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Extreme events in nature: An ecological history of the present

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The zoonotic disease Covid-19 is yet another warning shot to humanity. The imbalance throughout history between our ecological footprint and the earth's biocapacity has grown to a point that it now poses a threat to civilisation. How can we deal with this?

Humanity is facing an existential crisis with the pandemic caused by the highly infectious coronavirus. Apart from this pandemic, the world in recent times has experienced other extreme natural events like super cyclones, floods and forest fires.

In this essay I point out that the common driving factor behind many of these events is the unfolding of an imbalance between the human appropriation of the natural resources of the earth's ecosystems (the ecological footprint) and the carrying capacity of the biosphere (the biocapacity). If we are to arrive at a long-term solution that corrects this imbalance, we need to first visualize the challenge with Covid-19 through the ecological history of humankind.

Coincidence of extreme events and Covid-19

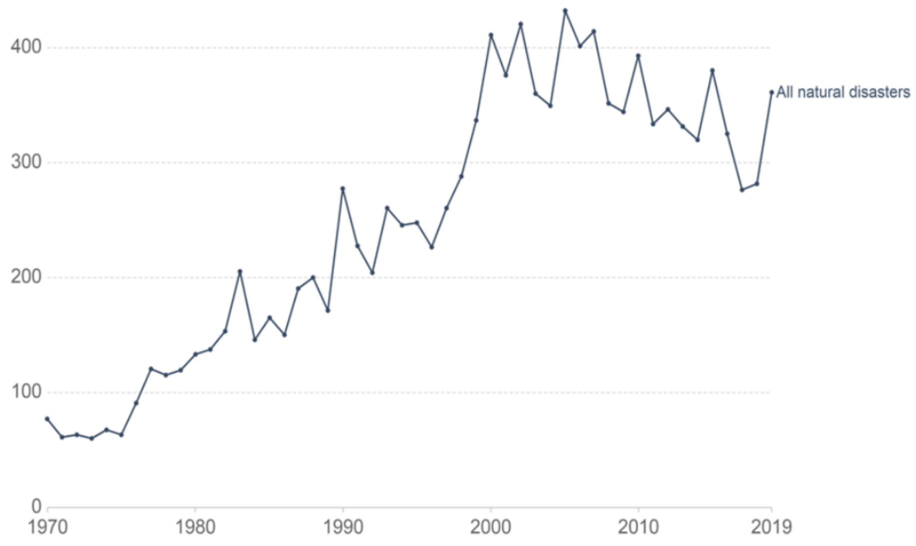
In October 2020, the world is still in the midst of the Covid-19 pandemic and we cannot, as yet, make an assessment of what its total impact will be. All countries have seen their normal socio-economic life derailed. My narrative about the development of this disease is that the extreme damage caused to the health of humans has an ecological linkage.

Extreme Events

It is noticeable that apart from Covid–19, India in the recent past has also faced several cyclonic storms that have had a catastrophic impact. The frequency of such extreme events has been growing.

Already in 2020, India has experienced one super cyclone that hit the eastern coast of India in West Bengal and Odisha on 20 May, which saw wind speeds and devastation that had not been seen in the region since 1737. A second severe cyclone made landfall near Mumbai on 2 June, an unusual event of a cyclone crossing the west coast. The increasing frequency of cyclones, their extreme severity, and the rising frequency of incidents of extremely heavy rainfall, arise mainly because of changes in temperature on land and sea. Such extreme events render millions of people homeless, destroy standing crops, and wipe away the infrastructure built over the past many years; causing huge damage and wasting our environmental and human-made capital.

Figure 1: Total worldwide number of natural disaster events recorded



Source: EM–Dat (2019) CRED International Disaster Database (ourworlddata.org)

Global satellite data show that the frequency and scale of forest fires have also been increasing over time in recent years. Vast tracts in Brazil, Russia, Indonesia, and Africa have been burning for quite some years. Apart from others, both the Amazon rainforest — one of the wettest places on earth and a major carbon sink of the planet — and the very biodiverse forests of Indonesia, are burning at several places, causing a huge erosion of both biodiversity and the environmental capital stock of the planet. India too has been witnessing forest fires in Uttarakhand over years. There were 1,000 fires in 2019. These are attributable to the exceptionally dry nature of the region caused by unusually low rainfall. The number of fires however came down in 2020 because of action undertaken by the forest department and by local communities.

Is there any underlying common causal or driving factor of these disparate extreme events as experienced in India and elsewhere? Or is it just coincidental? The coincidence itself sends us a message from nature, warning us about a deep malady that can have a devastating impact in the contingent event of such a coincidence. What is common among the driving factors of all such events is that they are all caused by human interventions in the form of an overuse of resources or a running down of the biocapacity of the local and global ecosystems. The destruction of wildlife habitats and the ongoing climate change are both hurting humanity, Covid-19 being a "clear warning shot" (Carrington 2020).

Essentially, what has happened is that global warming, climate change, and the destruction of the natural world for farming, mining, and construction of infrastructure have driven wildlife into contact with the humans. According to the United Nations, a vast natural forest area of 290 million hectares was lost to the world between 1990 and 2015. This deprived billions of large or small animals, birds, insects, and other micro-organism of their habitats.

The rate of loss of biodiversity on land in this age of the Anthropocene is estimated to be 100 to 1,000 times faster than during any preceding geological age, before the arrival of *Homo sapiens*. According to the 2020 Global Assessment of the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES):

> Around 1 million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history. The average abundance of native species in most major land-based habitats has fallen by at least 20%, mostly since 1900. More than 40% of amphibian species, almost 33% of reef forming corals and more than a third of all marine mammals are threatened. The picture is less clear for insect species, but available evidence supports a tentative estimate of 10% being threatened.

Apart from deforestation, climate change has also destroyed wildlife habitats, which has created opportunities for pathogens in animal bodies to get new hosts in the human body (United Nations 2020; Carrington 2020).

Since the turn of the century many new diseases have emerged, all linked to the transmission of microbes from animals, birds, and other life forms to human beings. The Middle Eastern Respiratory Syndrome (MERS), the Severe Acute Respiratory Syndrome (SARS), Covid-19, Avian flu, Swine flu, Ebola, Zika fever, and the West Nile fever: these are all zoonotic diseases caused by pathogens of various kinds jumping from animals to humans (Wong et al. 2020; Ye et al. 2020). The problem is that we do not as yet have an adequate understanding of the origin of these viruses, the nature of their mutation and fatality rates in humans. It is like the throw of a dice to get the answer to a question. The phenomenon is not only random in nature but possibly so uncertain that it cannot be modelled using the calculus of probability to make predictive simulations.

Human interventions and non-linear behaviour of the ecosystem

As humans are an integral part of the biosphere, one may ask how is it then that human behaviour can so evolve that it may be held responsible for biodiversity loss? This can happen because of two reasons: (a) human intervention to change the land use pattern of the ecosystem for economic development; and (b) nonlinearity of the functioning of the ecosystem (Dasgupta 2020).

> With globalization, human beings' ability to intrude into any ecological niche that is occupied by various organisms with whom we have not evolved has exposed us to unfamiliar pathogens.

Most human activities that result in an appropriation of resources — particularly those involving land use changes — cause fragmentation of ecosystems both on land and water. The sum of the productivities of such fragmented ecosystems would, in fact, be less than that of an undivided productivity. This contributes to the erosion of the biosphere and causes nonlinear complex behaviour of its ecosystems (i.e., disproportionate change in the final outcome as compared with the size of an initial disturbance). It fundamentally weakens their resilience, making them vulnerable to exogenous shocks.

Moreover, the processes driving the spread of an infectious disease like Covid-19 are also nonlinear. With globalization, human beings' ability to intrude into any ecological niche that is occupied by various organisms with whom we have not evolved has exposed us to unfamiliar pathogens. Biodiversity loss creates niches for pathogens that are waiting in the wings in small numbers to explode into a large population, creating conditions for new pathogens to evolve through mutations as part of a nonlinear process. The nonlinearity of the behaviour of Covid-19 is such that one cannot be certain about how it will evolve and how to control the spread and treat the disease, even if a vaccine is invented. Besides, the quantitative studies on the transmission of the infectious disease point to the fact that large-scale movement of people and goods have made the socio-ecological system quite fragile. This mobility in human economies in the era of global integration has eroded the modularity of our socio-economic system. It has facilitated the invasion of the coronavirus from zoonotic sources into cells of the human body in one part of the world, the disturbance soon reverberating across the world.

How is it that humanity has ended up in the 21st century with such a deep problem of sustainability of human existence? For a perspective of how the present state has emerged, we need here to reflect on the history of the emergence of the imbalance between the ecological footprint of humans and the biocapacity of our planet, an imbalance that is responsible for the present crisis.

History of the struggle between humans and the ecosystems of the biosphere

Earth was formed as a planet in the solar system about 4.5 billion years ago. According to the theory of evolutionary biology, life emerged on earth at least 3.7 billion years ago. There exist now on earth 1 trillion different species, out of which only 1.8 million have been named. These currently living species constitute only 1% of all species that have ever lived on this planet.

Modern intelligent humans, *Homo sapiens*, the only extant species of the hominid group, who now dominate earth, emerged in the evolutionary process about 300,000 to 500,000 years ago in east Africa (near Ethiopia) and South Africa (near the pinnacle point).

Other than in the last 10,000 to 12,000 years, in their long history on earth humans have obtained their subsistence through a combination of food gathering and hunting animals. Ninety nine percent of human history is one of humans as hunter-gatherers. To begin with, they used to move in small mobile groups and followed the most successful and flexible way of life that caused the least harm and damage to ecosystems. It enabled them to spread across the face of the globe and every terrestrial ecosystem in various continents from the Arctic of the north polar regions to the dry lands of Australia and South Africa and both the American continents. (Ponting 2011).

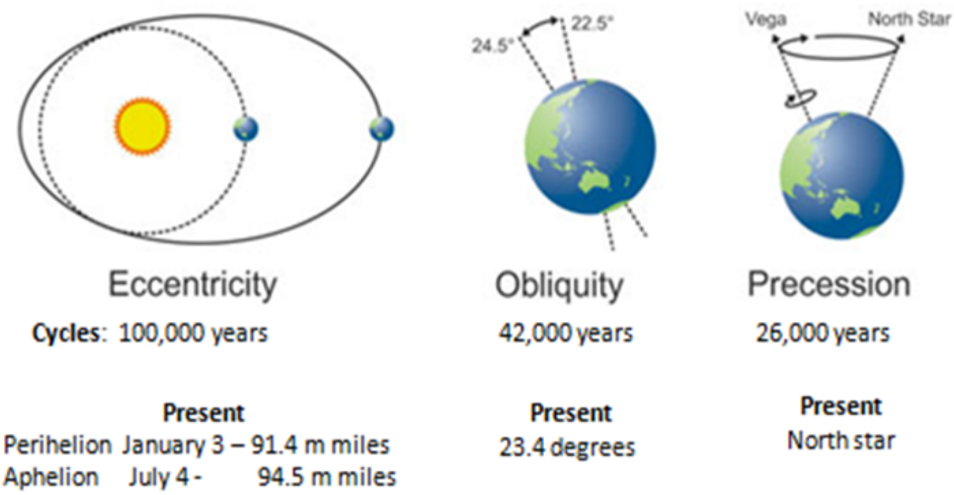
Ice Age and early human migration

How was such migration possible for the early humans? Such migration started soon after humans learnt about the controlled use of fire and to make tools out of stone (the Palaeolithic and Neolithic ages). It is during the period of the last glaciation and the Ice Age that a large part of the earth's surface was covered with ice due to a fall of surface temperature in many parts of the planet below zero degree Celsius. As a result, the polar ice sheet got extended and the seas were frozen and became shallow, enabling nomadic tribes to cross the straits at places to reach other continents of the earth's land mass.

Milankovitch theory of cycles and climate on earth

The Ice Age is a cyclical phenomenon; a period of glaciation is followed by an interglacial warm period. The phenomenon is explained by Milankovitch's theory of cycles and climate, according to which once every 96,000 years, the earth's orbit around the sun changes from the circular to the elliptical and again returns to the circular position (Buis 2020). It happens because of the stronger combined gravitational pull of Jupiter and Saturn on earth, both of which planets have a much larger mass than earth or any other planet of the solar system. The climate and the Ice Ages — their timing and intensity — depend on this cycle along with the two other astronomical phenomena of the axial precession[1] and axial tilt (nutation).[2]

Figure 2: Milankovitch Cycles



Seasonal and latitudinal variations of solar radiation received by the Earth

Source: Author's own compilations and design.

The climate on our planet is influenced by the impact of these three cycles on solar radiation as received by the earth. The glaciation of the earth occurs when for several millennia, the earth is at a distant location from the sun on the elongated elliptical path with an eccentricity (the degree of elongation of an ellipse that is oval shaped as compared with the circle which has zero eccentricity) on the higher side. The duration of glaciation is several millennia because of the long duration of the cycle of 96,000 years. These astronomical phenomena have relevance to today's debate on the imminence of climate change.

First great transition in human history

After the end of the last glaciation 11,700 years ago, the landscape that emerged of continents, lakes, rivers and seas, hills and boulders, forests and grassland, etc., formed the contours of the natural map of our known world. The deposition of huge biotic masses of plants and animals under the ice sheets over hundreds and thousands of years contributed to the formation of the humus content of soil and its build-up.

> [The] first great transition of human history was accompanied by the beginning of interference of humans in the ecosystems of the biosphere, marking the onset of its degradation.

Humankind invented agriculture by domesticating plants and animals, cultivating land for an intensive system of production of food and fibre, and by rearing cattle for milk, meat, and animal energy. Humans developed tools and implements like the plough and the wheel for such agricultural activities. These developments revolutionized the productivity of both land and labour, generating a surplus over the subsistence requirement for the tiller of the soil. There now emerged settled societies with all their hierarchies and complexities. The surplus of agriculture was mobilized by the ruler (king) of the society who redistributed it among the different socio-economic groups of the ruling classes, priests and soldiers, artisans and traders (when exchange started), builders of monuments, etc. The early civilizations of Babylonia, Egypt, the Indus Valley, China, and the Mayan civilization of central America (Guatemala) are illustrative of such developments (Ponting 2011).

This first great transition of human history was accompanied by the beginning of interference of humans in the ecosystems of the biosphere, marking the onset of its degradation. According to the classical economists of the 18th and 19th centuries, the emergence of a surplus output over subsistence due to the higher carrying capacity of land led to the growth of the human population. Thomas Malthus, the British classical economist, thought this growth would be in geometric proportion while food production would grow at a lower rate of arithmetic progression due to the fixed amount of land available. As a result, according to Malthus, there would ensue a long period of struggle in human history over several millennia between the human population and food production, one chasing the other.

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This struggle resulted in a history of degradation of the ecosystems of the earth. The degradation took the following forms:

1. Conversion of forest land into crop land for cultivation or pasture. This triggered a huge biodiversity loss and the emergence of zoonotic diseases of various kinds from time to time.
2. Intensification of cultivation by the use of irrigation and fertilizers, which was often carried out without proper drainage resulting in water logging and salinization of soil, and desertification.
3. Overgrazing by animals of pasture denuded the land of vegetation. Degradation due to these two processes is illustrated by the fact that the seat of Babylonian civilization of ancient times is now one of the desert of the Middle East. Stories of desertification of North Africa and Sahara would be similar.
4. Migration of population and wars for occupying land and natural resources. Illustrations of the impact of migrations and war abound in history, e.g., the fall of the Roman empire due to the barbarian invasion; fall of the Byzantine empire due to the invasion by Arabs, Turks, Slavs, Bulgars, Normans, etc.; invasion of Mongols in Eastern Europe and India, development of the huge empire of Genghis Khan, among many others.

As humans migrated and trade took place, knowledge, technology and culture got propagated and benefited humanity at large through the early forms of trade imperialism. At the same time, germs and diseases also spread across countries and continents. These often resulted in extreme events of epidemics or pandemics. There was the bubonic plague (Black Death) in 13th and 14th century Europe that depopulated 40% of the population. Plague had in fact devastated many parts of the world since the days before the Common Era (Ponting 2011).

The imbalance in history between the human demand for basic necessities of food and the capacity of the ecosystem has largely expressed itself in the form of hunger and famine in years of droughts and unfavourable climate. An accentuating factor of the impact of such calamities has often been the inequality in the distribution of food and necessities in society, which has been determined largely by hierarchies and power structures ever since the emergence of agrarian settlements in different parts of the world. One may, however, point out that the imbalance between human numbers and food was corrected by Malthusian checks like the pestilence of the bubonic plague — a zoonotic disease — in medieval Europe.

History has also shown that humans finally circumvented or tided over crises by the development of technology, augmenting the productivity of land and labour, and by the discovery of medicines, vaccines, and medical treatment. All these proved Malthus' prediction wrong. The inventions of the wheel for grinding cereals, making pottery, spinning fibre and of the driving cart for transportation were landmark developments in early stages of human civilization. The later innovations of machines (by application of the principle of generating kinetic energy by circular rotation), initially driven by renewable energy (watermills and windmills), greatly facilitated the productivity of labour and of natural resources to yield a social product during the long eras of feudalism in agrarian societies of medieval Europe and Asia.

The second great transition: The industrial revolution

A second great revolution or transition, if we want to call it that, took place in human history 250 years ago, when the use of non-renewable fossil fuel-based energy was introduced to drive machines and transport vehicles.

The first industrial revolution was based on coal-based steam power that vastly increased the efficiency of driving machines and transportation. The steam locomotive engine and rail transport came as great inventions. Steam powered printing presses facilitated human communication. These led to the development of a division of labour in industrial activity that revolutionized productivity.

The second wave of the industrial revolution came with the use of hydrocarbons and internal combustion engines for road transportation and for electricity. The latter was the most clean and efficient energy form for end use. It provided the most efficient way of obtaining end-use energy at the burner tip, from basic energy resources.

> Today, we need 1.7 units of earth to ensure a balance between the ecological footprint and biocapacity of our planet…

However, as in the case of the agricultural revolution, this second great transition in the form of the industrial revolution, which began in western Europe, involved significant costs in the form of (a) a depletion of non-renewable fossil fuels; and (b) emission of carbon dioxide and other greenhouse gases causing a heating up of the planet.

In terms of the ecological footprint created, the carbon footprint from carbon dioxide emissions has contributed to more than half of the total ecological stress on earth caused by humans. The carbon footprint is measured in terms of the forest land area required to absorb the carbon dioxide emissions from fossil fuels, in excess of that absorbed by the carbon cycle of photosynthesis and by the oceans. The carbon footprint would be at least half of the total ecological footprint of human land used for meeting the entire demand for crops, animal products, industrial goods, infrastructural and urban development, and waste absorption. This is measured in units of use or diversion of photosynthetic land area, normalized to units of equivalent cropland area with average global crop productivity. Today, we need 1.7 units of earth to ensure a balance between the ecological footprint and biocapacity of our planet, according to the Global Footprint Network, using the data of 2016.

If there were no carbon dioxide or other greenhouse gas (GHG) emissions from anthropogenic sources in the coming years, the earth might well cycle back again to the Ice Age in 50,000 years from now. However, according to scientists at the Potsdam Institute of Research on Climate Impact (2016), we are unlikely to see the next Ice Age for another 100,000 years because of the current rate of the carbon dioxide emissions. This finding indicates the profound impact of human interference with the ecosystems of the planet. But does this postponement of the next Ice Age give us any comfort? There are, in fact, problems of uncertainty of whether the impact of such carbon dioxide emissions on the Milankovitch cycle can last so long in the current geological time scale. This is a non-issue as what matters to us are happenings on the human time scale. Even if the carbon dioxide concentration is kept elevated over hundreds and thousands of years and the Ice Age gets postponed, the damage that would be caused in the coming decades and centuries due to super cyclones, floods, rise in the sea level, droughts, desertification and forest fires would threaten the very existence of human civilization on earth.

The forest fire in Karnataka's Bandipur Tiger Reserve destroyed thousands of acres of forest in February 2019 | Naveen Kadalaveni (CC BY-SA 4.0)

The issue now is how to meet the challenge of sustainability of humanity at the present juncture. Dasgupta (2020) in his interim report on the Economics of Biodiversity for the government of the United Kingdom points to the ecological footprint as having exceeded the biocapacity since the 1960s. He considers the ecological deficit (i.e., the short fall of biocapacity from the ecological footprint) in terms of land use as responsible for the enormous biodiversity loss of the planet. The emergence and alarming rate of spread of Covid-19 is a warning signal of humanity crossing the safe operational limits of the functioning of the biosphere.

The sustainable development goal of the UN requires that an economy should operate within such safe operational limits. Since the GDP of a country or the world is determined by the actual use of biocapacity and the productivity of its use to yield GDP, the delimiting of the ecological footprint to ensure sustainable development would require reducing the growth rate of GDP and raising the productivity of biotic resources (biocapacity) of the earth. The rise of the productivity of environmental resources also has to offset the secular decline of the biocapacity of the earth, a decline that is being experienced over time because of the degradation of the ecosystem in terms of its ability to reproduce natural resources.

In the long term, to prevent the onset of pandemic diseases like Covid-19, it is important that we attain the goal of sustainable development. If we assume that the UN Sustainable Development Goal is to be attained by 2030, Dasgupta's report points out that given the growth rate of global GDP per capita at 3.4% per annum and the rate of decline of global natural capital stock at 0.3% per annum, as experienced during the period 1992-2014, then the productivity of bioresources in terms of GDP would have to grow at 9.1% per annum. This is going to be too tall an order given the fact that the historic rate of growth of such economic productivity of bio-resources has been 2.5% per annum.

Now, if the productivity of natural resources cannot grow at such a high rate, the only other option is to make serious efforts to reduce the size of the footprint by reducing the growth of both population and that of per capita income. Is that feasible?

Conclusions

The root of the Covid-19 pandemic and of the other extreme natural events that the world is experiencing is the disruption of the ecological balance between the human appropriation of resources of the biosphere and the biocapacity of our ecosystem. This has expressed itself in the forms of biodiversity loss and climate change, which again affect each other. We are confronted with a tough choice today between lives and livelihoods (because the Covid-19 pandemic is devastating our fellow beings), and between economic growth and halting the erosion of the environmental capital stock of the biosphere.

> The feasibility of …a change would depend on our sense of values and ethics about growth, well-being and sustenance of other species.

This takes us to the fundamental question: how do we reduce the requirement of growth of the global economy that is essentially driven on one side by the capitalist forces of indefinite accumulation of wealth and growth of economic power in the OECD (Organization for Economic Cooperation and Development) countries, and on the other side by the requirement of a rapid removal of poverty of Afro-Asia in the non-OECD countries?

The reduction of the size of an economy and its growth would call for a change in the preference structure of society and a redistribution of income and wealth so that the new total demand can limit use of the biosphere's resources within the regenerative capacity of the biosphere. The feasibility of such a change would depend on our sense of values and ethics about growth, well-being and sustenance of other species. These would require *a change in our ways of thought* and our long-run policies. This is necessary to reduce the scale of our consumption demand, on the one hand, by changing our value system and preference structure and, on the other, by making scientific advances and innovating new technologies and social organization of production to raise the productivity of bioresources.

> For meeting today's existential crisis, we are now facing the issues of a conflict between growth and saving nature, and between lives and livelihoods.

All these ultimately lead to the need for setting up two goals of equal importance:

(a) control our greed and demand by developing an enlightened set of preferences of the structure and level of consumption; and

(b) cooperation of people at the global and local level for an equitable sharing of the benefits from the use of natural resources.

All religions and faiths of the world have preached the values of empathy, sharing, charity, and compassion so that society does not collapse due to chaos in times of environmental crisis. For meeting today's existential crisis, we are now facing the issues of a conflict between growth and saving nature, and between lives and livelihoods. To meet this challenge, we need to sustain our march of progress in science and technology, especially in the domain of genome and biomedical research, to ensure food and health security. This development of knowledge has to be translated into that of social well-being through the choice of appropriate strategies and policies of development. Finally, all these initiatives and actions need to be combined with our intellectual and emotional commitment to humanity, for the universal and equitable sharing of global resources for the development of all.

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Footnotes:

1 The axis of the earth, which is rotating like a wobbling top, again rotates making a conical shape completing one conical cycle in 26,000 years. This causes the astronomical phenomenon of the axial precession.

2 The axis of the earth makes an angle with its orbital plane around the sun (called ecliptic), which varies between 22 degrees and 24 degrees. One such cycle of variation from and back to 22 degrees taking 40,000 years. This causes the astronomical phenomenon of the axial tilt.

References:

Buis, A. 2020 'Milankovitch Cycles and their role in earth climate”. *Global Climate Change Features,* NASA. 27 February 2020.

Carrington, D. 2020. 'Coronavirus: 'Nature is sending us a message', says UN environment chief'. *The Guardian*. 25 March 2020.

Dasgupta, P. 2020. *The Dasgupta Review–Independent Review on the Economics of Biodiversity Interim Report.* HM Treasury

Harari, Y. N. 2014. *A Brief History of Humankind*. Penguin Random House.

Ponting, C. 2011. *A Green History of the World: The Environment and the Collapse of Great Civilizations*, Penguin Books.

Potsdam Institute of Research on Climate Impact. 2016. 'Human-made climate change suppresses the Next Ice Age'. 13 January 2016

United Nations. 2020. 'Nature's Dangerous Decline 'Unprecedented'; Species Extinction Rates 'Accelerating'. *Sustainable Development Goals* blog. 6 May 2020.

Wong, G., Bi, Y. H., Wang, Q. H., Chen, X. W., Zhang, Z. G., and Yao, Y. G. 2020. 'Zoonotic origins of human coronavirus 2019 (HCoV-19/SARS-CoV-2): why is this work important?' *Zoological Research*, 41(3): 213-219.

Ye, Z. W., Yuan, S., Yuen, K. S., Fung, S. Y., Chan, C. P., & Jin, D. Y. 2020. 'Zoonotic origins of human coronaviruses'. *International Journal of Biological Sciences*, 16(10): 1686-1697.