Doomsday scenarios: an appraisal

Jeremy J. Ramsden*

Euro Mediterranean Academy of Arts and Sciences
and
The University of Buckingham, MK18 1EG, UK

Works foretelling the imminent demise of humanity due to resource depletion are reviewed. It is shown that this depletion and the accompanying growth of the human population is a consequence of man's invention of the machine as an instrument to control and dominate nature. The proposed use of more advanced technologies to restore nature to its pristine state is, therefore, self-contradictory. Mankind is faced with a stark choice: to continue in more or less the same way until the doubtless bitter end; or to work towards creating a new, "thinking" civilization in which machines are wholly subordinate or even nonexistent.

1. Introduction

Latterly, there has been a resurgence of books and papers discussing the more-or-less imminent demise of (civilized) life as we know it on Earth. These works have ominous titles such as "Can a collapse of global civilization be avoided?"[1] and "Rapid discharge of the earth–space battery foretells the future of humankind".[2] Curiously, the different studies typically ignore each other,[3] each one cultivating a little patch of what is evidently a very great field. Also typically, the authors are apparently unaware of the antecedents of their ideas, confining citations to papers from the last few years (occasionally decades), although it seems to be *de rigeur* to quote Malthus.[6] The

* E-mail: jeremy.ramsden@buckingham.ac.uk

1 P.R. Ehrlich and A.H. Ehrlich, Can a collapse of global civilization be avoided? *Proc. R. Soc. B* **280** (2013) 20122845.

2 J.R. Schramski, D.K. Gattie and J.H. Brown, Human domination of the biosphere: Rapid discharge of the earth–space battery foretells the future of humankind. *Proc. Natl Acad. Sci USA* **112** (2015) 9511–9517.

3 To give a concrete example, ref. 4 does not cite the previously published ref. 5, nor any other works by that author, although his work on the topic is highly relevant.

4 J.H. Brown et al., Macroecology meets macroeconomics: Resource scarcity and global sustainability. *Ecol. Engng* **65** (2014) 24–32.

5 J. Lovelock, *The Revenge of Gaia. Why the Earth Is Fighting Back — and How We Can Still Save Humanity*. London: Allen Lane (2006).

6 T.R. Malthus, *An Essay on Population*. London: Dent (1958) (first published in 1798).

Nanotechnology Perceptions **12** (2016) 35–46
Received 28 February 2016; *accepted* 31 March 2016

doi: 10.4024/N06RA16A.ntp.12.01

purpose of this essay is to give a more comprehensive overview of the matter than can be found in the previously published books and papers, from which, hopefully, rather more insightful conclusions may be drawn, leading naturally to indications for actions that might actually achieve something.

2. Population and resources

The core idea of Malthus was that population N increases exponentially with time t (or as a Fibonacci series, which amounts to the same thing):[6]

$$N = \exp(rt)\,, \tag{1}$$

where $r > 0$ is some rate coefficient. This is indisputable. At the same time, Malthus asserted that food supply F grows only arithmetically:

$$F = ft\,, \tag{2}$$

in which case at some epoch, regardless of the starting values of each (population and food), population will overtake food supply ($N>F$; we can suppose that the units of F are annual supply for one person or something similar) and mass starvation will ensue. The assumption of arithmetic growth of food supply appears to be somewhat arbitrary — it could equally well be asserted that it is geometric (hence exponential), zero, or even negative. The arithmetical growth idea was, presumably, based on contemporary evidence of the growth of agriculture. Malthus' overall thesis is not, therefore, vindicated. Nevertheless, it has served as a powerful inspiration during the last 200 years, as a signpost indicating the fragility of our situation on the planet if the ruling principle of human existence is "be fruitful and multiply".[7]

Actual observation also refutes Malthus' thesis: world population has continued to grow exponentially without any sign of abatement. This places mankind in a very different situation from that of all other species, whose growth may be expected to follow a sigmoidal course, representable by a logistic equation

$$N = K/(1 + \exp\{-r[t-m]\}), \tag{3}$$

encompassing first an interval of exponential growth (with rate coefficient r), then passing through a point of inflexion (at time $t = m$), and finally leveling off at the carrying capacity K. This behaviour may be readily observed in the wild and even in the laboratory; for example in a bacterial culture. Mankind, with his extraordinary ingenuity, can make K increase and, furthermore, it is well established (by Kurzweil[8] and others—cf. Moore's law) that technologies grow exponentially. Therefore, a modified equation should more properly apply to man, something like

$$N = (K_0 + \exp[ft])/(1 + \exp\{-r[t-m]\})\,, \tag{4}$$

where K_0 represents the resources available to primitive man.

Many economists would confidently assert the validity of such a viewpoint; or, in other words, that growth can continue indefinitely.[9] Traditionally, food production is linked to land

[7] Genesis 1, 28

[8] R. Kurzweil, Nanotechnology dangers and defenses. *Nanotechnol. Perceptions* **2** (2006) 7–13.

[9] W. Beckerman, Economists, scientists and environmental catastrophe. *Oxford Economic Papers* **24** (1972) 327–344.

for growing crops or allowing animals to graze, and the supply of land is limited by the finite surface area of the Earth. This limitation is, however, already being overcome by the creation of multistorey greenhouses illuminated using artificial lamps. One does, of course, need energy to power the lamps and the ultimate source of the energy available on Earth is solar radiation, which is also finite: the flux per unit area and the area that can be used to capture it. Even if one could do better than plants at capturing solar energy, the amount of available energy would only increase a fewfold. This limitation has been somewhat obscured by the exploitation of fossil fuel resources (stored solar energy) and fissile elements such as uranium. The latter is a finite mineral resource but, as Kaku points out,[10] referring to a concept of Kardashev and Dyson, energy supply is a crucial factor in determining civilization level.[11] A Type I civilization that has mastered planetary resources can reach out to master stellar resources (and, presumably along the way, exploit anything useful from other planets in the solar system). Note that the exp[ft] term in equation (4) does not represent a single technology, but a succession of technologies, each of which grows exponentially until it is superseded by something better. Hence, the confidence of the majority of economists would appear to be fully justified by the even greater confidence of physicists in man's ability to continue to develop ever more advanced technologies.

For all nonhuman species, food represents the totality of the resources they require to live. Only humans consume, in addition to food, minerals, metals and energy. The metals extracted from the minerals are very necessary for constructing the greenhouses and lamps and energy-harvesting apparatus, as well as the spaceships needed to exploit planetary and stellar resources. Insofar as the planet is (almost) a closed system, we cannot actually run out of metals and other valuable non-food resources.[12] Admittedly, with use, the metals tend to be dispersed ever more finely and irretrievably in the environment—a trend exacerbated with nanotechnology—and are, in effect, "used up"—but this problem, too, can be overcome with essentially unlimited energy.

Malthus' successors have ignored all this hubris and have battened onto the "human predicament" of not only Malthus' hobbyhorse of overpopulation, but also overconsumption of natural resources and "the use of unnecessarily environmentally damaging technologies".[1] It is perfectly true that surveys of the state of the planet present a very sombre outlook.[13–15] Resource scarcity in the near future is deemed to be "critical".[4] The capacity of humans to innovate and adapt to circumvent the K_0 available to primitive man (called the "Malthusian–Darwinian

[10] M. Kaku, *Visions*. Oxford: University Press (1998).

[11] Economists would tend to agree that mastery of energy conversion is a driver of economic growth (R. Kümmel and D. Lindenberger, How energy conversion drives economic growth far from equilibrium of neoclassical economics. *New J. Phys.* **16** (2014) 125008).

[12] Hydrogen is one of the very few substances that can escape from the planet. Proposals to make hydrogen the main energy storage material are somewhat alarming because leaks of hydrogen into the atmosphere will tend to be lost forever into outer space.

[13] V.D. Markham (ed.). *AAAS Atlas of Population & Environment*. Washington, DC: American Association for the Advancement of Science (2000).

[14] *Safeguarding Human Health in the Anthropocene Epoch*. The Rockefeller Foundation–Lancet Commission on Planetary Health (published online 16 July 2014).

[15] Mason has pointed out that the assessment in ref. 14 may, in fact, be unduly optimistic since there are a number of notable omissions, such as the ecologically deleterious effects of massive pesticide use.[16]

[16] R. Mason, The sixth mass extinction and chemicals in the environment: our environmental deficit is now beyond nature's ability to regenerate. *J. Biol. Phys. Chem.* **15** (2015) 160–176.

dynamic, MDD[17]) is presumed to be very limited; reaching, let alone surpassing, a Type I civilization is not even discussed. Ref. 2 introduces a "sustainability metric" Ω, defined as

$$\Omega = \Psi/(BN), \tag{5}$$

where Ψ is the total chemical energy stored as phytomass (including net annual primary production, NPP, via the conversion of solar energy) and B is the per capita human metabolic requirement for one year; plotting Ω against time since the start of the Christian era shows a rather uniform decline from around 70,000 years to only a few hundred years at the present time. Ocean phytomass appears to have been neglected, hence the conclusion may be unduly alarmist. It is puzzling that there is no acceleration of decline after the Industrial Revolution: is this evidence that the great increase of B that that revolution induced and enabled was offset by a battery of energy-conserving innovations?

Be that as it may, the Schramski et al.[2] approach does at least have the merit of being, essentially, a back-of-the-envelope calculation, and is all the more powerful for it. Similar overall conclusions were reached by the work of Meadows et al.,[18] in which a computer model of world dynamics was used to explicitly predict the future course of population and resource availability. The results predicted collapse around the middle of the present century. The approach has received its due share of criticism.[19] Salerno has pointed out that the model is highly sensitive to parameter choice,[20] implying that the world really is so sensitive; or that more accurate input concerning the main variables (even today a difficult task) is required; or that the model is wrong. Burke has presented results from a different set of models that yield more optimistic outcomes.[21] The problem with the computer modeling approach (i.e., solving a set of differential equations representing the system being modeled) is the severity of the assumptions that have to be applied to make the model tractable.[22] No doubt many plausible-looking optimistic models could be constructed, and many pessimistic ones, but all share the kind of assumption (e.g., around "average types" and "average events"[22]) that makes them wrong. That is quite apart from the problems associated with transforming the differential equations into difference ones; substantial errors may arise from the digitization.

In summary, the argument of this (large) group of doomsday scenarios is that an indefinitely increasing population must, sooner or later, outstrip the availability of resources—material and energetic, and of course one needs material resources to harvest the energy—on a finite planet.

3. Remediation through sustainability (conservation)

The dire warnings of the doomsday scenarios of §2 are countered by the argument that sustainability can be achieved if population growth and consumer demands are moderated. In

[17] J.C. Nekola et al., The Malthusian–Darwinian dynamic and the trajectory of civilization. *Trends Ecol. Evolution* **28** (2013) 127–130.
[18] D.H. Meadows, D.L. Meadows, J. Randers and W.W. Behrens, *The Limits to Growth*. Washington, DC: Potomac Associates (1972).
[19] See, e.g., J.J. Ramsden, Nanotechnology and Gaia. *Nanotechnol. Perceptions* **10** (2014) 173–189.
[20] J. Salerno, Sensitivity in the world dynamics model. *Nature* (Lond.) **244** (1973) 488–492.
[21] F.E. Burke, Ignorance about limitations to growth. *Nature* (Lond.) **246** (1973) 226–230.
[22] P.M. Allen and M. Strathern. Complexity, stability and crises. In: *Complexity and Security* (eds J.J. Ramsden and P.J. Kervalishvili), pp. 71–92. Amsterdam: IOS Press (2008).

effect, the strategy is to bring the coefficients *r* and *f* in equation (4) into balance. In the most favourable case, one could even start to recharge the depleted resource stores of the planet. This is the argument of Sachs,[23] which appears to have the official sanction and support of the United Nations. "Sustainability science" has become an active field,[24] but criticized for its surprising detachment from established ecological principles.[25]

Costanza et al. advocate recognizing the proper value of ecosystem services as a first step in well managing them.[26] This would enable the diseconomies associated with economic growth to be properly accounted for, and was long ago advocated by Mishan.[27] As he points out, "a law recognizing this principle [of amenity rights] would have drastic effects on private enterprise". This phrase encapsulates both the simplicity of the solution required to bring *r* and *f* into balance (enacting a simple legal instrument) and the root of the opposition of Beckerman and others, which is little more than the laziness of some entrepreneurs. What is the use of technological progress if it is not used for beneficent ends? Presumably Weir, writing in 1886, had little doubt that a Brunel or a Stephenson would have done all they could to remedy any disamenities resulting from their work, and surely the profits from their enterprises were more than adequate to properly pay for any diseconomies. As it was, the magnificence of their creations and the grandeur of their vision sufficed to cover any disadvantages. But later, "the elevation of society was lost sight of in a feverish desire to acquire money. Beneficial undertakings had been proved profitable; and it was now assumed that a business, so long as it was profitable, did not require to be proved beneficial".[28] This attitude belies the likelihood that the required legislation will be effectively enacted. Of course, it could be argued that appropriate actions have been taken, starting with (in the UK) the Alkali Act of 1863 (not referred to by Weir), but the fact that environmental degradation has continued apace suggests that these measures have not been adequately effective. The abolition (in 2011) of the Royal Commission on Environmental Pollution, established in 1970, ostensibly as an economy measure, is indicative of the difficulties faced by the legislative approach, which limit the hopes that should be placed in the creation of international regulatory bodies, as advocated by the Ehrlichs.[1]

Besides, many assessments suggest that it is too late for remediation:[16] environmental degradation has reached a point at which it cannot be reversed by our present technological capabilities. Apart from more or less local problems, it is the vast scale of global warming[29] and the resulting climate change that present an unsurmountable challenge. The strenuous attempts currently being undertaken to limit global warming—whether or not it is anthropogenic—may at least delay the onset of real global catastrophe long enough to allow human ingenuity to find a solution. That is a hopeful message, and it implies that measures to arrest environmental

[23] J.D. Sachs, *The Age of Sustainable Development*. New York: University of Columbia Press (2015).
[24] J.J. Ramsden, What is sustainability? *Nanotechnol. Perceptions* **6** (2010) 179–195.
[25] J.R. Burger et al., The macroecology of sustainability. *PLoS Biology* **10** (2012) e1001345.
[26] R. Costanza et al., Changes in the global value of ecosystem services. *Global Environ. Change* **26** (2014) 152–158.
[27] E.J. Mishan, *The Costs of Economic Growth*, p. 72. London: Staples Press (1967).
[28] A. Weir, *The Historical Basis of Modern Europe*, p. 394. London: Swan Sonnenschein, Lowrey & Co. (1886).
[29] G.C. Holt and J.J. Ramsden, Introduction to global warming. In: *Complexity and Security* (eds J.J. Ramsden & P.J. Kervalishvili), pp. 147–184. Amsterdam: IOS Press (2008).

degradation (including global warming) should be accompanied by equally strenuous measures to foster innovation. The latter is emphatically not going to be achieved by setting up vast bureaucratic plans such as the "Horizon 2020" research and innovation framework programme of the European Union (EU). Every independent assessment of these programmes has shown that they actually inhibit innovation, partly by impoverishing the participating countries through the taxation that goes to pay for them and partly by the dampening effect of the bureaucratic controls on those that actually participate in them.[30] While property speculation and meretricious computer "apps" remain more attractive targets of investment than practical inventions and applications of scientific discoveries, the ability of mankind to innovate its way out of the impending crisis is stagnating. A way out of such a state of affairs, no less dangerous because of its apparent impalpability, can perhaps only be found by psychological means.

4. Culture

The collapse of large and complex empires has long intrigued mankind. Gibbon's *Decline and Fall* created a sensation when it was first published,[32] and Shelley's well-known *Ozymandias* reflects the awe inspired by the relics of past magnificence.[33] But Gibbon's work was, essentially a chronicle of events, to be sure with a commentary, yet leaving unexplained the ultimate question of why? A similar impotence accompanies Needham's even more monumental *Science and Civilization in China* (1954–2015, with volumes still being produced).[34] In the Orient, rise and decline seem to be taken for granted, as part of the natural order of things. Tuan has written about the "awareness that their [the Chinese] own civilization, however mediocre now, had its millennium of supremacy approximately between A.D. 300 and 1300. So why begrudge Westerners their millennium, dating from 1300? It is a matter of taking turns".[35] Writing in 1989, Tuan was recalling the mood in England around 1950. He was, perhaps, being overly generous regarding the duration of the Western millennium of supremacy.[36] In another

[30] Whether the bureaucratic approach is harmful or beneficent depends on the context. For example, Needham remarks that "between the fifth century B.C. and the 15th century A.D. Chinese bureaucratic feudalism was much more effective in the useful application of natural knowledge than the slave–owning classical cultures or the serf-based military aristocratic feudal system of Europe.[31]

[31] J. Needham, Science and China's influence on the world. In: *The Legacy of China* (ed. R. Dawson), p. 303. Oxford: Clarendon Press (1964).

[32] E. Gibbon, *The History of the Decline and Fall of the Roman Empire*. London: J. McGowan (1825) (originally written 1776–1788).

[33] The first paragraph of the last chapter of Gibbon's mighty work[32] concludes with "the public and private edifices, that were founded for eternity, lie prostrate, naked, and broken, like the limbs of a mighty giant; and the ruin is the more visible, from the stupendous relics that have survived the injuries of time and fortune."

[34] See the useful summary of the greater work in J. Needham, Science and China's influence on the world. In: *The Legacy of China* (ed. R. Dawson), pp. 234–308. Oxford: Clarendon Press (1964).

[35] Y.-F. Tuan, Cultural pluralism and technology. *Geogr. Rev.* **79** (1989) 269–279.

[36] And perhaps overly critical regarding his own? But China's economic growth only started to markedly increase in the early 1990s, and the really phenomenal growth only started in the early years of the present century. At the time of writing ref. 35, the Cultural Revolution (1966–1976) appeared to have permanently entrenched mediocrity (and worse) into the affairs of the nation. Hence it is perhaps not surprising that the recent economic growth appears to have been fuelled more by Western ideas than autochthonous ones, and many of the apparent achievements of the past two decades must rank as meretricious and transient rather than as solid and enduring.

monumental work, Spengler was in no doubt that the decline of the West had already set in,[37] and the furore that greeted—and continues to greet—that great work recalls the acute discomfiture that must have been felt by the listeners of Amos who, after cataloguing the transgressions of the various cities and nations around Israel, doubtless much to its self-satisfaction, then announced "for three transgressions of Israel, and for four …". Unlike the approach of the doomsayers outlined in §2, whom we might call "neophysiocrats", Spengler tackles what might be called the inner cultural decay of civilization. That is much harder to understand and unravel, let alone remedy, than material decline.[38]

Cultural decline has overall received less attention than material decline, perhaps because above all it is much harder to chart quantitatively. Something along the lines of counting the number of published documents and, separately, mathematical papers (as was attempted in ref. 39) constitutes, at best, a start of the task of finding a solution. It wholly neglects the quality of content; the modern equivalent of the "penny dreadful" contributes as much weight as an elegantly concise treatise on the nature of scientific explanation. Within science, however, all is not well; given the recent spate of retractions of scientific papers, one can see that sheer number may be very misleading indeed. Quality is, however, more difficult to measure than quantity. Perhaps the most tangible evidence of a decline in quality is the increasing fragmentation of intellectual work. Naturally a scientific paper a few pages long such as ref. 1 or 2 lacks the comprehensive coverage of a work like ref. 37, with more than a thousand pages. But even within the restricted aims of a paper like ref. 1 or 2 there are glaring omissions, which make the work easy to criticize and, correspondingly, diminish its impact.

With the aim of helping the management of collapse, Hadlock has compiled a book devoted to collapse.[40] It is far from comprehensive, however, and needs to be read in conjunction with a wider-ranging work, such as ref. 41. One notable omission is the Bak–Sneppen model of endogenously driven extinctions. Although a digital computer is needed to fully appreciate its significance, the model itself is simple enough to be categorized as "back-of-the-envelope": species are assigned random fitnesses and at each iteration the least fit species is removed (i.e., made to become extinct), along with its nearest neighbours *regardless of their fitnesses*; the extinct species are replaced by new, emergent ones with randomly assigned fitnesses.[42] The model demonstrates that internal interactions within an ecosystem can trigger avalanches of extinctions at irregular intervals (without suggesting that is actually what triggered them), without the operation of any effectively endogenous factors such as environmental pollution.

The last chapter of Spengler's work is entitled *Die Maschine*:[37] mechanization is perceived as the culmination of (European) cultural development. Through mechanization man sought to dominate nature (*die Welt nach seinem Willen* lenken [emphasis in the

---

[37] O. Spengler, *Der Untergang des Abendlandes*. Munich: dtv (1993); first published by C.H. Beck (1923).
[38] Material reasons for the decline of Rome have also been proposed, such as excessive consumption of pork, and lead poisoning, but have never been taken wholly seriously.
[39] J.J. Ramsden, Maintaining national ascendancy. *Nanotechnol. Perceptions* **11** (2015) 75–87.
[40] C.R. Hadlock, *Six Sources of Collapse*. Washington, DC: Mathematical Association of America (2012).
[41] J.J. Ramsden and P.J. Kervalishvili (eds), *Complexity and Security*. Amsterdam: IOS Press (2008).
[42] P. Bak and K. Sneppen, Punctuated equilibrium and criticality in a simple model of evolution. *Phys. Rev. Lett.* **71** (1993) 4083–4086.

original]).[43] This is rightly perceived as a European phenomenon; Feng Yu-lan wrote "The Chinese philosophers had no need of scientific certainty because it was themselves that they wished to know; so in the same way they had no need of the power of science, because it was themselves that they wished to conquer. To them, the content of wisdom was not intellectual knowledge, and its function was not to increase external goods".[45]

It is, of course, mechanization that has given mankind the power to alter nature, and vastly increase his population. While it is true that the Roman hegemony mainly sought to plunder conquered lands and bring the spoils back to Rome, with little thought of sustainability,[37] the ability of the Romans to alter nature was extremely limited and, indeed, it was not even their aim. The invention of the steam engine was the decisive moment in history—European, but eventually it conquered the rest of the world and even contemporary China is subservient to it—after which man and machine were locked into a relationship that might be called self-dependent and mutual slavery. That invention is the point of history at which world population and world GDP begin their abrupt (on a linear scale) increase.[47]

In summary, man's cultural development led to the machine, inseparably coupled to the idea of domination over nature, which has enabled the despoilation of nature lamented in §2.[48]

5. Remedies for (cultural) decline

The most optimistic viewpoint is that we shall develop appropriate new technologies in a timely fashion to avert catastrophic decline.[51] The dilemma presented by the realization summarized at the end of §4 is that one cannot possibly remedy the despoilation that has its root in technology by applying yet more technology.[52] In principle, indeed, it might be physically possible to

---

43 See also ref. 44.

44 O. Spengler, *Der Mensch und die Technik*. Munich: C.H. Beck (1931).

45 Quoted by Needham.[46]

46 J. Needham, Science and China's influence on the world. In: *The Legacy of China* (ed. R. Dawson), p. 301. Oxford: Clarendon Press (1964).

47 See, e.g., Fig. 10.2 in ref. 29.

48 Lest there be any doubt about the reality of the predatory attitude of man towards nature, Blackbourn has undertaken a comprehensive and dispassionate survey of "improvements" in Germany,[49] including the great "correction" of the Rhine by Tulla and his successors. Although there was a great deal of approbation for these works, it was by no means unanimous. Uhlmann was a noted critic,[50] well aware that "every such [human victory over nature] revenges itself on us" (actually a quotation from Engels, presumably included because of the political orientation of the Germany in which Uhlmann worked). The greater the work, the greater the revenge: this was certainly true in the case of the Rhine—the disappearance of Rhine gold, the collapse of the fishing industry (also due to pollution), flooding due to the loss of floodplains and riparian forest, general ecological degradation (species loss and so forth), scouring the riverbed, lowering the water table—most of these being wholly unexpected consequences.[22]

49 D. Blackbourn, *The Conquest of Nature*. New York: W.W. Norton & Co. (2006).

50 D. Uhlmann, Künstliche Oekosysteme. *Abh. Sächs. Akad. Wiss. Leipzig, Math.-nat. Klasse* **54** (1980) Heft 3.

51 There is an even more optimistic viewpoint—we might call it superoptimistic—which denies that there is any problem with the environment, that nature can adapt to changing circumstances, and that we can therefore continue to promote economic growth indefinitely (cf. ref. 9).

52 Advocating solving the problems of economic growth by promoting yet more growth would be a similar fallacy.

restore nature to a pristine state by applying nanotechnology, the apotheosis of advanced technology.[19] The problem is that any technology is, ultimately, directed towards dominating nature;[37, 44] hence, even if there are local patches of remediation, overall degradation must proceed as inexorably as the global increase of entropy in any system.

An additional difficulty of salvation by science is the fact that as enslavement by machine progresses, man's capacity for independent thought and, hence, path-breaking innovation must inevitably decline. This was already perceived aeons ago: a pupil of Confucius saw a gardener who, to get water for his flower-beds, repeatedly went down to the spring with his bucket. So he asked him whether he would not like to lessen his labour. "How can I?" replied the other. "You take a long piece of wood for a lever," said Confucius' pupil, "weighted behind, but light in front; with this you dip for the water and it comes up without the least trouble. They call this device a draw-well." But the gardener, who was something of a philosopher, answered: "I have heard my teachers say: 'If a man uses machines, he carries on all the affairs of life like a machine; whoever carries on his affairs like a machine gets a machine-like heart; and when anyone has a machine-like heart in his breast, he loses true simplicity".[53] Mishan also points out that "If machines are becoming like men, men are no less determined to become like machines in the most literal sense".[55]

The pragmatic viewpoint is that any measures to alleviate environmental degradation will at least buy humanity the time likely to be required for developing technologies powerful enough to avert catastrophe. Some measures that fall into this category are already being implemented—such as the carbon cap-and-trade schemes operating in several regions around the world. They mostly seem to be far too mild to have any significant impact on the problems—but perhaps if they were more severe, they would not be accepted by those to whom they should apply.

The pessimistic viewpoint is that the degradation—including global warming—has already proceeded so far that remediation—indeed any action—is futile, hence we might as well continue with whatever we have been doing, and let matters take their course. Opinions diverge regarding what will happen when catastrophe occurs; or, in other words, how will we recognize that catastrophe is upon us? Most of the doomsayers are not at all explicit on this point, namely, what will actually happen? Possibly this coyness arises because, whatever it is, it will be too awful to contemplate. The biggest unknown is whether a kind of mass extinction of humankind (in which, let us say, at least 90% of the present population will disappear) is compatible with the continued existence of the remainder under conditions very similar to those prevailing today, or whether the event will drive all survivors back to an earlier epoch, possibly one as primitive as the Stone Age.

According to an even more pessimistic viewpoint—let us call it subpessimistic—all higher forms of life will be eliminated, humans included, leaving little more than bacteria still alive on the planet. The fate of the passenger pigeon in North America should serve as a warning of how suddenly and completely catastrophe can strike.

---

[53] Quoted by Schweitzer in ref. 54, p. 268.
[54] A. Schweitzer, *Civilization and Ethics*, 3rd edn. London: Adam & Charles Black (1949).
[55] Ref. 27, p. 147.

6. Cycles in history

The manifestly periodical nature of many natural phenomena, such as daylight, the phases of the moon and the passage of the seasons, doubtless served as a model for the idea that human history, too, is cyclic in nature. There is ample empirical evidence for the idea—the thousands of years of recorded Chinese history display a remarkably consistent pattern of the founding of a new dynasty, consolidation, blossoming and zenith followed by decline and disorder. This constitutes one cycle. If time is plotted horizontally and the degree of civilization vertically, we would have something looking like a sine wave. This pattern was written about rather extensively by ibn Khaldun.[56] He introduced the concept of *asabiya* (group feeling) as the parameter characterizing the course of events (asabiya would be closely correlated with "degree of civilization").

The notion of man as predator and nature as prey[44] implies that we could model their codependence in the fashion of Lotka and Volterra.[57–59] Keeping the notation of §2, the Lotka–Volterra model is encapsulated in two equations:

$$\mathrm{d}F/\mathrm{d}t = F(f - c\,N) \tag{6}$$

and

$$\mathrm{d}N/\mathrm{d}t = N(b\,c\,F - d) \tag{7}$$

where F now quantifies not just food but all of nature (which, ultimately, serves to provide food for mankind, of course), b is the efficiency of conversion of nature into man and c is the "efficiency of predation"—how effective man is at destroying nature, and d is man's death rate. This system of equations has an oscillating solution,[58] tracing out a wavelike progression with time, with the peaks and troughs of F and N phase-shifted with respect to each other. N could be interpreted as the product of population and degree of civilization (or *asabiya*) rather than simply as population. Although these equations obviously ignore countless details, much as Newton's law of gravity ignores countless topographical details of the planets of the solar system, in essence it provides a straightforward explanation of historical cycles that is hard to refute, much as the prediction of planetary motions based on Newton's laws gives highly satisfactory results. The puzzle is perhaps only why no previous civilization has ever succeeded in remaining at its zenith; the basic structure of equations (6) and (7) appears to be too strong to be interfered with.

Curiously, most of the mainstream effort in the field of population dynamics has focused on mathematical refinement of equations (6) and (7),[59] rather than carefully examining how the symbols should be interpreted. Clearly even equations (6) and (7) have a wide range of applicability. For example, a rather local application would be to tourism: tourists prey on a

---

[56] Abd Ar Rahman bin Muhammed ibn Khaldun, *The Muqaddimah*. Cairo: (ed.) Muhammad Tawit at-Tanji (1370).

[57] A.J. Lotka, Analytical note on certain rhythmic relations in organic systems. *Proc. Natl Acad. Sci. USA* **6** (1920) 410–415.

[58] N.S. Goel, S.C. Maitra and E.W. Montroll, On the Volterra and other nonlinear models of interacting populations. *Rev. Mod. Phys.* **43** (1971) 231–276.

[59] M. Iannelli and A. Pugliese, *An Introduction to Mathematical Population Dynamics*. Springer (2014).

tourist spot, which becomes developed, despoiled and unattractive and later on, like the ruins of Rome, becomes again attractive. And there is surely a great deal to be done regarding the interpretation of *t*. Ibn Khaldun thought that it was counted in generations;[56] other interpretations are perhaps also possible.

7. Conclusions

The weight of evidence pointing to environmental degradation is too great to be dismissed. Its origin is the development of machinery, with which man's powers are enormously amplified. With the goal of dominating nature—in other words, exploiting it for man's ends—the use of machines, and technology in general, can never be truly benign towards nature. It follows that only complete renunciation of machinery would allow nature to be restored.

But such renunciation would be a denial of man's predatory nature and cannot, therefore, be truly contemplated. Hence it would appear that man has no real choice but to continue headlong along his present path. Perhaps Kurzweil's "singularity" offers a glimmer of hope: thereafter humans become redundant but their spirit lives on in the machines they have created.

It is entirely within the spirit of this destiny that meanwhile economic growth should continue, with scant regard for "sustainability", which will not make very much difference anyway.[60] Is there really no other way? Spengler concludes his essay[44] with the image of the Roman soldier who died on guard duty in front of one of the gates of Pompeii, because no one released him from his duty when Vesuvius erupted. Thus should we be, continuing true to the nature of what we have become until the inevitable catastrophe.

Well before the collapse of the Roman Empire, contemporary authors such as Tacitus were voicing their concerns about the direction in which society was moving. Collapse was not averted, and we cannot determine whether it was even delayed as a result of some attention having been paid to such critics. Mishan[27] has adumbrated the essence of a growth-free economic policy that might restore humanity to humankind and recreate civilization.[62] Schweitzer goes further,[54] and writes with the explicit aim of bringing about a "new temper of mind" as the only way of preventing the ruin of mankind, and avers that "this revolution will come about, if only we can make up our minds to become thinking men." At least with that idea we have the possibility of an alternative path to follow. It may not be able to prevent catastrophe, but will serve as a guide through a painful transition period.

Appendix

Apart from catastrophe driven by population growth and environmental degradation (including resource depletion), a few other scenarios could also bring our existence on Earth to an end. One is the detonation of a large proportion of the thousands of nuclear warheads kept in military arsenals. This eventuality and its consequences have been extensively discussed elsewhere and will not be further elaborated upon here. Another possibility is a collision between the Earth and

---

[60] A recent report on the future development of the United Kingdom[61] is full of references to economic growth, without even the merest hint that any other path is worthy of consideration.

[61] *EU Membership and the Bank of England*. London: Bank of England (2015).

[62] In contrast to "Die Zivilisation ist selbst eine Maschine geworden".[44]

a large cosmic body. The most concrete realization of this eventuality appears to be the possible impact of the comet Swift-Tuttle in the year 2126.[63]

Eschatology is an important part of a number of religions, perhaps most notably Christianity. Schweitzer[54] has pointed out how the early emphasis on the presumed fast-approaching end of the world was transformed into a life-affirming viewpoint fully aligned with the developing ethos of society in Europe that culminated in the Industrial Revolution and its sequels. Contemporary Christian churches therefore tend to align themselves with the promotion of "sustainability" as the means to prolong the present order indefinitely.

The difficulty faced by Christianity, with its firm belief in a "second coming" (of Christ), and likewise by movements such as Marxism, with its "inevitable" proletarian revolution, is how to attract acolytes and motivate them to action? If the culminating event is indeed inevitable, what need is there to do anything in particular? Quite a lot of Paul's exhortations to the various young churches in the eastern Mediterranean region deal with this problem, admonishing Christians not to be passive.[64] Marx rather neatly solved the problem by proposing that it was important to "consciously participate in the historical revolutionary process of society which is taking place before our very eyes";[65] this "conscious participation" was the key role to play, rather than seemingly purposefully working towards the revolution as a definite goal. The difference is, perhaps, a subtle one, but at any rate it was clear that any kind of obstruction was bad. And by conscious participation one could hasten the revolution.[66]

Eschatology, in whatever form, excludes the cyclical notion of history (§6). What is the practical implication of accepting the latter? It would seem reasonable to attempt to prolong the zenith for as long as possible, but once decline has begun, there may be no way back. It would, therefore, be rational to accelerate the decline, on the premiss that this will equally accelerate the rebirth. That is, perhaps, rather a big assumption: the slowness or rapidity of the decline may well leave traces in the intervening chaotic interval that might affect the quality of the rebirth. At the very least, however, one should strive to ensure that as much as possible of mankind's intellectual legacy in its enormously multifarious forms is preserved for the future. Hence, for example, efforts to preserve some of the obscure languages that are fast dying out seem to be highly laudable.

---

[63] B.G. Marsden, *Periodic Comet Swift-Tuttle* (circular no 5636). Cambridge (Mass.): Central Bureau for Astronomical Telegrams, International Astronomical Union (1992).

[64] E.g., the epistles to the Thessalonians.

[65] R.C. Tucker, *Philosophy and Myth in Karl Marx* (2nd edn). Cambridge: University Press (1972).

[66] "Force is the midwife of every old society pregnant with the new one" (*Das Kapital*, vol. 3, ch. 31).[67] Marx might equally well have said that it is the lubricant, except that the tribological metaphor is perhaps less picturesque than the obstetrical one.

[67] R.C. Tucker, *The Marx–Engels Reader* (2nd edn), p. 436. New York: W.W. Norton & Co. (1978).