The 'photosynthetic ceiling' is not about to fall on our head!

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The notion of the 'photosynthetic ceiling' is all the rage in environmental circles. It is the idea that humanity will consume an increasingly large and disproportionate amount of the photosynthetic capacity of the Earth, to the point where in the short term it would use it all up. Although based on the results of research published in established scientific journals, the 'photosynthetic ceiling' is actually, argues Daniel Tanuro, a whimsical and mystifying idea.

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In his recent best-seller *Collapse* Jared Diamond presents the thesis of the 'photosynthetic ceiling' as follows:

It might at first seem that the supply of sunlight is infinite, so one might reason that the Earth's capacity to grow crops is also infinite. Within the last 20 years, it has been appreciated that that is not the case, and that's not only because plants grow poorly in the world's Arctic regions and deserts unless one goes to the expense of supplying heat or water. More generally, the amount of solar energy fixed per acre by plant photosynthesis, hence plant growth per acre, depends on temperature and rainfall. At any given temperature and rainfall, the plant growth that can be supported by the sunlight falling on an acre is limited by the geometry and biochemistry of plants, even if they take up the sunlight so efficiently that not a single photon of light passes through the plants unabsorbed to reach the ground. The first calculation of this photosynthetic ceiling, carried out I 1986, estimated that humans then already used (e.g. for crops, tree plantations of golf courses) or diverted or wasted (e.g., light falling on concrete roads and buildings) about half of the Earth's photosynthetic capacity. Given the rate of increase of human population, and especially of population impact, since 1986, we are projected to be utilizing most of the world's terrestrial photosynthetic capacity by the middle of this century. That is, most energy fixed from sunlight will be used for human purposes, and little will be left over to support the growth of natural plan communities, such as natural forests. [1]

Why make it simple when it can be complicated?

The explanations by Diamond about the biochemistry of plants, the geometry of their foliage, the photons which cross them, the parameters of temperature and rainfall conditioning the vegetation, the limits of growth in desert areas constitute an accumulation of peripheral considerations on the subject and give the feeling that Diamond is introducing the reader to matters of frightening

complexity. However, he does nothing but state the obvious, that indeed the quantity of plants that can grow on an area of size X during a period of time T is limited. This remains obvious even taking into account that the sun will continue to emit light for a time almost infinite on a human scale (4.5 billion years). This is neither mysterious nor paradoxical. As the surface area of our planet is approximately 466 million km2, there is obviously a 'photosynthetic ceiling'. In other words there is an absolute maximum capacity to manufacture organic matter. Since plant photosynthesis is the basis of all forms of life, there is also an insurmountable limit for the development of life on earth. Diamond did not need to wait for recent calculations to realize that the production of biomass has a limit: the work of Vladimir Vernadsky on the concept of biosphere, at the beginning of the last century dealt with exactly this point.

The issue is not the concept of a 'photosynthetic ceiling' but to understand whether we are approaching it and if so, is it at the rapid pace that Diamond claims. Empirically it is enough to notice that there are many living organisms not used by human beings. But one can also produce figures that, although approximate, give a reliable order of magnitude. According to the International Energy Agency, land and oceans produce respectively approximately 140 billion and 32.6 billion tons of biomass per annum. Expressed in energy terms, this 172.6 billion tons is equivalent to 79.2 gigatons of oil equivalent (Gtep), which is approximately 8 times the annual world consumption of energy. Of these 79.2 Gtep, human beings only consume 3.8 Gtep or 6% of the total. This is distributed as follows: 2.1 Gtep in food, 0.4 Gtep in wood and paper and 1.3 Gtep in wood-fuel. [2]

Where in the devil does Diamond get the idea that, 'already in 1986 we used, diverted, or wasted about half of the photosynthetic capacity of the planet' and that we will use 'most' of it from 2050 onwards? In the Further readings recommended at the end of the book (*Collapse* does not include references in the strict sense) we are referred to only one source: an article published in 1997 in the journal *Science*. [3] The authors of this text, P. Vitousek *et al*, inform us that 10 to 15% of land on the planet is occupied by cultivation or urban and industrial zones, and 6 to 8% by permanent pastures, a total of 16 to 23%. But this is an estimate of the occupied area of land, not an estimate of the impact of its use. To go from the land occupied by humans, to its impact on the total biological production, we have to take into account two additional elements that act against each other.

The first element is that the human impact goes well beyond the limits of the occupied land. Vitousek et al put forward in this respect a completely relevant point when they note that 'all the ecosystems are affected by the increase of CO_2 in the atmosphere'. All the ecosystems are probably also affected by persistent organic pollutants (DDT and PCB are found virtually everywhere). But the case of CO_2 is more telling because, up to a certain point, the photosynthetic activity increases across the planet as a function of the concentration of CO_2 in the atmosphere. Insofar as the combustion of fossil fuels over the last two and a half centuries has injected carbon into the atmosphere which was captured previously in the depths of the Earth's crust for tens of million years and which did not take part in the carbon circulation through the atmosphere, the biosphere and the oceans, there is no doubt that human activity today influences all natural environments across the planet, without any exception.

The second element acts in the opposite direction: our species is far from consuming all the biological production from the land we occupy. We take neither the birds that live in our fields, nor the ground worms that dig the earth, nor the leaves of the apple trees in our orchards, and we exploit only one very small part of the biomass produced by the forest ecosystems that we maintain. With scientific certainty, one can thus only say that humans take between 3.2% and 6% of the total biological production, that human activity uses 16% to 23% of the land, and that all the ecosystems across 100% of the surface of the planet are affected by this activity, via the production of fossil CO_2

and chemical pollutants in particular. To avoid any misunderstanding, it should be stressed that this figure of 100% of ecosystems that are influenced does not mean in itself that we would be exceeding the limits of the biosphere. Indeed, other species than ours influence the ecosystems beyond the share of the photosynthetic production that they consume, so that by summoning all these 'influences' one would exceed the 100%.

A new concept: the 'dominated' biomass

Vitousek et al and after them Diamond, are not satisfied with this assessment. Perhaps is it too simple and too clear for their liking? Nevertheless, beside the concepts of 'total biological production' and 'consumed biological production', they also introduce the concept of 'biological production dominated' by human beings, which they add to the former and which they derive from an estimate of the fraction of the land transformed or degraded by human existence. Let us quote them: 'Estimates of the fraction of land transformed or degraded by humanity (or its corollary, the fraction of the land's biological production that is used or dominated) fall in the range of 39 to 50%'. Ten years earlier, in another publication on the same subject, co-authored with Ehrlich and others, Vitousek, put forward the figure of 30.7%. It is undoubtedly this progression (10 to 20% in ten years) which leads Diamond to predict that at this rate the photosynthetic ceiling of the Earth will be nearly totally appropriated by humans in 2050. [4]

However, this reasoning does not hold water. There are two important objections. The first is technical: the estimate of land transformed or degraded by humanity during its history is an impossible task. The authors of the study recognize this: 'The variety of human effects on land makes any attempt to summarize land transformations globally a matter of semantics as well as a substantial uncertainty'. We should add that their conclusions are also a matter of semantics and substantially uncertain… But it does not matter, because the second objection is more fundamental: nothing gives them authority to deduce, 'by corollary', that all the biological production on land transformed or degraded by human activity, 'is used or dominated' by our species. The authors here mix up apples with pears: on the one hand the fraction of the total biological production which we do indeed consume (and which is possible to calculate with a certain degree of precision), and on the other hand *a certain* fraction of this production of which we consume absolutely nothing (the estimate of which is 'substantially uncertain'). To repeat: all the biological production from productive land transformed by human activity obviously, 'is not all used or dominated' by humanity. The same thing applies even more for degraded land: if one assumes that the formation of the Sahara was encouraged by excessive burning, as some researchers believe, it does not necessarily follow that we 'use or dominate' the life of the scorpions and other small animals, nor that their activity in sand bring us closer to the 'photosynthetic ceiling'.

The calculation of Vitousek and friends is far from robust and of very little use for ecologists, because it gives a doubly distorted image of our impact on the biosphere. Indeed, on the one hand, by mixing up 'use' and 'domination', it tends to inflate the human appropriation of the natural resources. *On the other hand*, paradoxically, it reduces the share of the ecosystems affected in one way or another by our activity. This share, which has been 100% for several decades, even for two centuries, cannot obviously grow any more, and it will hardly decrease - or if it does it will be very slow and only if we wisely decide neither to produce any more fossil CO_2 nor persistent polluting organics.

_Science and ideology

One should wonder why researchers such as Vitousek and his/her colleagues are not satisfied with the report summarized above: 16% to 23% of occupied land 2% to 6% of the consumed production, 100% of affected production? The answer is that they are looking for indicators to support their thesis: that humanity is a species which takes too much space on earth and consumes too great a part of its resources, and that this species is increasing more and more rapidly. It is not forbidden to undertake research on this basis. But for it to have scientific value, the research methodology must respect the criteria of rigour and logic. The concept of 'used and dominated biological production' does not meet these requirements.

The basic thesis for this work, is not scientific but philosophical when Vitousek et al. state that homo sapiens, 'which is only one from the 5 to 30 million animal species on Earth, controls a disproportionate share of the resources of planet'. Why is it disproportionate and compared to what? No scientific argument is advanced to confirm that we are being abusive by consuming between 3.2% and 6% of the biological production of the planet. By the way, this production constitutes a renewable flow, and is not a limited stock, as pointed out Michel Husson. [5] We should add that the share taken by humanity is not diverted (or taken away?) from the natural cycles. From a strictly quantitative point of view, our consumption in itself does not mean that we are 'eating the capital' of the earth resources.

It is absolutely true that over-fishing and over-hunting endangers numerous species of fish and mammals, and it is a major subject of concern that requires energetic action. But these actions are not helped by an indicator of the total consumption of all combined biological productions, especially if this indicator amalgamates 'consumption' and 'domination'. In what way would the estimate of a consumption of 3.2% to 6% of the total biological production, or of a 'domination' of more than 50% of this production, help the decision makers to control cod fishing in the North Atlantic, or the hunting of the African elephant? To act on these matters, one needs accurate facts, not only quantitative but also qualitative, relating to the populations of cod and elephants. To say that a total consumption of 3.2% to 6% is 'disproportionate' is an opinion that one could describe as misanthropist. Other humanistic opinions can be added to this political debate. And it cannot be settled in the name of science, especially when this science consists of inventing parameters cut to measure to camouflage opinions as natural laws.

Now we know the source of the assertions in *Collapse* that this 'photosynthetic ceiling' is being reached, and understand better the debate on this concept, one should note that Diamond uses this dubious source by transforming it subtly, to make it even more attractive. Under his pen, the 'biological production used or dominated' becomes a production 'used, wasted or diverted', which is even worse. But this, obviously is not serious. Very few if any forests in Europe can be regarded as original primary forest. Almost all were transformed by human activity. Nevertheless, especially when they are not managed for profit, forests play an essential part in the protection of biodiversity, the maintenance of the land, and the management of water reserves. To claim that the photosynthetic capacity of this vegetation is on the way to being entirely 'used, wasted or diverted' for the benefit of our species is an obvious exaggeration, which risks ridiculing the environmental struggle.

The thesis of the photosynthetic ceiling diverts attention from the real threats - climate change, chemical pollution, nuclear and genetic hazards, and from those who are responsible for them. At the same time, it contributes to spreading a deep anxiety about the so-called problem, which if it were true, would be of such a magnitude that the only solution would be a drastic reduction of the population. And it is indeed here that Jared Diamond and his friends want to

go: to spread the idea that any environmental policy is likely to fail unless drastic demographic steps are imposed on the people of the South, and that immigration from the South to the North is stopped. In *Collapse*, Diamond goes as far as comparing Chinese immigrants in Australia and the United States with the invasive species of insects and harmful mushrooms causing problems in the American forests. In France, a similar assertion would bring Jean-Marie Le Pen before the courts of law, but environmentalist Jared Diamond, member of the leadership of the WWF, Pulitzer prize winner, twice-crowned best author of a scientific book, seems above any suspicion. This could not be further from the truth: those who deliberately confuse the facts of the ecological crisis - by pointing to the so-called responsibility of the poor rather than capitalism - play a dangerous game. It will encourage the rise of racism and the irrational, as well as making barbarism acceptable.

P.S.

* From Socialist Outlook (Feb 2008,issue 14). Translation from the French by Socialist Outlook.

Footnotes

[1] Jared Diamond, *Collapse: How Societies Choose to Fail or Survive*, Penguin books, 2005. p 491

[2] It should be noted that the 1986 study to which Collapse refers and that we will now examine, suggests an even a lower estimate: 3.2%.

[3] P. Vitousek et al, 'Human Domination on the Terrestrial Ecosystems', *Science*, vol. 277, 1997.

[4] Vitousek, P.R. Ehrilch, A.H. Ehrilch, P.A. Matson, 'Human Appropriation of the Products of Photosynthesis', *Bioscience*, 36, 1986, pp 368-373.

[5] Michel Husson, 'Six milliards sur la planète. Sommes-nous trop ?', Textuel, Paris, 2000