1. Four ideas that will not change the world (Steinberg, 2015, pp. 215-219)

- **Misperception 1: technological breakthroughs and scientific advances happen by themselves.** Discoveries are not self-propelled: they occur in a social context. Political decisions are a fundamental force in scientific and technological discoveries and innovations.

- **Misperception 2: a society growing reacher automatically improves its environmental conditions.** The environmental Kuznets curve (EKC, the conjecture that economic growth initially harms the environment and afterwards improves it) does not hold for all pollutants. Urban waste treatment seems to be consistent with the EKC, but carbon dioxide emissions or biodiversity loss do not. Even when EKC holds, it may be just a spurious correlation: some factor simultaneously contributes to economic growth and environmental quality.

- **Misperception 3: a good strategy to solve environmental problems is to let markets operate freely (without environmental regulations).** Markets will not save the planet. Environmental quality and sustainability are both public goods and unregulated markets are inadequate institutions to provide public goods (private agents underinvest in such goods).

- **Misperception 4: individual decisions and local, isolated initiatives are sufficient to solve global problems.** Working in isolation (like recycling alone) is not powerful enough to address the bigger issues. It is only through active engagement in politics that major improvements in environmental quality will be achieved. This misperception is an instance of the fallacy of composition: what is true or works at some scale, is also true or works at a larger scale. Big environmental problems require an adequate match: to think big and change rules. Installing solar panels at home is a move in the right direction but environmental legislation has the scope for inducing real change.

Steinberg, Paul F. (2015): Who rules the Earth? How social rules shape our planet and our lives, Oxford University Press, Oxford.

2. The mineral resource crisis (Kesler and Simon, 2015)

- **Mineral dependence.** Advanced societies depend crucially on the consumption of mineral resources (metals, fossil fuels, mineral fertilizers). The global footprint of a smartphone: uses more than 40 elements (aluminum, potassium, and silicon for the screen; carbon, cobalt, and lithium for the batteries; indium and tin to conduct electricity in the touch screen; nickel for the microphone; lead and tin, solders; antimony, arsenic, boron, phosphorus, and silicon in semiconductors and chips; oil for the plastic housing; bromine in the plastic forfire retardation; copper, gold, and silver in the wiring; tantalum for the capacitors; the rare-earth elements gadolinium, neodymium, and praseodymium for the magnet, neodymium, dysprosium, and terbium to reduce vibration, and dysprosium, gadolinium, europium, lanthanum, terbium, praseodymium, and yttrium to produce colors); these elements are produced in distant places (almost 90% of the rare earths are mined in China, lithium in Chile, cobalt in the Democratic Republic of Congo, aluminum in Australia, phosphorus in Morocco, nickel in Canada); in 2015, nearly 5 billion people owned a mobile phone.

- **Current threats to the mineral supplies: growing demand.** With China and India being the largest consumers of mineral resources, it might be that mineral will be exhausted sooner than expected (China, representing 20% of world population, consumes 49% of world coal, 46% of world steel, 43% of world aluminum, 34% of world copper, and 11% of world oil). With growing population, a growing mineral consumption is needed to maintain per capita production.

- **Current threats to the mineral supplies: environmental costs.** Extraction and consumption of mineral resources have increased pollution and environmental degradation/destruction (global warming, acid rain, destruction of the ozone layer, pollution of groundwater).

- **Responses to the threats.** (1) Decrease mineral consumption and increases recycling and conservation. (2) Invest more in exploration to find new sources/resources and in new extraction techniques.

Kesler, Stephen E.; Adam Simon (2015): Mineral resources, economics and the environment, Cambridge University Press, Cambridge, UK.

3. Limits to growth (Meadows et al., 2005)

- **Increasing cost of sustaining growth.** An expanding population combined with an increasing accumulation of physical capital requires more resources to be diverted to cope with global ecological constraints (depletable natural resources and limited absorption capacity of emissions). This will eventually restrain the capacity of expanding production and the sustainability of economic growth.

- **Scenarios.** The inability to continuosuly sustain an expansion of production will cause a population contraction. (1) The end of growth take the form of a collapse (rapid decline in output, population, health and an increase in conflict, inequality, ecological devastation following a growth overshoot). (2) It may take the form of a smooth adaptation to the Earth's support capacity (through some corrective action).

- **The big question.** Has humanity already overshot the Earth's carrying capacity (surpassed the global ecological constraints?).

- **Evidence of soft landing or apparent success in attaining sustainable growth?** During the last decades: new technologies to lower pollution have been developed, consumers have adapted habits, international agreements have been signed, new institutions have emerged, higher income levels have reduced population growth, more widespread awareness of environmental problems… humanity already overshot the Earth's carrying capacity.

- **The global challenge.** A sustainable world economy demands that the poorer countries reach higher consumption levels. This transition will have to be accompanied with technological, social and political changes consistent with long run goals. Those changes will need decades, but meanwhile the ecological footprints of humanity becomes bigger.

- **Three outlooks.** (1) Optimism: with adequate information, people will choose the right solution (global solutions to avert overshoot or, at least, collapse). (2) Cynicism: people will not stop responding to just short term goals and will not sacrifice current welfare levels to benefit future generations (reality will be ignored). (3) Middle road: lessons will be learned the hard way (a sustainable path will be reached, and collapse averted, only after having suffered global crises resulting from inaction or insufficient responses, but at the price of exhausting resources, losing attractive options, suffering more inequality and tolerating more conflict).

Meadows, Donella; Jorgen Randers; Dennis Meadows (2005): Limits to growth: The 30-year update, Earthscan, London.

4. People is the ultimate resource (Simon, 1996)

- **More people, good.** "Adding more people to any community causes problems, but people are also the means to solve these problems. The main fuel to speed the world's progress is our stock of knowledge, and the brake is our lack of imagination. The ultimate resource is people —skilled, spirited, hopeful people— who will exert their wills and imaginations for their own benefit as well as in a spirit of faith and social concern. Inevitably they will benefit not only themselves but the poor and the rest of us as well." Having more people creates more problems but people are the means to solve them.

- **Natural resources.** "…our supplies of natural resources are not finite in any economic sense. Nor does past experience give reason to expect natural resources to become more scarce. Rather, if history is any guide, natural resources will progressively become less costly, hence less scarce, and will constitute a smaller proportion of our expenses in future years." The same conclusion is said to apply to energy: more people will speed the development of cheap energy supplies.

- **Doomsters.** "The doomsters reply that because there are more of us, we are eroding the basis of existence, and rendering more likely a 'crash' due to population 'overshoot'; that is, they say that our present or greater numbers are not sustainable. But the signs of incipient catastrophe are absent. Length of life and health are increasing, supplies of food and other natural resources are becoming ever more abundant, and pollutants in our environment are decreasing."

- **The world's problem.** "The world's problem is not too many people, but lack of political and economic freedom. Powerful evidence comes from pairs of countries that had the same culture and history and much the same standard of living when they split apan after World War II —East and West Germany, North and South Korea, Taiwan and China."

- **Simon's view: there are no limits.** "In the short run, all resources are limited. An example of such a finite resource is the amount of attention that you will devote to what I write. The longer run, however, is a different story. The standard of living has risen along with the size of the world's population since the beginning of recorded time. There is no convincing economic reason why these trends toward a better life should not continue indefinitely."

- **The economic mechanism behind the bright future: the dynamics that has worked in the past projected in the future *ad infinitum* (what has happened is not a fortuitous chain of circumstances).** "Greater consumption due to an increase in population and growth of income heightens scarcity and induces price run-ups. A higher price represents an opportunity that leads inventors and business people to seek new ways to satisfy the shortages. Some fail, at cost to themselves. A few succeed, and the final result is that we end up better off than if the original shortage problems had never arisen. (…) The most important benefit of population size and growth is the increase it brings to the stock of useful knowledge. (…) Progress is limited largely by the availability of trained workers. In the long run the basic forces influencing the state of humanity and its progress are (a) the number of people who are alive to consume, but also to produce goods and knowledge; and (b) the level of wealth. Those are the great variables which control the advance of civilization."

- **What is new.** What differentiates our age from previous ages is the fall in mortality and the rise of life expectation. What is common is the desire for improvement, the continuous search for betterment. To achieve this, complacency must be avoided: improvement needs effort.

Simon, Julian Lincoln (1996): The ultimate resource 2, Princeton University Press, Princeton, NJ.

5. The technological bluff (Ellul, 1989)

- **Opposition between people and machines.** People adapt badly to modern techniques: people do not adapt to machines nor machines to people. There is a permanent maladaptation between the social and the technical world. Societies evolve slowly; techniques and machines evolve quickly. Societies rely on the past (habits, traditions, rules, conventions); technologies look at the future.

- **The great technical innovation.** The eventual integration of the social into the technical world, from which a new humanity will emerge.

- **Technolatry.** Ellul views Simon's overoptimistic claims as pseudoscientific absurdities: Simon just projects tendencies (without justifying on which grounds the projection is legitimate) and simply presumes that every discovery/invention will have beneficial effects (masquerading inconvenient phenomena for his theses, like the simultaneity of rural depopulation and urban overpopulation). What is good in a computer virus?

- **Rise of the technocrats.** "The technocrats have a strange blindness to the complex reality of the world and to the lessons of common sense (e.g., that no system can grow indefinitely in a closed and finite universe, a truth that they treat sarcastically). Their great knowledge and narrow specialization prevent them from understanding questions outside their field. Yet they write authoritatively about tomorrow's world (…) They are thus plunged into electronics and computers without a thought that perhaps in the future being able to till a bit of ground or light a wood fire or do proper grooming might be more useful than being able to tap on a keyboard. Such is their casual ignorance of most of what constitutes our world (…) They immediately retort that what opponents want is a return to the Middle Ages. As they see it, there has to be growth. They will not accept any other hypothesis. They find their justification in the fact that increasingly everything depends on the application of techniques. Not only is technique good, not only is it indispensable, but also (…) it alone can also achieve all that human beings have been seeking throughout the centuries: liberty, democracy, justice, happiness (by a high standard of living), reduction of work, etc. "

- **Technology is ambivalent.** Technique and technology are not neutral: they may have good and bad effects. For technological optimists, technology is globally good. Technology's ambivalence is captured by for theses:
  (1) all technical progress has its price (creation involves destruction, frequently people's lives: no progress is free from shadows);
  (2) at each stage it raises more and greater problems than it solves (law that problems grow with the growth of techniques);
  (3) its harmful effects are inseparable from its beneficial effects (cars generate congestion; more and cheaper food available, obesity): favourable effects tend to be apparent in the short-term (and be concrete and clearly identifiable), whereas the negative effects tend to become evident is the long run (and are perhaps diffuse and abstract);
  (4) apart from the desired and the foreseen, it has a great number of unforeseen effects (surgical interventions replace one infirmity by another; cultivation impoverishes the soil; unexpected harmful effects of DDT; accidents of new technologies).

- **Technology is essentially unpredictable.** Technical change is not teleological: it has no goal. There is no predetermined destination for technical change: it is errhatic. Therefore, it is unpredictable (and that makes social evolution also unpredictable).

- **The paradox of Harvey Brooks.** The costs and risk of a new technology are usually assumed by a small fraction of the population, while its advantages tend to be widespread.

Ellul, Jacques (1989): The technological bluff

6. The Seneca effect (Bardi, 2017)

- **The Seneca effect.** "Increases are of sluggish growth, but the way to ruin is rapid." (*Nunc incrementa lente exeunt, festinatur in damnum*, Lucius Anneaus Seneca, Letters to Lucilius 91, 6.)

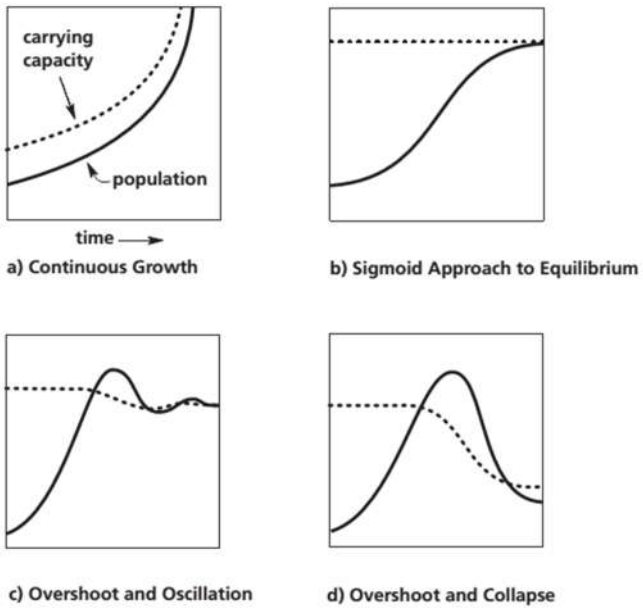
- **Taxonomy of collapses.** (1) **Black elephants** (Donald Rumsfeld's 'known unknowns'). You choose to ignore (or understimate the effects of) an elephant that you know is in the room (a pyramid scheme). (2) **Gray swans**. A specific occurrence of this kind of event cannot be predicted but its frequency can be determined (so precautions against it could be taken: earthquakes). (3) **Dragon Kings**. They are outliers of a distribution in terms of their large size (the size of Paris in comparison with the rest of French cities). Though their existence is conceivable on the basis of some trend, they are largely unpredictable and no precaution against them is in practice feasible. (4) **Black swans** (Donald Rumsfeld's 'unknown unknowns'). They lie outside the distribution: they are absolutely unpredictable (financial crashes, massive terrorist attacks) and are then capable of generating the biggest collapses.

- **Tiffany's fallacy.** Existence of resources cannot be equated to having them: to actually get known resources one must invest other resources to locate, reach, extract, process and transport them (in the 1961 movie *Breakfast at Tiffany's* the female leading character enjoyed having breakfast while looking at jewels on display behind a glass, but that is not the same thing as possessing the jewels).

7. Dynamics of World3 (Meadows et al., 2005, ch. 4)

- **World3.** World3 is a model of the world economy by Meadows et al. (2005) "to understand the broad sweep of the future": the ways in which the world economy will interact with the Earth's carrying capacity over many decades.

- **Ways to approach the carrying capacity.** Continuous growth, convergence to the carrying capacity from below, overshoot with cyclical convergence and overshoot followed with collapse (see the chart on the right). The authors believe that the world economy is already above the Earth's carrying capacity (overshoot).



- **Feedback loops.** Figs. 1 and 2 below show the feedback relationships regulation population growth and capital accumulation. Fig. 1 displays the connection between population and capital that goes through agriculture; Fig. 2, the one that goes through resources and services.

- **Scenario 1.** In Scenario 1 (see Fig. 3) the computer model World3 is run with parameter values that represent the continuation of the path the world economy followed during the 20th century. Population and production increase until the resource limit is reached. The impossibility of maintaining resource flows lead to a fall in output and life expectancy and a rise in death rates.

- **Scenario 6.** In Scenario 2 (see Fig. 4) the economy develops simultaneously (costly) technologies for pollution abatement, land yield enhancement, land protection, and conservation of nonrenewable resources. Full implementation of these technologies takes two decades but in the end the economy is relatively large and prosperous (though below the top level ever reached).

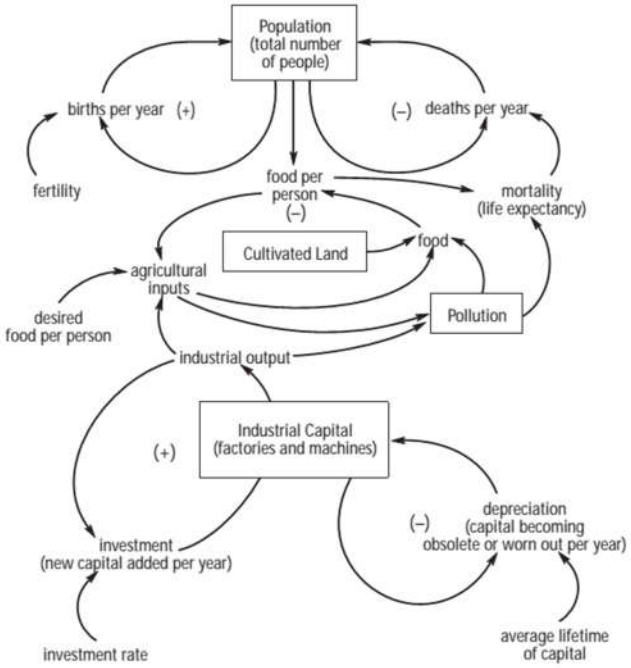


Fig. 1. Feedback Loops of Population, Capital, Agriculture, and Pollution (Meadows et al., 2005, p.144)

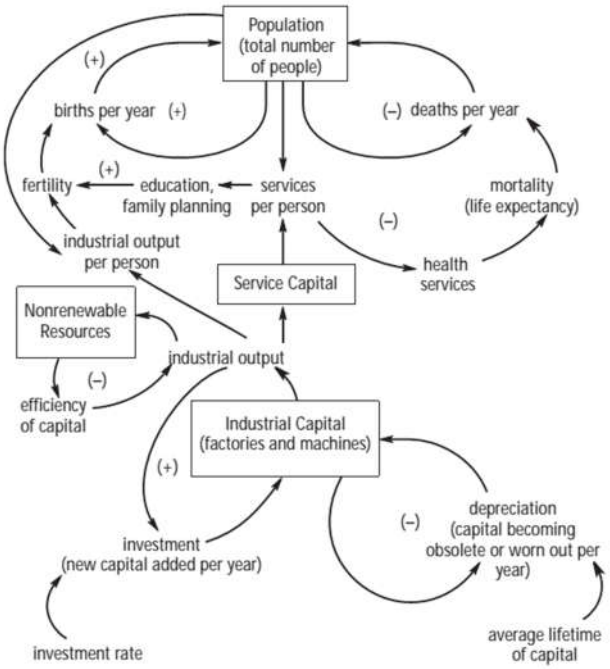


Fig. 2. Feedback Loops of Population, Capital, Services, and Resources (Meadows et al., 2005, p.145)

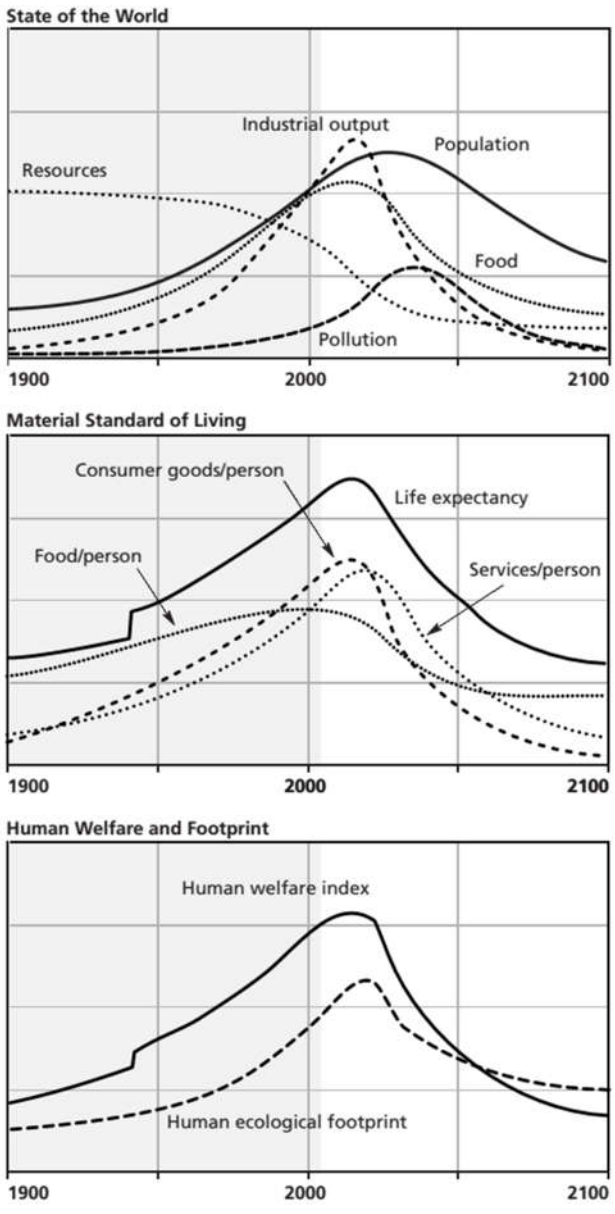


Fig. 3. Scenario 1 of World3 (Meadows et al., 2005, p.169)

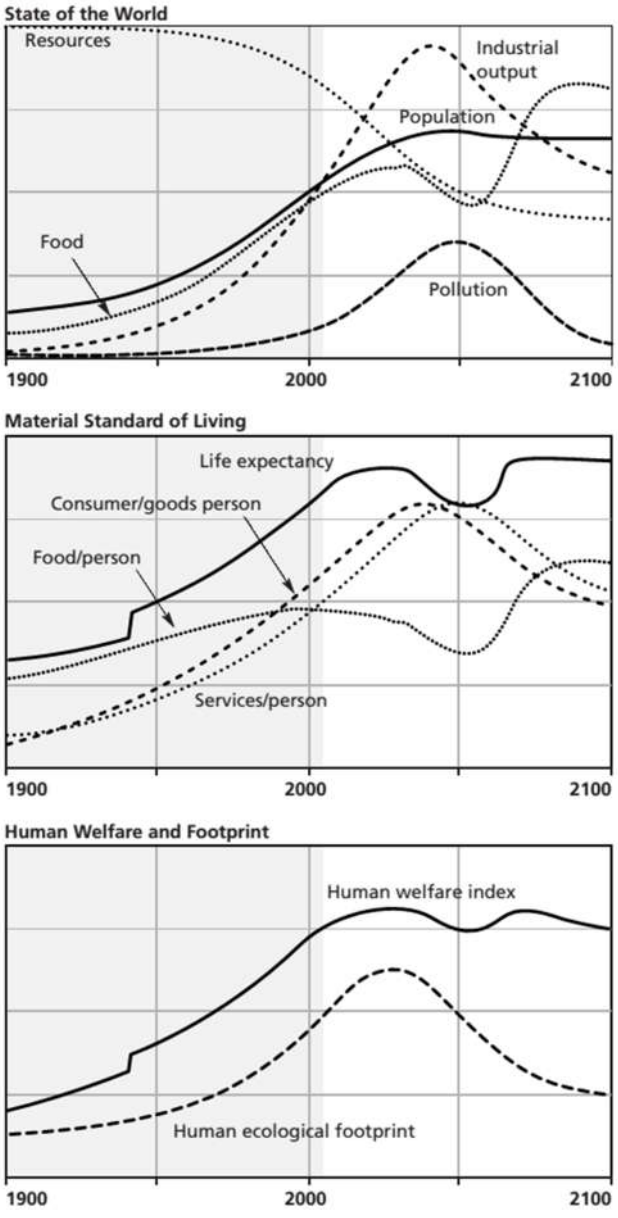


Fig. 4. Scenario 6 of World3 (Meadows et al., 2005, p.219)