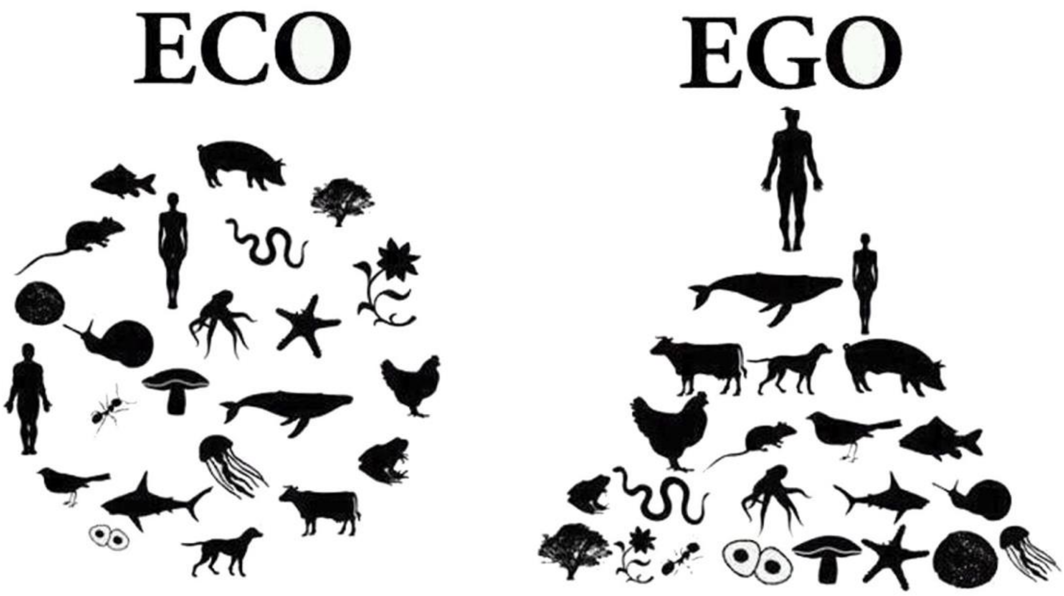
Abstract

One of most interesting concepts of our modernity belongs to the ecology - considering the scenario where we are, and the crisis not only economic that we live. The ecology is often a discipline among the others, following an anthropocentric vision where the Mankind is, more or less consciously, on the top respect to all the others species, and overall quite out of the ecosystem.

The fundamental value of the ecosystem for the life is at least underestimated or leave to the tv documentaries, in which often the main argument is the risk of extinction of some kind of animal; some fragile ecosystem and so on – in any case: far from our everyday life.

In last two centuries, the Mankind have deeply modified the life environment - and this happens with an intensity so high that the scientists (ecologists, anthropologists and so on) have named this period Anthropocene, a pretentious name probably for the shortest era in the history of our planet.

The concept is much simple as "revolutionary" and deep in its visual representation:



This picture shows what Guido Della Casa has called "deep ecology" … , in contrast with the concept of "superficial ecology" that is still, like a silent background, at the basis to the book "Limits To Growth"(however fundamental), commissioned, at early '70 in the last century, by Aurelio Peccei.

A study in which the role of Mankind was at the top of the evolutionary chain, both to the capacity of determine the own destiny (and for the others species), and for the vision, that is still now, anthropocentric. A vision to forget, if we want have more possibilities of surviving on the planet.

Far from (the sense of) equilibrium: some cognitive aspects of our way of life in the present era

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1. Fast and faster

One of the most relevant aspects of our society is the tendency to grow up in terms of capacity and speediness (we have constantly under the eyes faster and bigger cars than thirty-forty years ago). Generally speaking, our society requires constantly a surplus of energy to perform jobs faster than before.

The professor Ugo Bardi, associate-professor of Chemistry at the University of Florence, uses a kind of paradigm to show his students this phenomenon: the higher will be the intensity in use of energy, the faster our society will fall down.

In particular, Bardi has used a famous sentence that comes from the ancient philosopher Lucio Anneo Seneca: «It would be some consolation for the feebleness of ourselves and our works if all things should perish as slowly as they come into being; but as it is, increases are of sluggish growth, but the way to ruin is rapid»[1].

Useful cases, in both animal and human populations, show this: in the next paragraph, we will suggest a linguistic analysis about a best seller like *Collapse*[2].

1.1 Words to express the nature of the cliff

Jared Diamond, famous for his previous book[3], in *Collapse* has analyzed the way in which ancient populations – often in uncertain balance with the environment – have faced the question of their survival and in which cases their strategies have been successful or not.

The *leitmotiv* of the decline is the same of the growth: "fast" and "rapid". In particular, from the beginning: «Writers find it tempting to draw analogies between those trajectories of human societies and the trajectories of individual human lives—to talk about a society's birth, growth, peak, senescence, and death—and to assume that the long period of senescence that most of us traverse between our peak years and our deaths also applies to societies. But that metaphor proves erroneous for many past societies (and for the modern Soviet Union): they **declined rapidly** after reaching peak numbers and power, and those rapid declines must have come as a surprise and shock to their citizens»[4].

And talking about events happened on the Easter Island, he writes: «Around 1680, at the time of the military coup, rival clans switched from erecting increasingly large statues to throwing down one another's statues by toppling a statue forwards onto a slab placed so that the statue would fall on the slab and break. Thus, as we shall also see for the Anasazi and Maya […], **the collapse of Easter society followed swiftly** upon the society's reaching its peak of population, monument construction, and environmental impact»[5].

Again, through the book, when he writes about the Anazasi population: «That should make us modern Americans hesitate to be too confident yet about the sustainability of our First World economy, **especially when we reflect how quickly Chaco society collapsed** after its peak in the decade a.d. 1110-1120, and how implausible the risk of collapse would have seemed to Chacoans of that decade»[6].We don't give here extra examples but it is relevant to underline that Diamond cannot avoid an explicit parallelism with our society:«Like Easter Island chiefs erecting ever larger statues, eventually crowned by pukao, and like Anasazi elite treating themselves to necklaces of 2,000 turquoise beads, Maya kings sought to outdo each other with more and more impressive temples, covered with thicker and thicker plaster – reminiscent in turn of the extravagant conspic-

[1] Lucius Annaeus Seneca, *Letters to Lucilius*, n. 91. The complete description of this paradigm, called *The Seneca Cliff*, can be found online at: http://thesenecatrap.blogspot.it/2015/11/the-seneca-effect-why-decline-is-faster.html (all links are checked on July, 30th, 2017).

[2] Diamond (2005).

[3] Diamond (1997).

[4] Diamond (2005), p. 6. Bold mine.

[5] *Ibid.*, p. 110. Bold mine.

[6] *Ibid.*, p. 155. Bold mine.

uous consumption by modern American CEOs. The passivity of Easter chiefs and Maya kings in the face of the real big threats to their societies completes our list of disquieting parallels»[7].

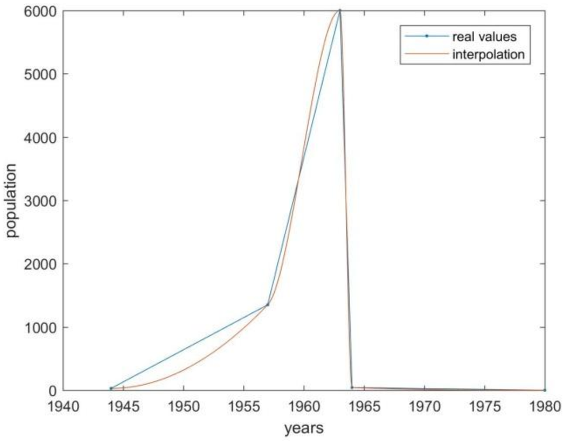
In nature, societies of animals normally find a balance with the environment (1) for the normal prey-predator dynamics[8], or (2) for the particular hard condition of the environment itself. However, in some (not properly natural) cases, it is possible to find out that, without natural boundaries (weather conditions and prey-predator dynamics), the populations grow up until the limit of carrying capacity of the ecosystem, like the history of the reindeer in St. Matthew Island's suggests us.

1.2 The reindeer of St. Matthew Island

Some scientist uses the analogy between Mankind and what happened in this remote angle of the world since 1944. Almost at the end of WWII, the US Coast Guard colonized the St. Matthew Island for a logistic reason. This Island – in the middle of the Bering Sea – before 1944 was deserted. Technicians and soldiers arrived to install a device useful for the navigation of ships around the area, and they brought with them 29 reindeer as food backup in case of bad weather or war problems.

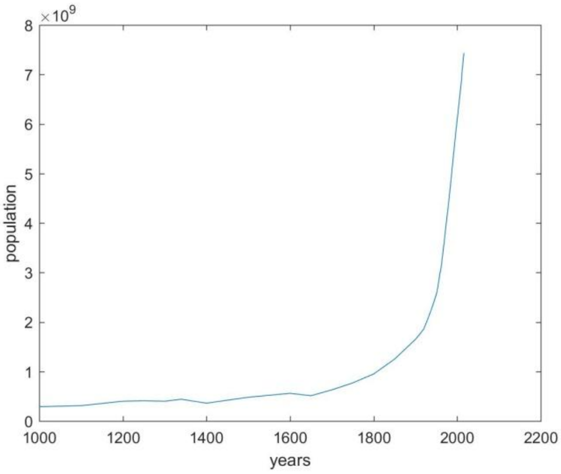
Some months later the war finished: people went back home and reindeers were vacated in an optimal habitat for them, without natural predators. For years the entire world forgets those reindeers and in 1957 some researchers reached the Island founding more or less 1,350 healthy animals. Only 6 years after, in 1963, there were 6,000 reindeers but their conditions were not good enough: they ate all lichen in the Island and they were only capable to grazing the sedge grass, but... also this resource of food was coming to the end.

One year later, in 1964, the population dramatically fall down and there remained on the Island only 42 members: the entire population died because of starvation. In addition, they were 41 female and only 1 male, become infertile for the lack of food. So, in the Eighties, also the last reindeer died. Here, the curve of the population:



Picture 1: Trend of reindeer's population. This graph – made in Mathlab with few points – shows the real values (broken line) and the interpolation (smooth line).

And here the graph of world population since 1000 b.C.:



[7] *Ibid.*, p. 177.
[8] See the Lotka–Volterra equations, explained also in an old book: D'Ancona (1942).

Picture 2: World population growth. Source: U.S. Census Bureau.

The nature of both curves is clear: we are in front of the exponential growth. About this kind of curves, there are more examples in which clearly emerges the “lack of perception” about the time in which the phenomenon ends definitively. One of the most popular is the following: «A French riddle for children illustrates another aspect of exponential growth-the apparent suddenness with which it approaches a fixed limit. Suppose you own a pond on which a water lily is growing. The lily plant doubles in size each day. If the lily were allowed to grow unchecked, it would completely cover the pond in 30 days, choking off the other forms of life in the water. For a long time the lily plant seems small, and so you decide not to worry about cutting it back until it covers half the pond. On what day will that be? On the twenty-ninth day, of course. You have one day to save your pond. (We are indebted to M. Robert Lattes for telling us this riddle)»[9].

The relevance of the cognitive aspect is more clear if we focus on a simple problem like the use of the seat belt. Jack Alpert, engineer in Eighties to the Ford Automobile, is one of the designers of the seat belt. In his words: «Doing research at General Motors in 1968, I realized that people’s thinking did not encourage them to wear seat belts. On the contrary, their thinking told them to not wear them. Since seat belts were about as good at preventing injury as the polio vaccine this was greatly troubling. I began, and continue today, to study learning environments that create such distortions in how a person gathers, processes and values information. The defects in these processes I call “temporal blindness.” My research looks for alternative learning environments that prevent time blindness from becoming part of a person’s thinking toolbox. The goal is to prevent time blindness in a future generation and thus create a cognitive solution to global problems»[10].

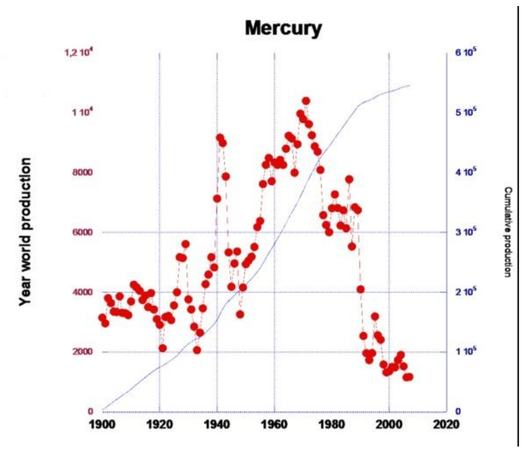
Probably the goal is too ambitious, however, it is symptomatic of the dynamic in which a technical problem shift to a cognitive one.

2. Some confirmation from science: the velocity of resources depletion

In this section, we will see in brief the resource depletion, starting from fundamental constituents of our everyday life: minerals.

2.1 A simple example: the thermometer

Some of us are sufficiently old to remember that our old thermometers contained mercury. The main reason because the mercury disappeared from thermometer is the toxicity, but not only: mercury is simply finished, like the graph below shows:



Picture 3: Trend of mercury extraction worldwide – source: U.S. Geological Survey.

Obviously, we have some other materials that substitute mercury, like gallium, but... it doesn't exist as concentrated element, but only as impurity of other materials. So, we have now thermometers that work with gallium and are also more precise than mercury one[11], but it is quite difficult to obtain only the gallium element.

[9] Meadows et al. (1972), p. 29.

[10] http://www.skil.org/Qxtras_folder-2/Jack%27s%20resume%207_03_files/Jack%27s%20resume%207_03.htm

[11] Schreiber et al. (2013).

2.2 Steel, aluminum, gold and so on: the recycling is the way of using them, but…

In 2006 in all the world were recycled 359 m tons of steel on a total production of 1,250 (36.7%). Nowadays the percentage is probably 40%. Each ton recycled save 1.135 tons of iron minerals; 0.635 tons of carbon and 0.055 tons of limestone (and the corresponding pollution)[12].

Following the International Aluminum Institute, around the 75% of 700 mtons of aluminum produced since 18th century is always in use. The production of aluminum from bauxite is the most energy-consuming, so the recycling is a very virtuous process: 1 kg of recycled aluminum save up to 6 kg of bauxite, 4 kg of other product involved in the production process and 14 kWh of electricity. The recycling, in this case, saves the 95% of energy.

EPA[13] estimates that 85% of all the gold produced throughout history is still in use and that this process of production is the most polluting activity among of all mining activities due to the use of heavy metals. The percentage of efficiency in recycling is 95%, but only 30% of the produced gold is the result of recycling. One of the problems of this activity, here as elsewhere, is tied to the electronics industry that uses small pieces of small size, which gets very difficult to recover.

Here too we are in the presence of cognitive bias linked to mathematics. We have written very good recycling rates: although we do not reach 95% for all materials, we hypothesize to be able to do so. Let's imagine, then, to recycle 95% of the material – gold, steel, and the anything we have analyzed – so that we have 95% each cycle of recycling. In our ideal world, we then imagine in 400 years of recycling 10 times a certain material to 95%. This means multiplying this percentage by the number of times we recycle, that is:

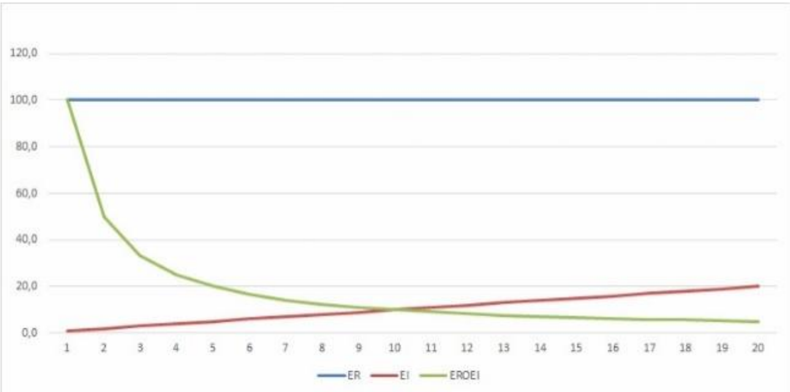
$$0.95 \times 0.95 \times 0.95 \ldots = 0.95^{10} = 0.60 = 60\%$$

So if we recycle 10 times, at the last step we will find 60% of the material we had at the beginning. If the times were only 5 we would still be 77%. Even the most virtuous process is intended to make the unit less.

2.3 The EROEI problem

The quality (and the slope) of the curve for declining about energy comes from the study on the EROEI. The acronym stands for "Energy Return (ER) On Energy Invested (EI)" and is the ratio between the useful energy that could be extracted from a source and the investment (always measured in energy) to build the implant used to extract the energy[14].Classical examples of this count are the extraction of oil. In order to have a qualitative measure of an implant is necessary having the net value of extraction (for example 100 barrels/day) and the value of energy necessary for the correct functioning of the implant (for example 2 barrels/day). So the EROEI is 50.

If we imagine using simple numbers to show the quality of the curve, the results are the following (with ER = 100 and EI = from 1 to 20):



Picture 4: ER, EI and EROEI trends, in an ideal case.

But to better understand "where we are" in the graph (always for the example of the oil extraction) a more useful parameter is the Net energy, defined as:

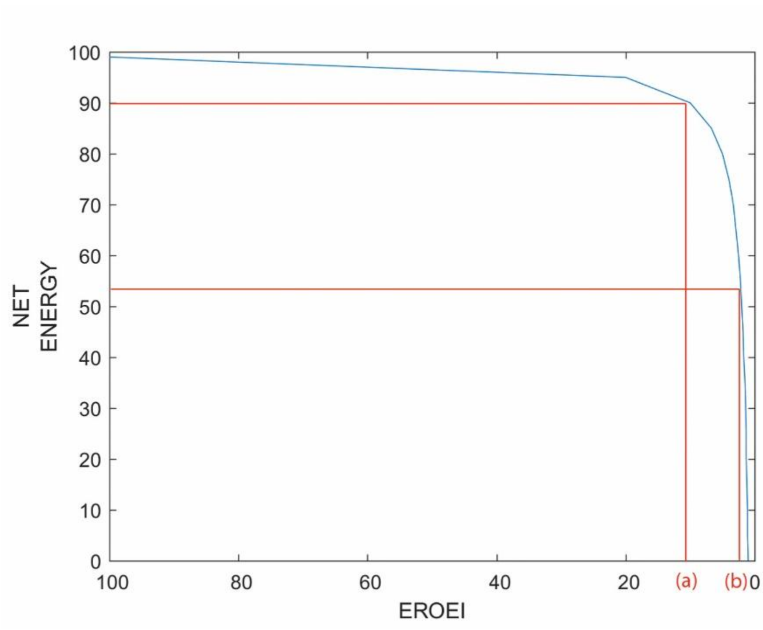
Net Energy (NE) = Energy Return - Energy Investment.

[12] Source: World Steel Association.

[13] United States Environmental Protection Agency.

[14]. A recent book has summarized the question about the limits of usability and offer a general overview of the concept: Hall (2017).

If we divide all terms for a single quantity ER, the result is NE/ER = 1-(1/EROEI), and, under the theoretical hypothesis of the ER always equal 100, the NE value can be expressed in percentage. So, the equation is NE(%)= 1-(1/EROEI)*100. Now, if we make a graph NE vs. EROEI the result is the following:

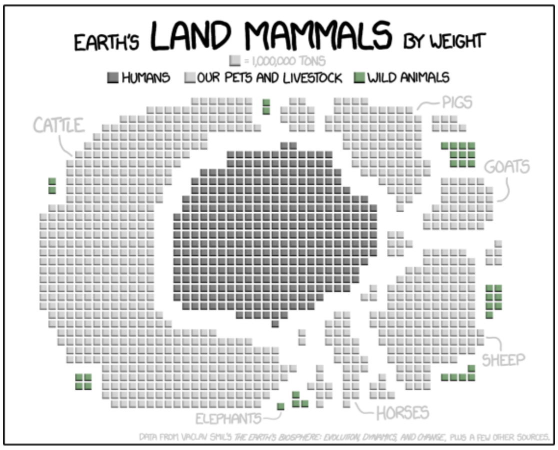


Picture 5: Net energy vs. EROEI, in an ideal case.

The red lines are exactly the meaning of the carrying capacity of the (eco)system: with EROEI = 10 (more or less the point (a)) nothing seems to happen, but if EROEI goes down again – from 10 to 2, for example so more or less the point (b) – the decreasing of net energy is dramatic[15].

3. Others depletions: the biodiversity loss

The young American cartoonist, creator of the webcomic *xkcd*[16], Randall Munroe, realised a graph with the Earth's land mammals by weight – with data coming from a Vaclav Smil study – to show in which proportion are animals "close to humans" respect to wild ones:



Picture 6: Mankind and "his friends". Source: https://xkcd.com/1338/

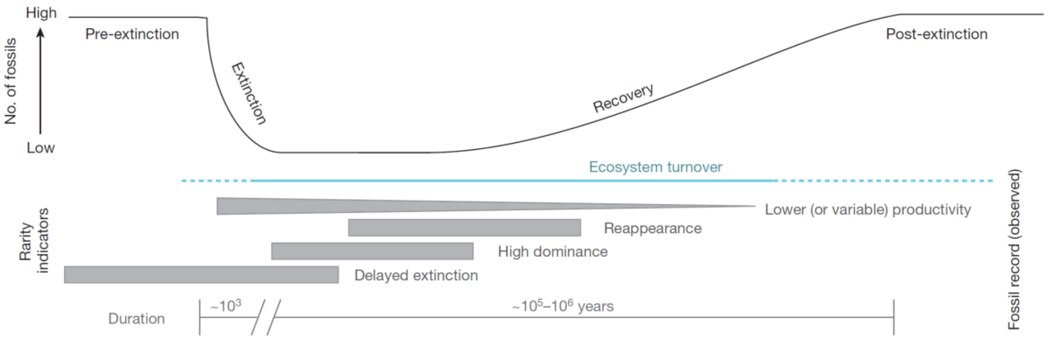
As shown by Cardinale et al. (2012) the study of biodiversity loss is a quite recent topic in ecology studies, because only «in the past 20 years remarkable progress has been made towards

[15] Also, in this case, there is an attempt to evaluate the psychological consequences about this phenomenon: Lambert J. G., Lambert G. P. (2011).

[16] https://xkcd.com/

understanding how the loss of biodiversity affects the functioning of ecosystems and thus affects society. Soon after the 1992 Earth Summit in Rio de Janeiro, interest in understanding how biodiversity loss might affect the dynamics and functioning of ecosystems, and the supply of goods and services, grew dramatically»[17].

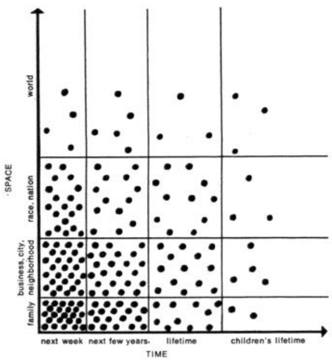
Repeated alarms about the loss of biodiversity following human activities have been launched (the most recent is the presentation of WWF's report in Italy on this topic). Other researchers, such as Hull et al. (2015), argue that going to assessing fossils, there is an unclear causal distinction: a shortage of finds does not allow to infer whether this is due to a mere rarity of that species or an extinction. In the words of the researchers: «Anthropogenic activities have led to mass rarity of many previously abundant flora and fauna. Mass rarity can look like mass extinction in the fossil record because the previously abundant taxa become so rare as to no longer be readily observed. Previously abundant and ecologically important groups, such as ecosystem engineers may not actually become extinct, but decline below the abundance threshold required for them to perform their ecological roles, becoming ecological 'ghosts'»[18]. It should be noted that even in this case there is no question of what is said to be an established fact (human activity as a cause of extinction), but only a methodological question about the inability / impossibility in some cases to distinguish causes. Returning on Bardi's "Seneca Cliff", these authors propose the following picture:



Picture 7: The sequence of taxonomic and ecosystem events across extinctions is unclear. Source: Hull et al. (2015), p. 348.

4. Conclusions

Remaining permanently in an anthropocentric perspective, Dennis Meadows, one of the authors of *The Limits to Growth* report[19], in an interview illustrates another psychological aspect that makes us blind to the future, said: «This would change the nature of man. We are basically now just as programmed as 10,000 years ago. If one of our ancestors could be attacked by a tiger, he also was not worried about the future, but his present survival. My concern is that for genetic reasons we are just not able to deal with such things as long-term climate change. As long as we do not learn that, there is no way to solve all these problems. There's nothing we could do. People always say again: We need to save our planet. No, we do not. The planet is going to save itself already. It always has done. Sometimes it took millions of years, but it happened. We should not be worried about the planet, but about the human species»[20]. An appearance that is illustrated clearly in the following figure:



[17] Cardinale et al. (2012), p. 59.
[18] Hull et al. (2015), p. 346. But, for another point of view, see also: Ceballos et al. (2017).
[19] Meadows et al., *cited*.
[20] On the website: https://damnthematrix.wordpress.com/2013/03/31/there-is-nothing-we-can-do-meadows/

Picture 8: Although the perspectives of the world's people vary in space and in time, every human concern falls somewhere on the space-time graph. The majority of the world's people are concerned with matters that affect only family or friends over a short period of time. Others look farther ahead in time or over a larger area-a city or a nation. Only a very few people have a global perspective that extends far into the future. (The caption is the original of Meadows et al. (1972)).

The world is an extremely complex system, but something – like the perception and the cognition of "where we are" – can be improved. Mathematics and Statistics are useful instruments for a better awareness. The dynamics of oil is the same of the others that we can find in Nature and this is not an isolated case.

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