Humanity's Increasing Effects on Earth's environments: The Anthropocene Epoch

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Following Laurence Foss's argument above, Victor explains in more detail one aspect of the human effect on the environment.

Nature's editors four years ago explained that:

The Anthropocene is defined not just by climate change or extinctions, but by a linked set of effects on Earth and its biosphere, from perturbations in the nitrogen cycle to the dispersal of species around the globe. Official recognition of the concept would invite cross-disciplinary science. And it would encourage a mindset that will be important not only to fully understand the transformation now occurring but to take action to control it.

Earth scientists now recognise that our species is a geophysical and ecological agent of unprecedented power, albeit with unsustainable growth expectations. Some authors suggest that humanity's control of fire, some 2 million years ago, ushered in a totally new controlling element, overriding nature. A further stage was the extensive development of agriculture and horticulture (Glikson, 2015). However, an emerging group of scientists now propose that "the second half of the twentieth century is unique in the entire history of human existence on Earth. Many human activities have accelerated sharply towards the end of that century. The last 50 years have without doubt seen the most rapid transformation of the human relationship with the natural world in the history of humankind" (Steffen et al., 2015).

Landscape changes by nature and human activity

Our mining, road, rail and dam building have modified the earth's surface at a greater rate than all the natural geological agents. Glaciers and rivers have been estimated to have moved about 10 billion tonnes of sediment each year over geological time. In comparison humans mine about 7 billion tonnes of coal and 2.3 billion tonnes of iron ore each year. Add the same amount of overburden plus construction materials and we have become a major contributor to altering our landscape (Sandiford 2011).

Since 2007, more than half of all people now live in cities, compared to just 15% at the turn of the 20th century. This has resulted in an exponential increase in demands on infrastructure, fresh water, and sewerage. Just the delivery of fresh water has necessitated the construction of more than 45,000 dams (>15m height) that together hold back some 15% of total annual global river runoff. In turn this has decreased the sediment carried to the ocean, which has increased coastal erosion (GWSP Digital Water Atlas, 2008). In many cases dams simply terminate river ecosystems. An extreme example is the total drying of the Aral Sea in central Asia (area of 68,000 km^2), where intense cotton farming has used up all the river waters flowing from the Himalayas.

The filling and emptying of large dams may generate earthquakes, such as one Indian dam that resulted in a magnitude six quake, and the Thomson Dam in Victoria creating a magnitude five quake. Meanwhile a big increase in seismicity of small earthquakes has resulted from intense injection of wastewater from oil and gas extraction and hydraulic fracturing [fracking].

Planetary and human energy release

All earth systems (apart from the atmosphere) are energised by the release of interior planetary heat in the form of volcanoes, thermal springs, and in the movement of tectonic plates resulting in earthquakes and the uplift of mountains. This natural metabolic rate is estimated to be about 44,000 billion watts.

For comparison, humanity generates some 16,000 billion watts from the burning of coal, oil and natural gas. Significantly, this is already more than a third of the earth's natural rate, and with humanity's energy use doubling every 34 years, it would surpass the natural rate by about 2060 (Sandiford 2011).

Deforestation and decreasing biodiversity

Agriculture, deforestation and population growth are interconnected. The whole Mediterranean was once surrounded by extensive forests with a very rich ecosystem, until the establishment of the Greek civilisation. Wood was used as a major fuel for cooking and heating, in kilns for tiles and bricks, in mining and smelters, and as a building material for houses, public buildings, carts, chariots, boats and sailing ships (Attenborough, 1987).

Back in the 4th Century BC, Plato wrote: "What now remains, compared to what existed, is like a skeleton of a sick man, all the fat and soft earth wasted away and only the bare framework of the land being left."

As the classical empires spread from east to west along the Mediterranean and north into Europe the forests were demolished. The creation of large cities contributed to deforestation. Overcrowding forced citizens to move to the hillsides where forests once stood to build their homes.

The provinces of North Africa were, originally, among the richest in all the Roman Empire. Six hundred cities flourished along the shore from Egypt to Morocco. The biggest was Leptis Magna with 100,000 people. By the end of the first century AD, North Africa was producing half a million tons of grain every year and supplying the growing city of Rome with most of its wheat (Attenborough, 1987).

Deforestation and relentless agriculture weakened the soil, allowing it to be eroded by rain into the sea, filling the estuaries and harbours. Ports like Ephesus were abandoned as the shoreline moved seaward some 5km. Urbanisation and the resulting degradation of the environment ultimately weakened the Roman Empire.

Deforestation on a similar scale to that which occurred in the Mediterranean also prevailed in the Indian subcontinent, in China, and in parts of sub-Saharan Africa, accelerated by increase in population.

South America suffered the largest net loss of forests in the decade to 2010 – about 4 Mha/yr (equivalent to 0.5 per cent of total forest cover) – followed by Africa, which lost about 3.4 Mha/yr. Although the rate of global deforestation has recently slowed, it continues at a high rate in several countries, especially Indonesia, where, by 2012, primary forest loss (0.84 Mha/yr) was estimated to be higher than in Brazil (0.46 Mha/yr), (Brack & Bailey, 2013).

In addition, Indonesia's forests contain high floral and faunal biodiversity including 10% of the world's plants, 12% of the world's mammals, 16% of the world's reptile amphibians, and 17% of the world's bird species. The forest's high biodiversity places Indonesia among the world's mega-diverse countries. Therefore extensive clearing of Indonesian primary forest results in habitat loss and associated plant and animal extinctions. The orang-utan, the Sumatran tiger and countless other endangered species are being pushed to the brink of extinction (Margono et al. 2014).

Human desire for ivory is also threatening the survival of elephants and hippopotami. The exaggerated value of limited supply leads to disproportionate exploitation of rare species, rendering them even rarer and thus more desirable and ultimately leading them into an extinction vortex. While not reaching the extreme of a mass-extinction, in the palaeontological sense, humanity has achieved extinction rates that are much higher than would be expected from the fossil record, highlighting the need for effective conservation measures.

Food requirements

The right to food is clearly not negotiable. Feeding our growing population and reducing hunger will only be possible if agricultural yields can be increased significantly – and sustainably. It is clear that an improvement in the management of agricultural soils and water becomes key to the achievement of global food security. There is in fact plenty of food. But too much of it is going to feed animals, too much of it is being converted to fuel and too much of it is being wasted.

FAO estimates that the world's growing population will require about 60 percent more food by 2050 compared to 2006. Over the next 35 years, 70 percent of gains in cereal production are expected to come from irrigated land. In some areas the shortage of surface water has led to unsustainable over-exploitation of artesian or fossil waters.

Soil is a non-renewable resource, and its preservation is essential to our food security. Yet overgrazing in marginal lands and much traditional agriculture has degraded and salinised the soil. Major droughts and storms have then blown these soils away. The loss of prime agricultural land by urbanisation has also resulted in increased runoff and pollution of nearby streams and seas (Kaushal et al. 2010).

Pollution

In India air pollution from ozone and soot caused far more loss of crop yield than climate change. From 1980 to 2010, the increase in temperature and change in precipitation as a result of anthropogenic climate change has caused a 3.5% decrease in wheat yield. However, air pollution has caused more than 30% decrease in wheat yield during the same period.

Since the emission of soot and ozone precursors is significantly larger in China than in India the impact of air pollution on Chinese agriculture is expected to be even larger. China is now the world's largest food importer.

The overall effect of human activities on the air, water, soils and rocks has extended beyond the continents into the surrounding seas. As it is not illegal to dispense with rubbish on the high seas it was found that half of all marine debris apparently comes from the land while the other half is from boats and ships.

Observations from 24 expeditions (2007–2013) across all five oceanic sub-tropical gyres, plus the Mediterranean Sea, coastal Australia and Bay of Bengal, involved 680 surface net tows and 891 visual survey transects of large plastic floating 'islands' of debris. The results suggest that a minimum of 233,400 tons of larger plastic items are afloat in the world's oceans plus 35,540 tons of microplastics. These range in size from being invisible to the naked eye to just a few millimetres in diameter, and are produced as large plastic items ultimately degrade into millions of microplastic grains.

According to the first rigorous global estimate published in *Science* (Jambeck et al. 2015) around 8 million tonnes of plastics go into the oceans each year. Around a third of this likely comes from China, and 10% from Indonesia. Most of the worst offenders are developing nations, largely due to fast-growing economies but poor waste management systems.

Microplastics are easily ingested by fish, mussels and other sea animals, and probably are linked to the passage of deadly, persistent chemicals through the environment, such as the pesticide DDT and toxic PCBs. One third of dead turtles from Moreton Bay in Queensland were found to have ingested mainly soft plastic items, as they mistake them for jellyfish.

Marine pollution by chemical wastes is an increasing problem. According to NOAA, 80% of pollution to the marine environment comes from the land. One of the biggest sources occurs as a result of runoff. This nonpoint source pollution includes many small sources like septic tanks, cars, trucks and boats, plus larger sources, such as farms and forest areas. Millions of motor vehicle engines drop small amounts of oil each day onto roads and parking lots. Much of this, too, makes its way to the sea. The burning of fossil fuels, but also mining have boosted the mercury levels in the upper 100 m of the ocean by a factor of 3.4 since the beginning of the Industrial Revolution. The highest levels of anthropogenic mercury are in the Arctic and North Atlantic oceans. Marine disposal of nuclear wastes has been ongoing. The former Soviet Union alone dumped 16 submarine reactors and 17,000 containers of radioactive waste into the Kara Sea, all slowly decaying. Eventually these will release their contents into the Arctic Ocean.

Shipping is a major contributor to ocean acidification. Cargo ships burn some of the nastiest fuel on earth: bunker fuel. Cheap and untaxed, it is low-grade oil, the dirtiest variety that ships burn when on the open ocean – and it is 4.5% sulphur by weight. The largest SO_x and NO_x production from shipping is seen in parts of the northern hemisphere, resulting in concentrating the sulphuric and nitric acids within a relatively shallow surface mixed layer (Hassellöv et al., 2013).

The Great Acceleration

The International Geosphere-Biosphere Programme (IGBP 1999-2003) produced a graphic synthesis of socio-economic indicators and human activities on the Earth. Graphs published in an updated report by Steffen et al. (2015) *The trajectory of the Anthropocene: The Great Acceleration* suggest that the Earth has left the Holocene and entered a new geological epoch, the Anthropocene, an epoch driven by the impact of human activities on the Earth System. The dominant trend of socio-economic graphs shows that economic activity continues to grow at a rapid rate. Meanwhile the Earth System indicators generally continue their post-industrial rise, especially carbon dioxide, nitrous oxide, ocean acidification and surface temperature. The post-1950 acceleration in these indicators remains clear and "are (1) beyond the range of variability of the Holocene, and (2) driven by human activities and not by natural variability" (Steffen et al. 2015). The human and natural environments have now become completely intertwined, and it is our responsibility to make people aware of this situation so that we can make rational community decisions for actions that would reduce the damage and improve our environment.

Humanity's undeniably major impact on Earth therefore justifies the naming of a new Anthropocene epoch, and the current exponential growth in human population and use of resources is simply not sustainable. Steffen and colleagues propose 1950 as the start date for the Anthropocene from an Earth System science perspective. The detonation of the first atomic bomb in the New Mexico desert, on 16 July 1945, and the worldwide spread of radioactive isotopes now provide a unique signal of human activity at the start of the Great Acceleration, and of the Anthropocene.

Conclusion

Reflecting on the Anthropocene and its grim environmental context, it is important to remember that not all societies have been equally impacted by the factors discussed above. While the developed world has enjoyed major increases in personal wealth, the developing third world has been largely left behind.

As OXFAM has reported: inequality is one of the defining problems of our age. In a world where hundreds of millions of people are living without access to clean drinking water and without enough food to feed their families, a small elite has more money than they could spend in several lifetimes. The consequences of extreme inequality are harmful to everyone - it robs millions of people of better life chances and fuels crime, corruption and even violent conflict. Put simply, it is holding back efforts to end poverty.

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