologists and stratigraphers (people who study geological strata) are rather conservative when it comes to defining the Geological Column (a conceptual column of rock that records time from the beginning of the Earth to the present day, see [5]www.stratigraphy.org/chart). The Geological Column (GC) is an evidence base that has been developed for c. 200 years in the context of modern science, (and arguably much longer qualitatively), and is an intricate recorded framework of time and events in Earth history. The GC allows geologists to go anywhere in the world and set local rock strata within a context of time, space, events and environments, and a global geological context. This approach is now applied to other planetary bodies beyond Earth, most notably Mars and the Moon. Individual units within the GC record a specific, time bounded, stratigraphic sequence. For example, the Jurassic Period extends from c. 201 to 145 million years ago (Ma) and the Callovian Period (a sub-unit of the Jurassic) extends between c. 165 and 162Ma. The shortest time interval represented by a GC sub-unit is a few thousand years and the longest sub-unit interval is around 400 million years (the Earth is c. 4.65 billion years old). Different Geological Periods are marked by change…in environment, in rock type, in fossil remains, in extinction events, and so on. A group of evidence-based experts within the 'International Commission on Stratigraphy' sit and agree on all things important relating to the GC.

With the above background in mind it is therefore surprising that such a body of experts would even consider a new geological unit that is perhaps only c. 70 years old: the name for this period is the *Anthropocene.* The base of the Anthropocene is arguable. Different researchers suggest the beginning of human Agriculture (c. 10,000 years ago), the beginning of the first Industrial Revolution (c. 1760-1840 CE), and the beginning of the 'Great Acceleration' (1950 CE). The concept of the Anthropocene is based on the observation that humans have become planetary change agents on a scale that is comparable to global geological processes, and with Earth-impacts that will leave lasting evidence within present and future rock columns. The evidence for this assertion includes: the scale of movement of geological materials by humans, cumulative deposits of mega-cities and associated infrastructure; impacts on sedimentary systems; disturbed movements of sediment due to riverine dam-interventions; plastics and other pollutants that have become a structural component of the sedimentary record; chemical spikes caused by nuclear bomb tests within sediments; and, cryptic but measurable changes in sediment geochemistry caused by climate change and other human activities.

Most researchers (see for example [6]Steffen et al., 2011) place the base of the Anthropocene at 1950 CE. Figure 1 demonstrates why. When we graph a range of parameters from 1950 we see numerous parallel exponential growth curves: e.g. for human population, GDP, water use, river dams, fertilizer use, transport, paper consumption, McDonalds restaurants, tourism, …and so on. This exponential growth in a wide range of phenomena caused by human activities have correlative impacts on the planet/environment including greenhouse gases in the atmosphere, deforestation, growth in domesticated land, deforestation, and ocean acidification. Geoscientists and collaborative bio scientists/ecologists developed the concept of the Anthropocene to signify something quite new, dramatic, and unprecedented, within the 4.6 billion years of Earth history summarised as: 1) one brand new human species (if a 24 hour clock were the whole of geological time, Homo Sapiens arrives at 1 second to midnight) hyper-rapidly becoming planetary impactors across a wide range of ecosystems and climate belts; and 2) highest magnitude impacts occurring post-1950.

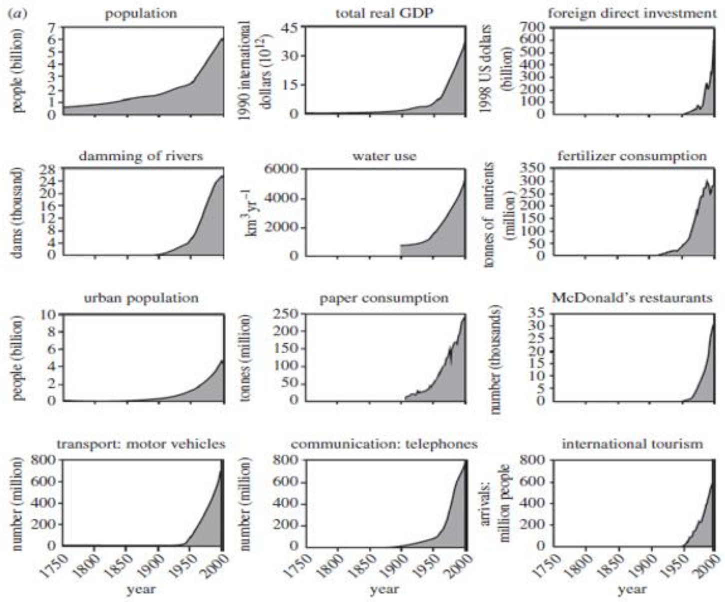

Figure 1 indicating exponential growth in human activity from 1950[6].

Deep Time and Earth's Environmental Extremes

It is possible to determine the average global temperature of the Earth looking backwards over time using e.g. carbon and oxygen isotope ratios as a thermometer proxy (e.g. from oxygen and carbon isotopes in deep ocean sediments and limestones). We can also determine ancient climates on Earth through the mapping of environmentally diagnostic geological deposits such as ice sheet moraines and tillites, desert sandstones, and tropical swamp coal deposits, alongside climate-specific fossils. Through this we know that the Earth was once completely covered in ice (Snowball Earth)[7], even to equatorial levels, some c. 720-635Ma, with extensive ice on Earth at six different periods lasting 300-30Ma respectively[7]. Technically we are in an Ice Age today, and have been, from c. 34Ma and particularly from 2Ma, although Anthropogenic global warming is probably changing this. Between 1300 and 1860 CE there was a 'mini-ice age' with significantly colder temperatures than today. Other periods of Earth have experienced a 'Hothouse Earth'[8] with warmer-hot temperatures compared to today, and no permanent ice. The Earth was mostly ice free, for example, between 500 and c. 370Ma, and again between 260 and 35Ma. Sea levels too have varied dramatically being up to 400m higher and c. 120m lower than today[9]. Only c. 20,00 years ago, sea levels were 120m lower than today, whilst for the bulk of the past 500Ma sea levels have mostly been 100-200m higher than today. Global average temperatures have been c. +14^{o}C hotter and c. -10^{o}C cooler than the average global temperature of today (15-16^{o}C): see Figure 2. During the age of the dinosaurs (the Mesozoic Period) Earth was ice free, with average temperatures c. +6^{o}C higher than today, and sea levels from about the same as today to +230m higher (resulting in a high percentage of continental areas beneath sea level), with an ecosystem thriving with reptiles, small mammals, birds, insects, and coniferous/ flowering plants, as well as diverse marine life including widespread corals, molluscs, fish, turtles, plesiosaurs, and ichthyosaurs.

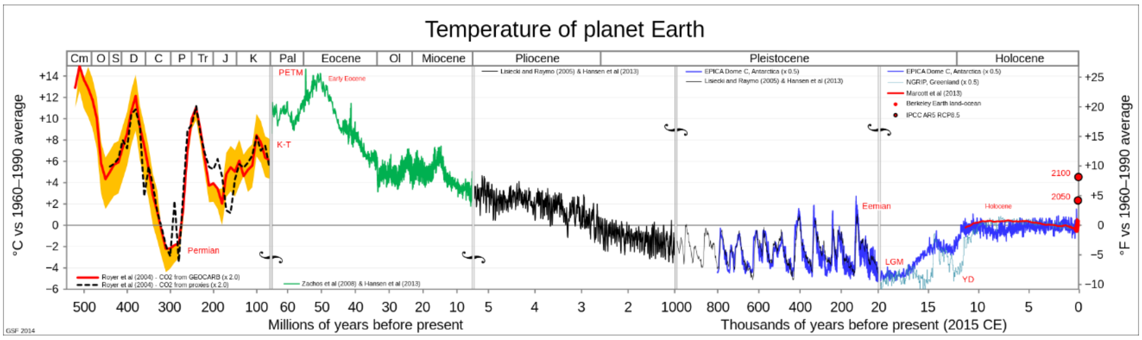

Figure 2: Global Temperature Variations relative to today from 500Ma to Present Day. Compiled by Glen Fergus[8].

Life first appeared on Earth some 3.8 billion years ago[10] within a world with no atmospheric oxygen. For the great bulk of geological time life comprised simple bacterial life forms. Complex life began to evolve from c. 700Ma and 'exploded' at the beginning of the Cambrian Period (c. 540Ma). Evolution since the Cambrian has produced ever more complex and diverse life forms. During the past 540 Ma there have been 5 Major extinction periods[11] where up to 90% of all terrestrial life became extinct, and numerous other minor extinction periods. Some 99%+ of all species that have ever existed on Earth have become extinct. Species extinction is a characteristic of Earth's life processes.

The conclusions from this analysis of Geological time particularly relevant to this article include: 1) In relative terms, Earth's environment has been remarkably consistent (e.g. relative to other planets within this, and other solar systems); 2) Even so, temperatures, sea levels, and ice coverage, have varied considerably; 3) Life was primitive for c. 8/9ths of the existence of Earth; 4) Complex life evolving over the past 500Ma has survived and thrived through environments significantly different to today…from an ice covered cold Earth, with low sea-levels, to an ice-free hot Earth with much higher sea-levels; 5) Our Species, *Homo Sapiens*, present on Earth for c. 200,000 years, has survived severe ice ages, lower and higher sea levels, warmer periods, and a c. 500 year long recent mini ice age. *Homo Sapiens* has also managed to survive and thrive in a wide variety of terrestrial environments, from the tropics to the sub-Arctic.

Homo Sapiens Population Growth and Consumerism

Figures 3[12] and 4[12] present graphical representations of global human population growth, population growth rates, and regional human populations respectively[12]. Time intervals end at 2100 CE and look backwards in time to 1700/1800 CE respectively. Prior to 1700 CE, the global human population was < 500 million, was c. 200 million in 1000 CE, and may have been as low as 2 million some 200,000 years ago[13]. Figure 3 indicates that the global human population reached 1 billion in 1805, 2 billion in 1925, 2.5 billion in 1950, 5 billion in 1987, and 8 billion in 2023, with a peak global population of > 10 billion predicted at c. 2050. Population growth rates reached the high point of 2.3% in 1963, falling to 0.9% in 2023 (similar to rates in c. 1930 CE). Figure 4[12] breaks the data down by continent demonstrating that Asia and Africa contribute most to the global population (some 59% and 18% of 2024's global population respectively) with Asia's growth flattening from 2050 and Africa's from close to 2100. Europe's population flattened around 2000, and the Americas will flatten around 2050. Post-flattening slow population declines are predicted.

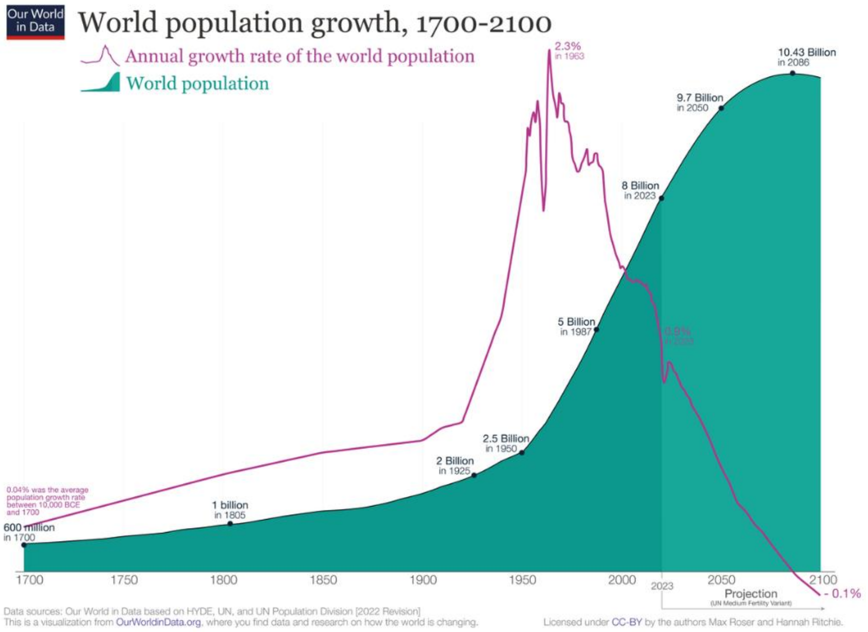

Figure 3. Homo Sapiens population growth over time from 1700-2100, with growth rates over time, Our World in Data[12]

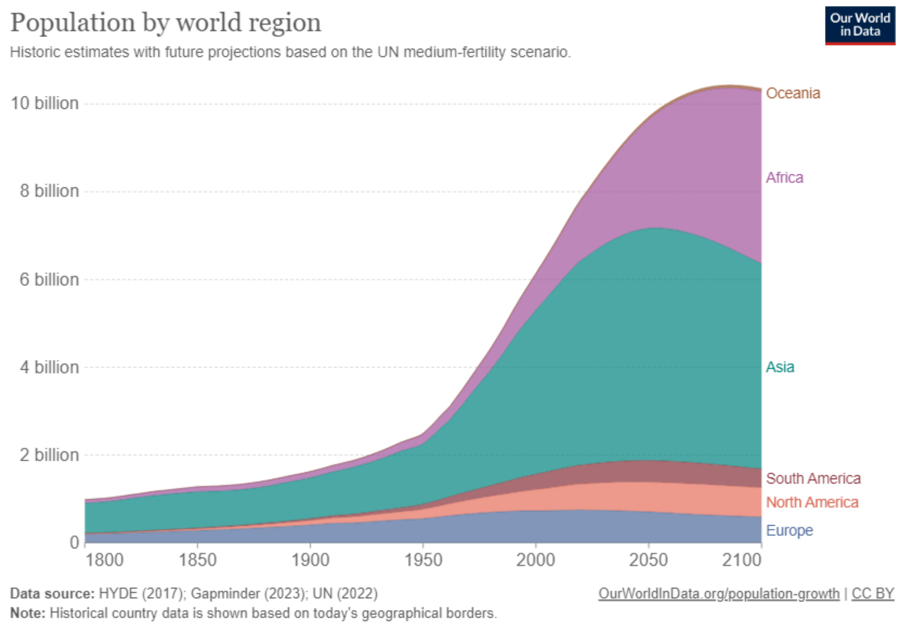

Figure 4. Population Growth and Numbers by Region. Asia is the largest population contributor but growth rates are falling. Africa's population could double reach > 4 billion by 2100. Our World in Data[12]

Figures 3 and 4 document a number of important trends: 1) for the great bulk of the period of Homo Sapiens on Earth (>99%) global human populations were under 1 billion and for most of Homo Sapiens time between 50-100 million (or around one to three modern Greater Tokyos); 2) rapid population growth was particularly acute from 1950, with the global population increasing from 2.5-8 billion in 73 years (an increase of 320%); 3) the global population is predicted to flatten out at c. 10 billion by 2100; 4) Africa is now demonstrating the highest growth and may increase from current levels of 1.2 billion to c. 4 billion by 2100; 5) Asia's population growth is finally slowing following a staggering increase from 2 billion in 1950 to 4.5 billion today.

It is no accident that the Anthropocene period coincides with unprecedented population growth rates within a large evolutionary-advanced biped (us). The sheer magnitude of population growth and the exceptionally high numbers of people demanding ever-increasing amounts of land and resources to sustain *Homo Sapiens* is the single most important driver of planetary environmental change. For this phenomenon to have happened in an unplanned manner at such tremendous speed is remarkable.

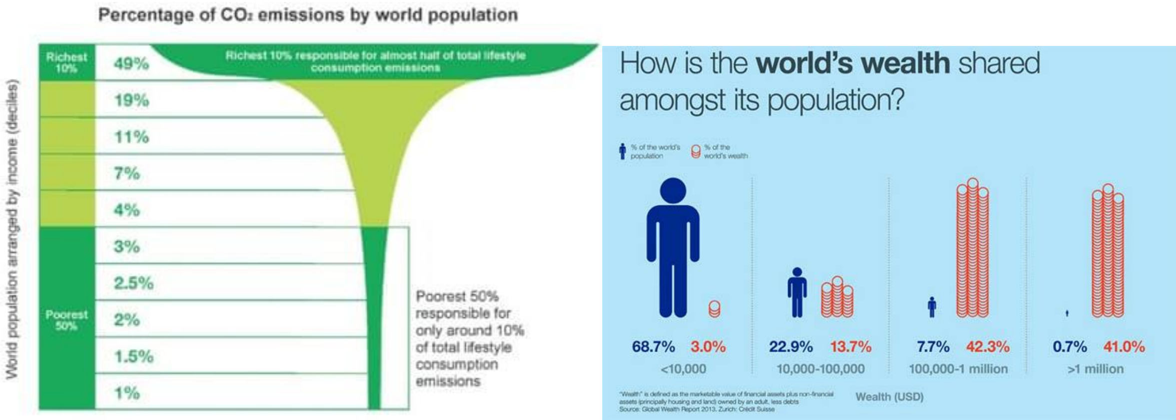

Figure 5. Graphical Representations of wealth inequality and CO2 production correlated to relative wealth. The richest 10%/20% of Earth's population produce c. 50/70% of global lifestyle CO2 emissions whilst the poorest 50% on Earth produce only 10% of global lifestyle CO2 emissions. Approximately 0.7% of humans own 41% of the world's wealth, and 8.4% own 83% of the world's wealth, whilst 69% of humans own only c. 3% of the world's wealth[14,15] *.*

If humans did not consume, or consumed low resource levels, then perhaps the numbers of humans on earth would matter little in terms of global impact. But humans do consume, and consume in enormous amounts, by any measure, as this article has presented. Of course humans are not all equal: *inequality* is a factor that is becoming increasingly scrutinised in terms of planetary impact. Numerous researchers and organisations such as Oxfam and Greenpeace, alongside academia, and various think-tanks, are calculating annual carbon footprints of countries, regions, the world, corporations, different socio-economic groups, and individuals. These calculations are useful for this article as CO2 footprints are a good proxy for wealth and more holistic planetary impact: they also have strong implications for avoidable deaths. CO2 footprint analyses are presented in terms of sub-groups, allowing a measure of variable and proportionate planetary impacts of various populations. Figure 5 presents two graphs from Oxfam which clearly show acute wealth inequality alongside correlative with highly disproportionate global lifestyle CO2 emissions, from the richest/most impactors to the poorest/least impactors. What is blindingly apparent is the extreme asymmetry in wealth, consumption, and environmental impact. The most glaring statistics communicate that less than 1% of the world owns > 40% of the world's wealth, with two thirds owning only 3% of the world's wealth. The richest 10% produce 50% of the world's global lifestyle CO2 emissions, and the poorest 50% producing only 10%. Placing this in a more individual context: UK's King Charles, who regularly speaks out on all things green, mostly publicly in recent times at the 2023 Dubai COP meeting, publishes his own CO2 emission figures. His personal global lifestyle CO2 emission was 423 tonnes of CO2 for 2023. This compares with an average UK citizen CO2 footprint of 11.7 tonnes, 4.7-6.6 tonnes for the global average per person, and 1.6 tonnes for the average person in the lowest 50% of carbon producers.[16,17] King Charles personally produces 90-64 x more than the average global citizen, and 264 times more than the average person within the 50% of lowest carbon producers. King Charles does produce less carbon however than other mega-carbon producers, with Carlos Slim and Bill Gates jointly responsible for producing > 14 million tonnes of carbon per year.[18]

Planetary Boundaries and the Sixth Great Extinction Period

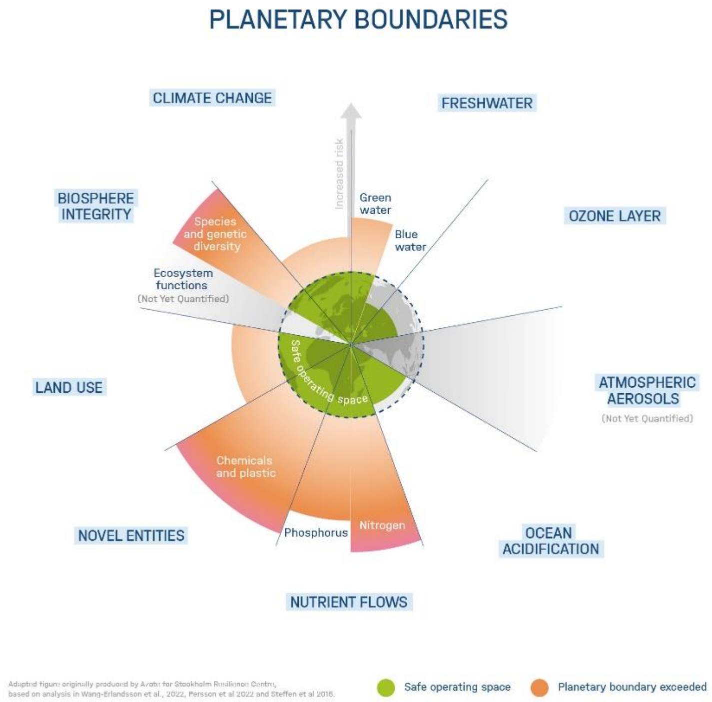

Figure 6. Planetary boundaries pictogram, displaying the relative positions of resource utilisation or environmental impact normalised to calculated safe planetary values.[19]

A concept that is both old and new is the idea of planetary constraints and boundaries. In simple terms the concept states that, for a healthy planet, there is a quantifiable limit to human activities that result in harmful impacts to Earth systems and environments: if this limit is greatly exceed whole-Earth negative impacts can result. A healthy Earth-like planet is defined as one whose holistic Earth Systems are balanced, in accordance with 'natural' planetary systems and processes, unperturbed by negative human activity, with a resultant ability to sustain a wide range of healthy ecosystems and life-forms. People have worried about aspects of planetary boundaries for a long time. Thomas Malthus (1766-1834 CE) hypothesised on aspects of demography and human impacts. He theorised that the growth in human population would limit the benefits of increased and improved food production, resulting in increased misery for the poorest. He also theorised that food would be a limiting factor on human population size. Malthus has been criticised because he was incorrect in literal terms: an ever-ingenious humanity increasingly improved its methods of food production, the status of public health, sanitation, and scientific medicine, which, cumulatively, resulted in population growth. A less literal, more holistic, interpretation of Malthus could praise him as ahead of his time, heralding the day when planet Earth would increasingly struggle to support humans in great numbers and high levels of consumption. During the 1970s, James Lovelock, again heralded danger, when he expounded his Gaia hypothesis. Lovelock encouraged us to look at Earth as one organic-like system, proposing the principle*: if humans significantly affect one aspect of of the Earth system, it will result in numerous foreseen and unforeseen impacts within other aspects of the Earth system*. Planetary boundary models such as presented in Figure 6[19], like Malthus and Lovelock, herald existential and future perils to Earth systems, presenting more systematic and quantitative approaches to previous workers. There are a range of specific Earth systems and environments that these analyses focus upon including climate, ecosystems, oceans, fresh water, land use, and land, air, and water quality. 'Safe Zones' are defined within which planet Earth functions as a 'natural Gaia planet', with 'danger' alerted once the safe zones are exceeded. The strong message: humans have exceeded/greatly exceeded Earth's planetary boundaries in far too many ways.

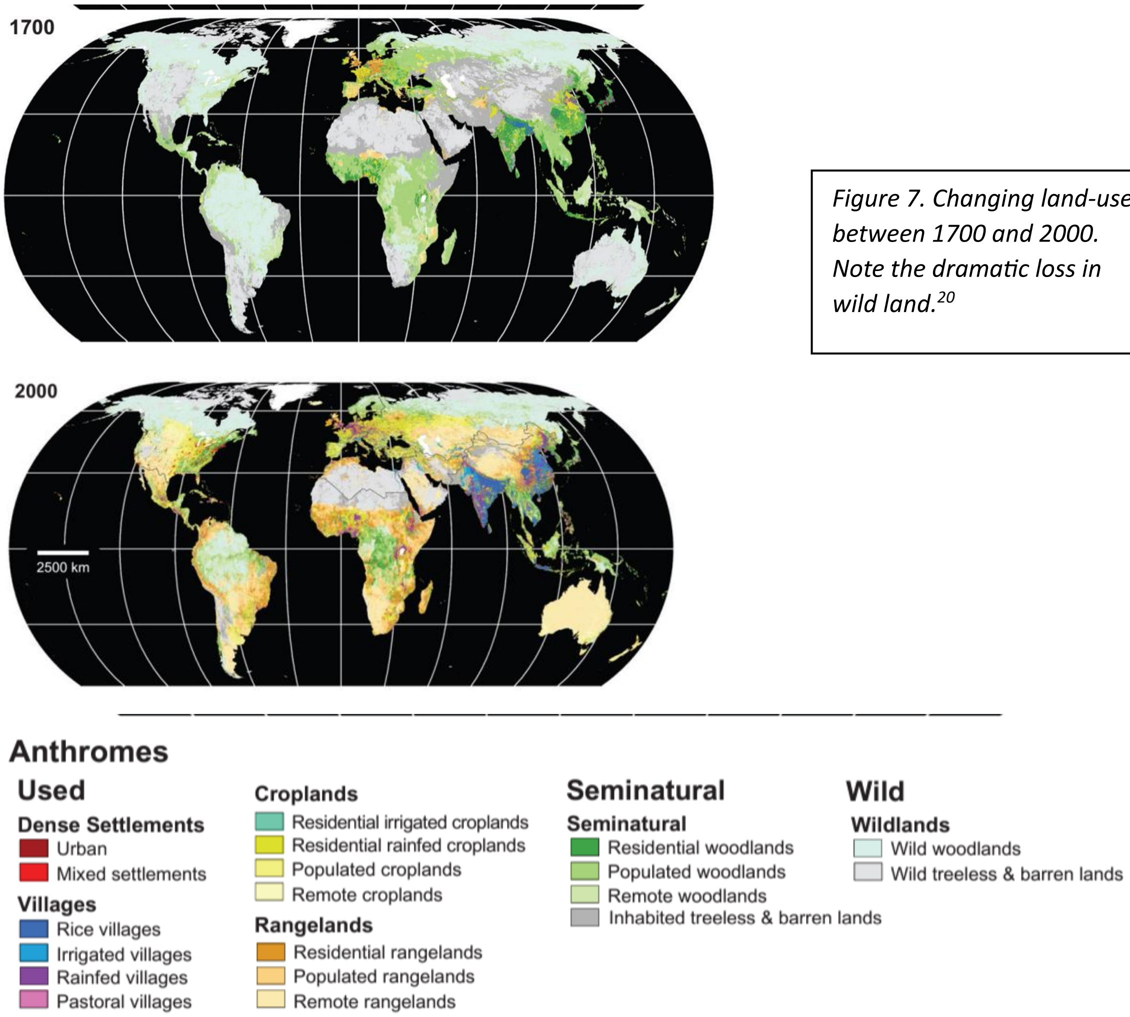

Figure 7. Changing land-use between 1700 and 2000. Note the dramatic loss in wild land.[20]

Two linked impacts caused by humans are the changes in land use and consequent measured decrease in planetary abundance of terrestrial, freshwater and marine vertebrates (Figures 7 and 8). Figure 7 shows how, within a few hundred years, (and particularly since the Great Acceleration), humans have spread into almost every terrestrial ecosystem, significantly impacting these systems at local, regional, and global scales. The increased population, together with the immense resources required to sustain the population have immensely reduced previous 'wild land' that had previously been unimpacted by Homo Sapiens. Figure 8 demonstrates that one of the biggest casualties of this land transformation, together with impacts on the ocean (e.g. fisheries, shipping, and pollution) is the loss in numbers of vertebrate species: the most recent estimate being a loss of 69% of the 1970 vertebrate species populations. Some argue that this constitutes the Sixth Great Extinction Period on earth, whilst others claim it is premature to make this claim. One thing is certain: non-human sentient beings (with the possible exception of animals we eat) are undergoing *an overwhelming experience of avoidable death* brought on primarily by habitat loss, changing land use, intolerance of humans towards animal neighbours who 'threaten them and their livestock', logging, deforestation, pollution, invasive species, and climate change. If the ADN's role was widened to include non-human species it would certainly have its work cut out.

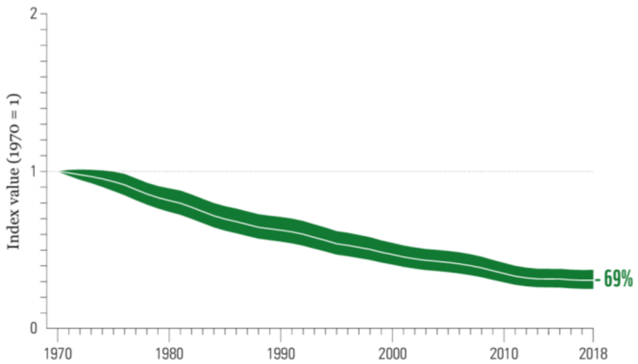

Figure 8. Average (and 95% confidence data limits) change in relative abundance of over 5000 terrestrial, freshwater, and marine vertebrate species globally. A dramatic fall in abundance of 69% between 1972 and 2018 is presented.[21]

Global Anthropocene Implications for Avoidable Deaths

Summarising the key discussion and analysis points above: 1) Armatya Sen's social choice, poverty development, and justice research concludes that outcomes from disasters, and society in general, are determined by skewed systems that favour those with the highest levels of social choice and entitlements. In simple terms: the poorest, most vulnerable, and least powerful are disproportionately adversely affected by disasters, economic depressions, social-welfare services, and so on. Deaths and major negative outcomes are a consequential result of the system/governance/social values/power structures, and do not constitute equitable 'natural justice'. The Avoidable Deaths Network is an example of an organisation that recognises this inequity and attempts to rebalance systems, in so doing reducing 'avoidable deaths'; 2) the very fact that the 'Anthropocene' concept exists at all is in recognition of the manifold ways in which humanity is forcing global-wide impacts on a geological scale. The *Great Acceleration*, from 1950, has witnessed the most significant planetary changing human impacts; 3) Deep Geological Time demonstrates that the Earth has been remarkable constant with respect to its surface environment when compared, for example, to the Moon or Mars, but within that 'constancy' has experienced a global ice age, numerous other ice ages, and a much warmer Earth with no ice. Sea levels have varied by hundreds of metres and land area increased/decreased accordingly. Simple life has existed for 8/9^{ths} of Geological Time, complex life for 1/9.th Homo Sapiens is a very recent Earthly occurrence. Life in terms of a whole-life-system is remarkable resilient. 99% of all life that has ever existed on Earth has become extinct; 4) for the great bulk of Homo Sapiens time on Earth human numbers were low (50-300 million), but since 1805, and particularly since 1950, humans are now measured in billions, increasing from 2.5->8 billion in 70 years; 5) humans have become high consumers, this being extremely variable within the human population, with 0.7% of humanity owning > 40% of the wealth, 10% of humanity producing 50% of the CO2, and the lowest 50% only producing 10% global CO2. A small number of wealthy individuals have a highly disproportionate impact on consumerism and resultant pollution; 6) One the the most apparent impacts of the Anthropocene has been the exceedance of numerous quantifiable planetary boundaries with consequent adverse impacts on Earth systems, environments, and life.

This final section presents scenarios for a future Earth through the lens of Avoidable Deaths (including non-human sentient life). Deep Time informs us that the extreme environments recorded within the rock record over the past 540 Ma or so (the time of complex life) have failed to kill-off life. Life has survived, indeed thrived, occupying every niche of Earthly ecosystems, from the deep ocean, to the polar regions and high mountains, as well as within the wettest and driest of terrestrial environments. Major ice ages, meteorite bombardments, mega-volcanic eruptions and earthquakes, violent-prolonged meteorological storms and droughts, changing atmospheric compositions and conditions, and major rises and falls in sea levels, have failed to extinguish life on earth. In fact life has become increasingly biodiverse and sophisticated with humans as the most recent 'peak' evolutionary species.

We can therefore be confident that even the worst scenario of climate change and human demographics/consumption is unlikely to totally extinguish life on this planet. Some species will become (and are) extinct through direct human action: this was and is avoidable. But a a whole-life-system will survive, and Earth systems will rebalance in accordance with the dominant causality of future times. An example of Earth environmental change and causality has occurred during the past 50Ma. The Palaeocene-Eocene-Thermal-Maximum, some 50Ma, saw average surface temperature of Earth at c. 27-34^{o}C (the present day average global temperature is 15-16^{o}C) and this was brought down, in part, by the creation and subsequent erosion of the Himalayas, which increased sediment fluxes, and locked up atmospheric CO2 within buried sediments and sedimentary rocks, to the point that, from 34 M,a ice began to form again on Earth and led to a major Ice Age from c. 2Ma.

Non-human sentient species *are greatly suffering* at the present time, probably in an unprecedented manner. Never in Earth history has so many Earth species, at a global scale, suffered because of the activities of *one other (human) species*. The worst action humans have undertaken in this respect is to deprive animals of the room and basic living space they need to be natural and wild. As more and more land and ocean fall prey to agriculture, fishing, industry, settlement, pollution, and so on, there is precious space left for non-human life. This comes to view starkly when top predators such as lions, tigers, wolves, and bears and even non-aggressive species such as beavers, become too much of a 'nuisance' to surrounding farmers and human residents, or they become valuable trophies for hunters, and local animal extinctions result. These surely constitute 'avoidable deaths' as do the 69% decrease in all vertebrates since 1970. If Armitya Sen's logic re social choice were translated to vertebrates then it's the human system that causes an unacceptable level of death, with vertebrates having numerous social 'unfreedoms,' and few 'entitlements' that allow them to survive in a human-dominated environment. These deaths are, by definition, 'avoidable'.

When considering avoidable deaths with respect to humans and hazards, the transformation of a natural hazard merely playing out its normal behaviour within uninhabited areas, to one where hazards now impact on humans and become *disasters* has markedly increased due to Anthropocene activities and increasing human populations. Climate change is extensively discussed elsewhere, and will not be analysed in detail here, but mention must be made of the additional energy now embedded within natural phenomena such as storms, cyclones, winds, sea level changes, and droughts. The rise in extreme weather is a direct cause of an enhanced atmospheric capacity to retain water, and increased systems energy producing higher and sustained wind velocities. Even in a warmer world, if humans were fewer in number, and society less unequal, the poorest humans would not be forced to occupy highly vulnerable environmental geographies: within flood plains, on steep mountain sides, adjacent to regularly flooded coastal swamps, or live in low-quality dwellings with respect to earthquakes. The juxtaposition of increased meteorological hazards, alongside 'regular' geophysical hazards, high levels of social deprivation and inequity, and high human population levels/densities leads to higher occurrences of avoidable deaths within disaster scenarios. The poorest suffer the most as is witnessed by disaster experiences in Bhopal, Kashmir, Solomon Islands, the London Grenfell Tower fire disaster, and the New Orleans hurricane, to name a few.

How can we manage this situation? How can we reduce avoidable deaths for humans and non-humans looking forwards? What needs to change? For this discussion carbon emissions reduction is 'given': there is a plethora of literature on that issue. This analysis focuses on three issues: 1) demography and consumption; 2) living with nature; and 3) allowing space for non-humans.

By far the most effective policy option for planetary management and lowering avoidable deaths with respect to disaster management is a decrease in human population/consumption levels and agreed limits to inequality. It can be argued that even if carbon emissions are reduced to zero, whilst other variables remain as they are, only one planetary symptom would be alleviated, without the root cause being addressed. A key question is: what is the optimal planetary human population and level of consumption/inequality for a sustainable Earth? A number of researchers and writers suggest that 3 billion is about the right number.[22] Whatever number is considered, it is probably at least 50% less than the 9-10/11 billion that will shortly eventuate. This population reduction will be a high-magnitude challenge and should be accompanied by global agreements on consumption levels, inequality, and wealth priorities. If human populations increased by 5.5 billion in c.70 years from 1950, surely, we can manage population trends in the opposite direction within similar timeframes? At present there is a paucity of discussion/consideration, and an absence of policy direction, on demographic trends, when compared, for example, with climate change / carbon reduction issues. The prediction of a rapidly growing African population, perhaps to as many as 4 billion, is discussed in the media and popular social science literature as a 'given', as if nothing can be done about it. Those populations that have reached population equilibrium or declining numbers, such as Japan, are often viewed through a negative lens that focuses upon 'ageing problems', 'lumbering economies,' the 'pension affordability crisis' and other pessimistic viewpoints. I would turn this type of argument around, suggesting that ageing issues will be transient as we move to lower populations and a more sustainable future. I point out that a prosperous but stable economy, with lower ambitions for 'economic growth', and with relatively low levels of inequality, is to be admired, not criticised. Those countries with rapidly growing populations and a high proportion of young people are not challenge-free: many countries struggle to find employment for the high youth population with resultant disenchantment, poverty, and a plethora of social issues. Population dynamics, particularly since 1800 CE are a dynamic phenomenon, which requires smart leadership. From a planetary management and avoidable deaths viewpoint, the concentration of wealth in such an incredibly small group of people, resulting in extreme inequality is probably a worst-case scenario. The concentration of wealth creates a small cadre of extreme privilege, power, and influence tending towards continuing profit-high-economic-growth-high consuming-centred global approaches. This will remain the case even if the world turns away from fossil fuels: the same philosophy will continue to push Earth beyond sustainable limits. Such a wealth concentration militates against arguments such as 'enough wealth has been created and has been for centuries: it's the inability to share wealth and focus wealth on the smartest priorities that is humanity's biggest challenge'. This latter argument/philosophy is the one that would resource inequality, reduce stress on planet Earth, give increased priority to non-human sentient life, and reduce avoidable deaths as far more people would have increased social choice and economic entitlement. The achievement of lower populations that consume at much-reduced rates and are equitable is *the* target to aim for.

My second suggestion for lowering avoidable deaths with respect to disasters is to give natural processes the room they need to 'be themselves'. A classic example is rivers and riverine flooding. More extreme weather is leading to increased magnitude floods and consequent higher degree impacts. Humans have chosen to engineer floods and rivers and to develop lifestyles that live with a zero-river flood, or once in a hundred-year major flood scenario. In past times humans tended to *live with floods*, rather than try to control them. We have placed millions/billions of people, homes, infrastructure, high value farmland, and industry, within flood-affected zones, by definition positioning them within increased risk areas, as environments change within a warming world. Some parts of the world, such as much of Bangladesh and Cambodia, whilst still suffering (to a lessening degree over time) from flooding, have increasingly adapted to *living with the floods* as part of a 'business as usual' philosophy. Many urban areas and rural developments grew quickly with variable/limited attention to future-proofing, given to their environmental situations and longer-term hazard risk. Increased higher magnitude floods now directly impinge through house and infrastructure destruction, or severe damage, because of the hydrodynamic nature of the floods itself as well as accompanying increased landslides, and ground instability. Farmers living in dynamic river situations can understandably complain at losing livestock, land, and crops, as mindsets are historically adapted to lower magnitude river activity. Through other lenses, it can be argued that too much is being asked of land that naturally floods. Future planning policies will increasingly: 1) look towards asking serious questions of development within floodplains; 2) ask farmers to rewild wide land borders adjacent to rivers, and horticulturalists to think carefully re multi-million-dollar investments in areas that will increasingly see large floods; and 3) adopt whole-catchment planning with nature/river-centred solutions at the forefront. It will however ask increasingly hard questions of human settlement and agriculture/industry geographies This approach would seriously decrease avoidable deaths and infrastructure damage. Similar arguments can evolve for all other hazard types and hazard prone areas including volcano, earthquake, fire, cyclone, and sea-flood phenomena. Whilst it is difficult to undo what has been done in the past, we can move forwards with a better-informed consciousness, and plan sustainably, through an avoidable deaths lens. Improving technologies will of course have their place, but there should be a lower reliance on hard engineering which is expensive to build and maintain, and has a time-limited efficacy period.

My third suggestion for reducing avoidable deaths is rewilding: this focuses on non-human sentient life, with collateral positive impacts for human avoidable deaths. Rewilding the Earth by up to 50% of its area is gaining momentum in some circles.[23] Re-wilders argue that the best way to allow nature to bounce back is to provide lots of space, and for humans to just get out of the way of wildlife. At its most radical is the idea of setting aside 50% of the terrestrial and marine areas on earth and allowing this space to revert to a pre-human environment. It is also argued that such rewilding will allow holistic natural Earth atmospheric and bio-ecosystems systems to re-equilibrate to near pre-human conditions, which will lower climate change and other environmental impacts, and reduce avoidable human deaths. One interim scenario on the way to lower human populations and high-area set-aside rewilding scenarios is to concentrate urban populations to 90%, develop highly environmentally-sustainable cities, and thus free up at least some land for non-humans.

Figure 8 summarises the options described above and presents possible future trajectories that summarise/synthesise the key themes of this article. The upper option is a 'status quo' option which will lead to more extreme levels of discomfort and increasing avoidable deaths for humans and non-humans. The middle scenario is a modification of the status quo with increased urbanisation, some rewilding, and lower levels of consumption and inequality. This option will still stress Earth systems and non-human life but will be more comfortable than option 1, lowering avoidable deaths. I add the variable 'technological interventions' as these will have a significant role to play in all options and may improve aspects of Earth futures, but do not address root causes. The lower option is the optimal option where humans plan to lower populations, consumption and inequality, live with nature, and allow sufficient room for wildlife. This will allow Earth systems to re-equilibrate over time, and, in the interim period, will allow for a more people-animal centred planetary approach which will, inevitably, reduce avoidable deaths. There is, no doubt, a strong element of utopia to the most radical option, and workers such as Waring et al.[13] hypothesise and model human systems in terms of a low probability with respect to the requisite amount of world governance that would be required. I am sure the reader will have their own opinions and am grateful for the space to present my thoughts.

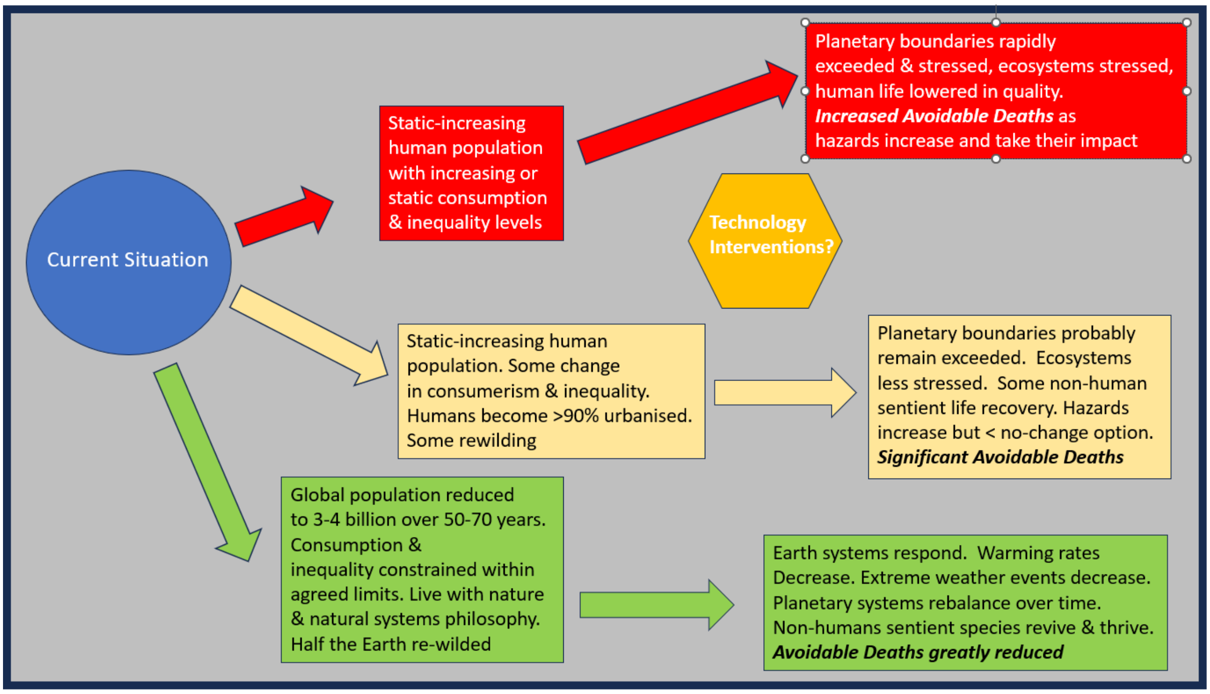

Figure 8. Future Human-Non-Human Scenarios and Avoidable Deaths

Brief Biography

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