

Ecological Footprint and Sustainable Population

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With humanity currently in overshoot, societal changes must be enacted to return to sustainable levels. While either a country's ecological footprint or population size could be altered to achieve the necessary level, combined efforts on both fronts would be most effective.

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A sustainable population corresponds to the total human population that the planet can support without diminishing the health of the biosphere and its ability to support humans, in the same numbers and at the same standard of living, into the future.

THE ECOLOGICAL FOOTPRINT

To assess this population, several calculation methods can be used, or even combined. In this contribution, we will confine ourselves to a single analytical element, the ecological footprint, which has the advantage of synthesising many ecological impacts caused by human activities. The concept of the footprint was initiated and refined by the Global Footprint Network (GFN) and is now the most widely used indicator of general sustainability in the environmental community and well beyond, since some countries have incorporated it into their national accounts.

According to the GFN definition, the ecological footprint measures the surface area of land required to produce the resources a population consumes and to absorb the waste it generates. This surface area is expressed in global hectares, i.e., hectares corresponding to a worldwide average. For simplicity's sake, we will speak in hectares [ha]. An important detail is that a country's ecological footprint only considers what is "consumed" there. It includes the footprint of imported products and subtracts the footprint of those that are exported.



The human population is putting pressure on natural systems around the globe, both on land and water.

Currently, at the global level, the average footprint per person is 2.8 ha/capita (global footprint of human activities divided by world population). The problem is that we only have 1.6 ha/inhabitant, which corresponds to what the planet produces in a renewable way each year, and which is called the average individual biocapacity.

The question that immediately springs to mind is: how is it possible to have a footprint (2.8 ha) greater than the Earth's biocapacity (1.6 ha), in other words to consume more than is produced? Well, we are quite simply drawing on the Earth's capital: for example, we are emitting more CO₂ than the oceans and forests can absorb, we are emptying the oceans of their fish, and we are sterilising arable land by concreting it over.

A KEY RATIO

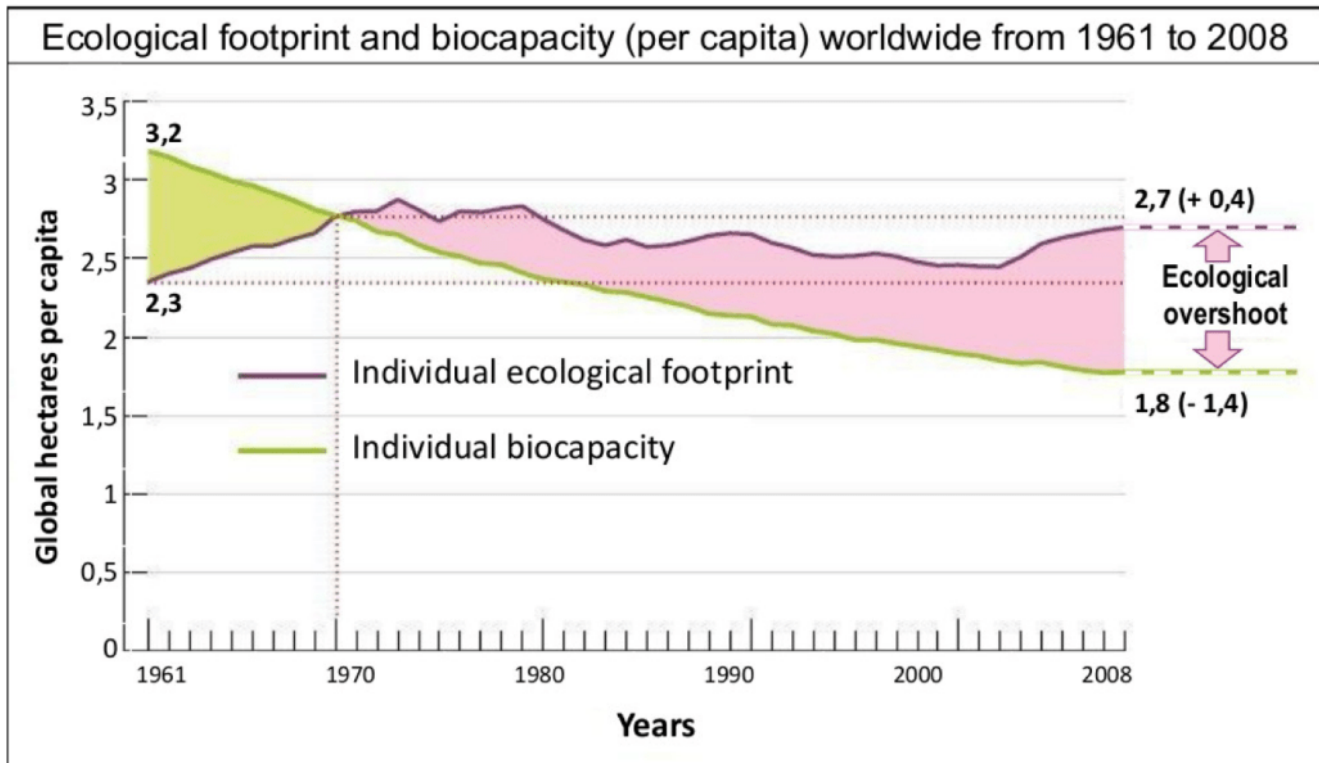
- Humanity 'uses' 1.8 planets. To arrive at this result, we relate the fact that an earthling has a footprint of 2.8 ha while the planet only has the capacity to provide 1.6 ha [$2.8 / 1.6 = 1.8$].
- Similarly, the GFN calculates what each country 'uses' as resources by relating not the country's footprint to its own biocapacity, but the country's footprint to the planet's biocapacity. This compares each country's consumption with what would be globally

sustainable. However, it is also of interest to explore how self-sufficient a country is, in terms of whether its own biocapacity is enough to supply the current consumption patterns of its current population.

This shows up how dependent they are on resources imported from elsewhere, which is a measure of overpopulation. If we compare their consumption with the planetary average biocapacity, replacing the (inevitably) low individual biocapacities of overpopulated countries with the (generally higher) biocapacities of the Earth gives these countries a false advantage. Bangladesh (with a footprint of 0.9 ha and a biocapacity of 0.4 ha) is a case in point, acting as an excellent case study since the GFN calculation [$0.9 / 1.6 = 0.6$] means that if everyone in the world lived like people in Bangladesh, they would use little more than half a planet. However, Bangladesh is using more than twice its own resources [$0.9 / 0.4 = 2.3$], by 'drawing' what it lacks from the rest of the planet. In what follows, in contrast to the approach taken by GFN, we will therefore focus on the ecological balance within countries by comparing their footprint with their own biocapacity.

EVOLUTION OF THE PLANET'S FOOTPRINT AND BIOCAPACITY

The planet's overall biocapacity increases slightly from year to year, as a result of productivity improvements, mainly in agriculture. However, as the world's population and per capita wealth continue to grow at a faster rate, the Earth's individual biocapacity is inexorably decreasing.



The graph shows change in global hectares per capita over the years, of individual ecological footprint and individual biocapacity. In 1970, the lines crossed and we went into ecological overshoot.

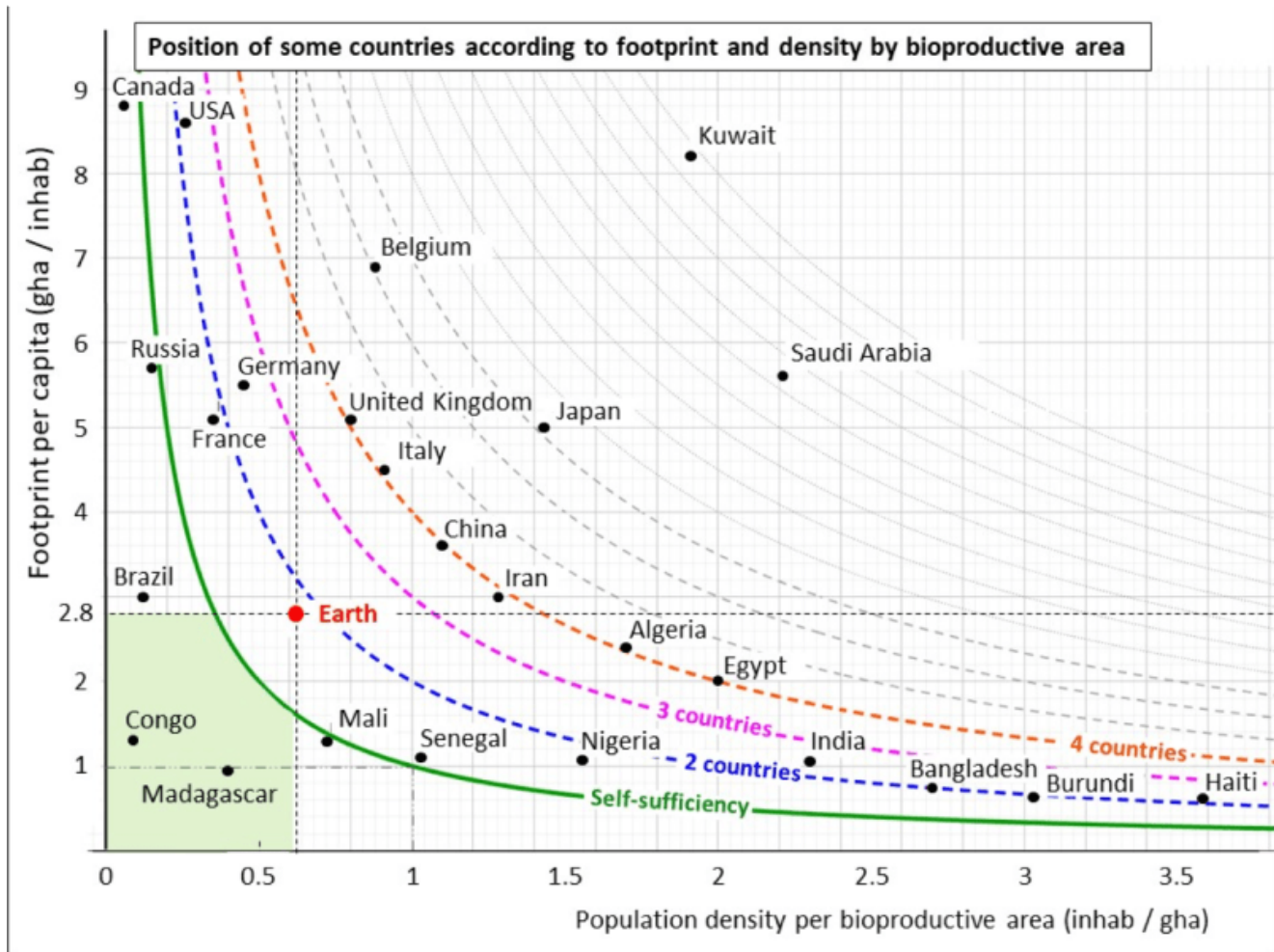
This very telling graph was published in the WWF’s “Living Planet Report” (French edition [1], page 40) in 2012 along with the caption: “*The decrease in per capita biocapacity is mainly due to the increase in the world’s population: the earth’s resources have to be shared between a greater number of humans. The increase in the planet’s productivity is not enough to offset the demand of this growing population*”.

It is therefore clear that the ecological overshoot in 2008 (and even more so today in 2023) is essentially due to the increase in population, which has more than doubled since the curves crossed in 1970.

COMPARING COUNTRIES AND THE PLANET

The following graph compares countries in relation to their self-sufficiency, with individual footprints on the vertical axis and “population densities per bioproductive area”[2] on the horizontal axis.

The green curve [3] corresponds to ecological balance where a country’s biocapacity is just equal to the resource use by its population, notionally representing self-sufficiency. Each line above the green line represents a multiple of the self-sufficient population, requiring use of resources equivalent to several times the bioproductive area of the country (2, 3, 4 and more).



Population density and per capita footprint of different countries, with lines denoting the level for self-sufficiency and overshoot.

With footprints above the world average, we find France close to the '2 countries' curve, Germany with two and a half times its surface area, then the United Kingdom and Italy using four times their country's biocapacity.

With individual footprints below the world average, we can see that Nigeria still uses almost twice its surface area's worth of biocapacity, Bangladesh, Burundi, and Haiti are at two, India is slightly above, and Algeria and Egypt use four times their surface area.

On the left and 'below' the self-sufficiency curve are Canada, Russia, and Brazil, whose biocapacity is greater than their footprint. That said, the footprint of the first two countries is much larger than the average footprint of a person living on Earth, and it is imperative that they reduce it. Their 'surplus' biocapacity is needed globally to offset the countries in deficit, not least by exporting food without which other countries would starve. All three also represent important ecosystems supporting many unique species and are vital to global biodiversity.

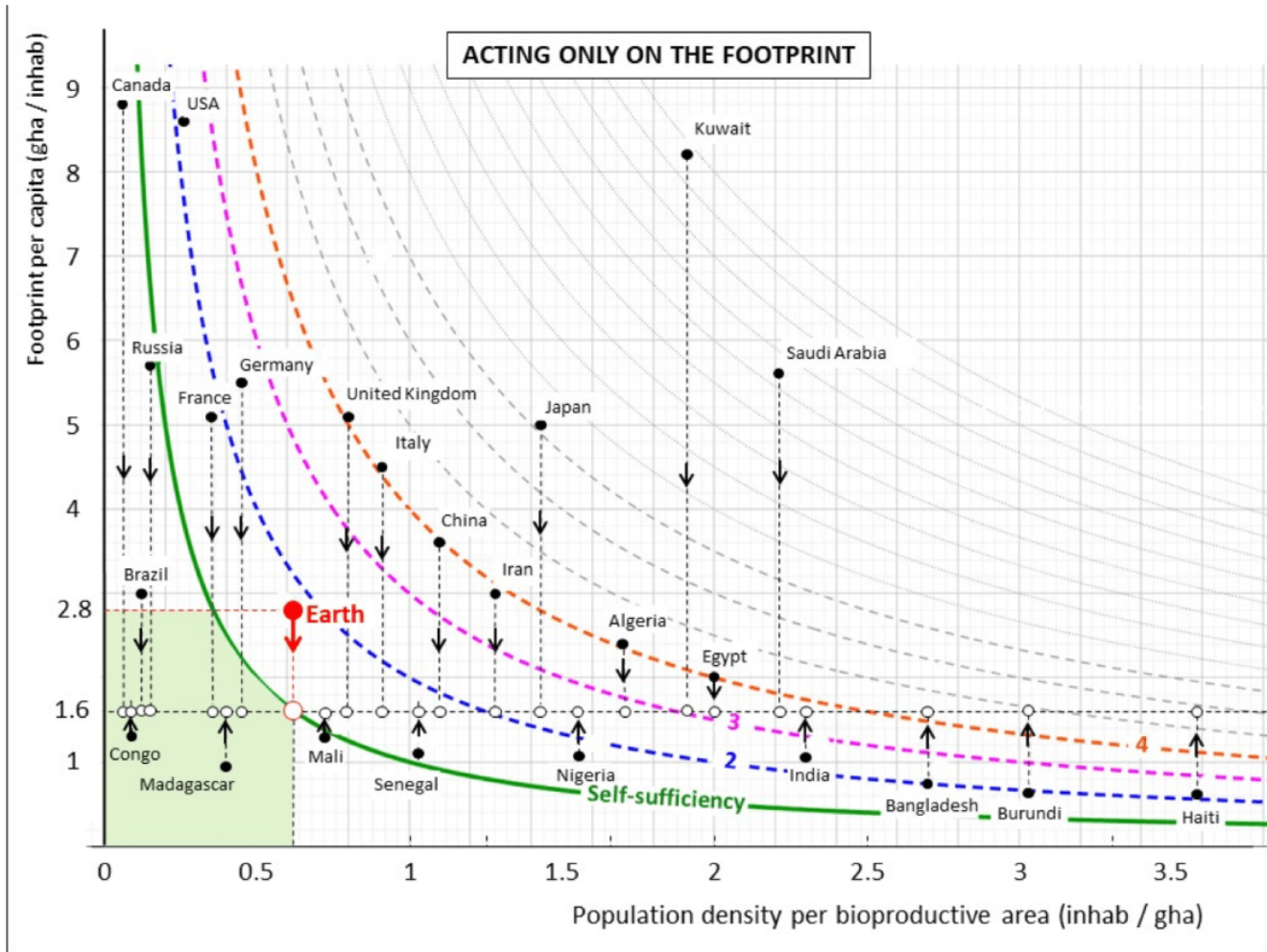
EQUILIBRIUM SITUATIONS ACCORDING TO DIFFERENT TYPES OF POPULATION AND FOOTPRINT

1) ACTING ONLY ON THE FOOTPRINT

First, we could achieve a situation of global equilibrium if each country, whatever its biocapacity, brought its footprint down to the level of the planet's average biocapacity. Graphically, this would involve a vertical shift of all countries towards the horizontal dotted line at 1.6 global hectares per person (see chart below). This would enable the planet's resources to be distributed equally.

The problem is that these resources are very unevenly distributed, and this would mean continuous transfers of agricultural resources over more or less long distances, which would consume a lot of energy.

In the end, the planet would indeed be in balance, but none of the countries would be in internal balance with themselves. Another disadvantage is that, once calculated, any growth in population anywhere would reduce the consumption permitted per person everywhere.

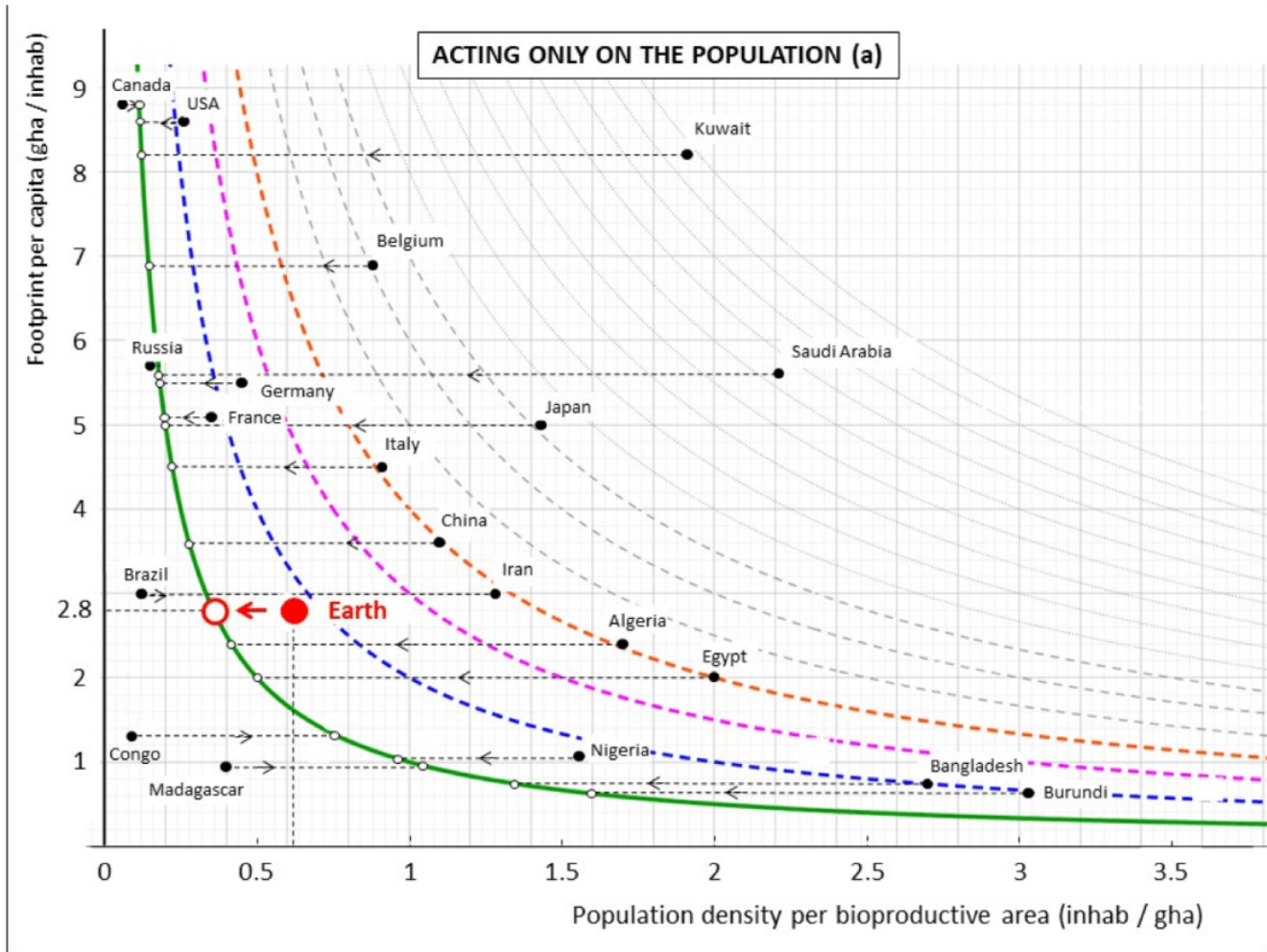


Population density and per capita footprint of different countries, with lines denoting the level for self-sufficiency and overshoot. Arrows show how countries would need to decrease or increase their footprint to reach the average needed for global self-sufficiency.

2) ACTING ONLY ON THE POPULATION

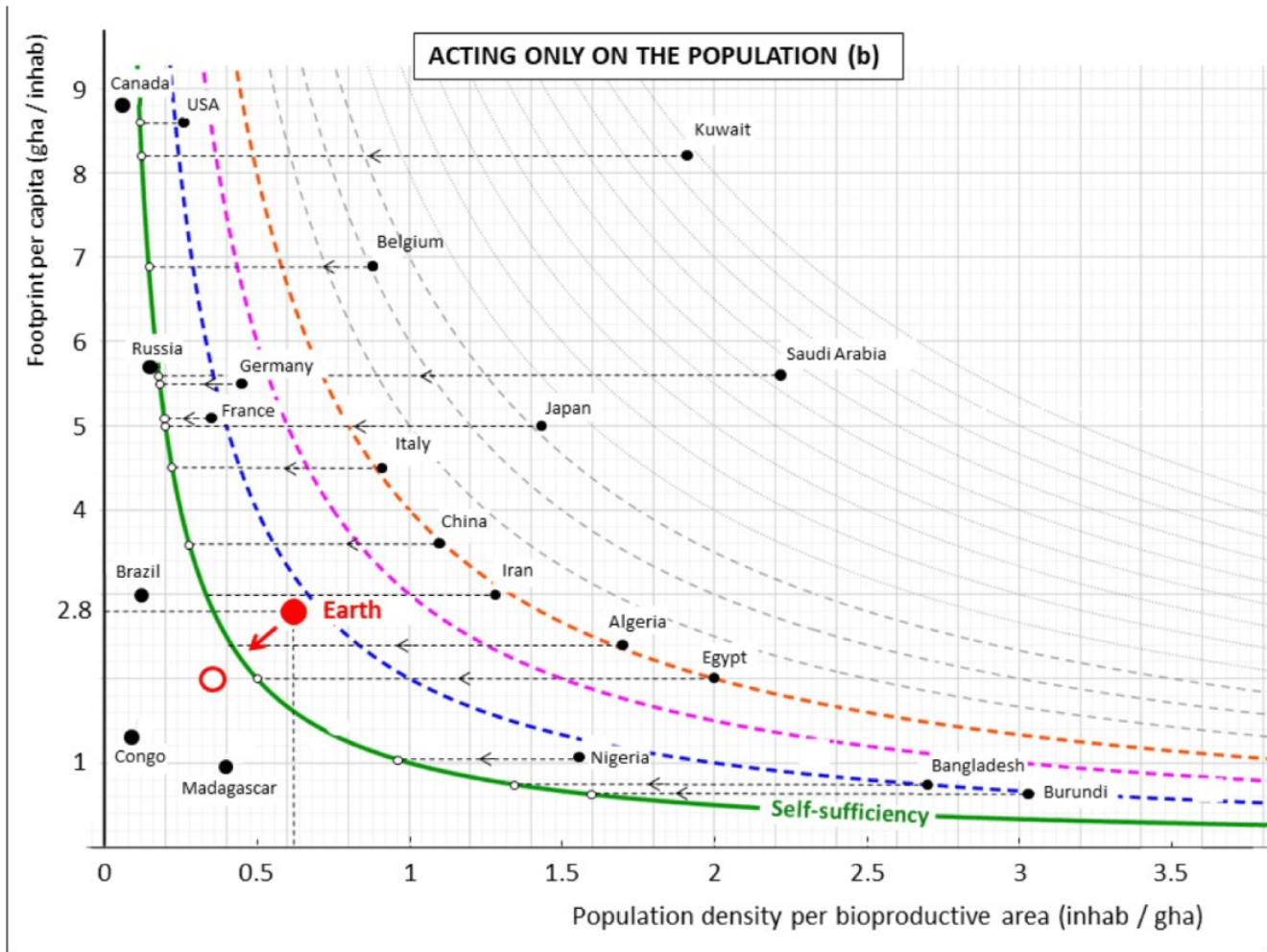
a) Hypothetically, we consider here that debtor countries can maintain their individual footprint, but must lose inhabitants until they return to equilibrium, whereas creditor countries can have more inhabitants until they use up all their biocapacity.

Graphically, this involves a horizontal shift [4] (in the direction of the self-sufficiency curve) to the left for the former (who are the most numerous) and to the right for the latter. The calculation gives a sustainable population of 4.9 billion (remembering that this figure requires poor countries to stay poor).



Population density and per capita footprint of different countries, with lines denoting the level for self-sufficiency and overshoot. Arrows show how countries would need to decrease or increase their population to reach the average needed for global self-sufficiency.

b) However, it can be argued that since most countries will have to reduce their population, it makes no sense to allow others to grow. This leads us to a new calculation in which the creditor countries remain at the same population level (and therefore at the same place on the graph). This option would mean using only three-quarters of the planet's biocapacity, leaving some for other species and as a safe buffer space. After calculation, this would be 3.6 billion.



Population density and per capita footprint of different countries, with lines denoting the level for self-sufficiency and overshoot. Arrows show how countries with an excessive population would need to decrease their population to reach the average for global self-sufficiency

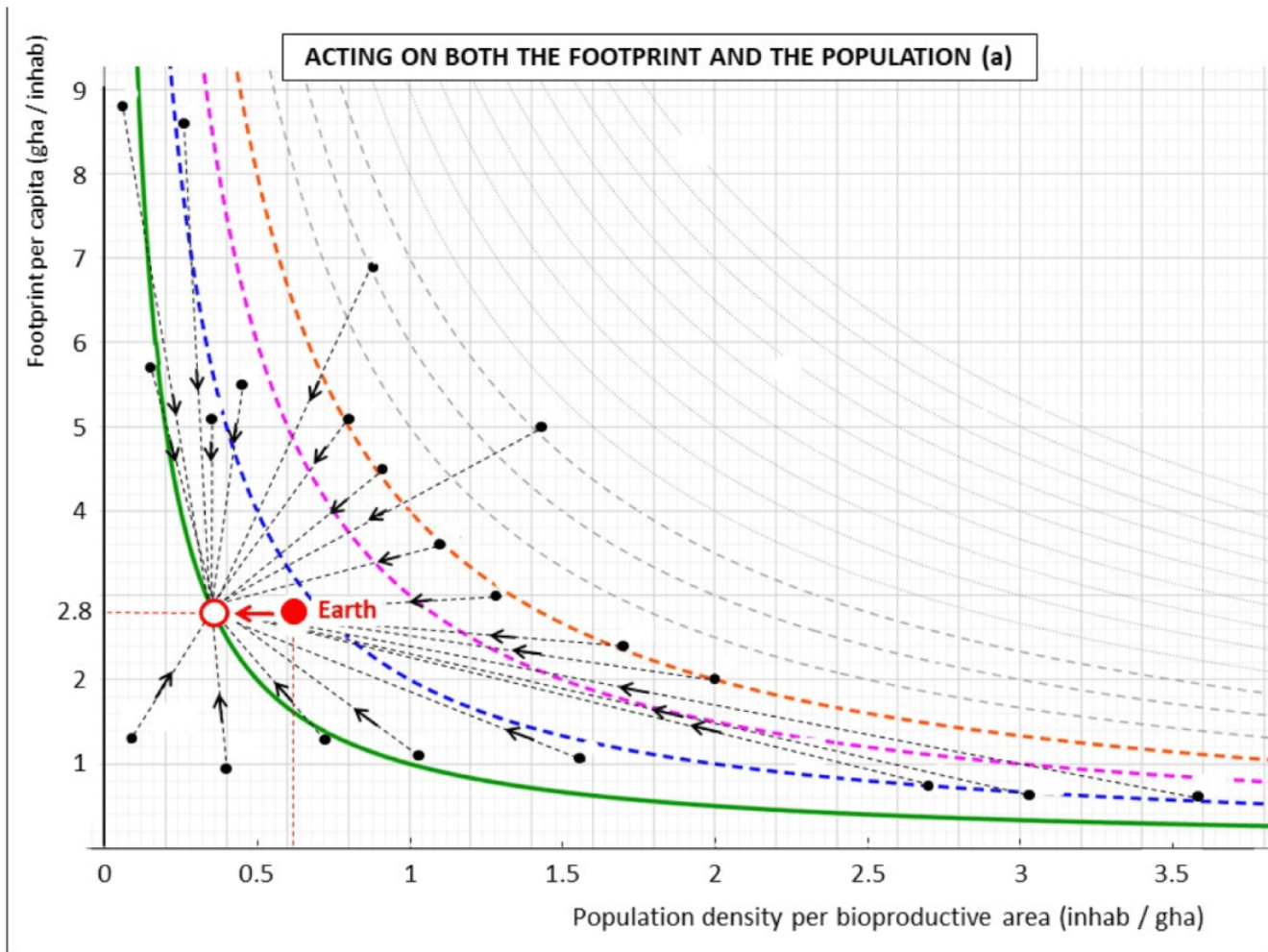
3) ACTING ON BOTH THE FOOTPRINT AND THE POPULATION

a) The disadvantage of the previous calculation is that the footprints remain unchanged, and we end up with very different lifestyles in different countries. To remedy this, we could ensure that the balance is achieved with the same footprint and the same individual biocapacity in all countries. There are, of course, an enormous number of possibilities. Here, we have arbitrarily chosen an average footprint of 2.8 ha/capita (i.e., the current individual footprint of an earth person), which has the advantage of corresponding to an egalitarian distribution of today's global consumption, but at a population that makes this sustainable.

Graphically, this involves shifting all the countries (and therefore the Earth) toward a single point. The sustainable population of each country would then be equal to its overall biocapacity expressed in global hectares, divided by 2.8.

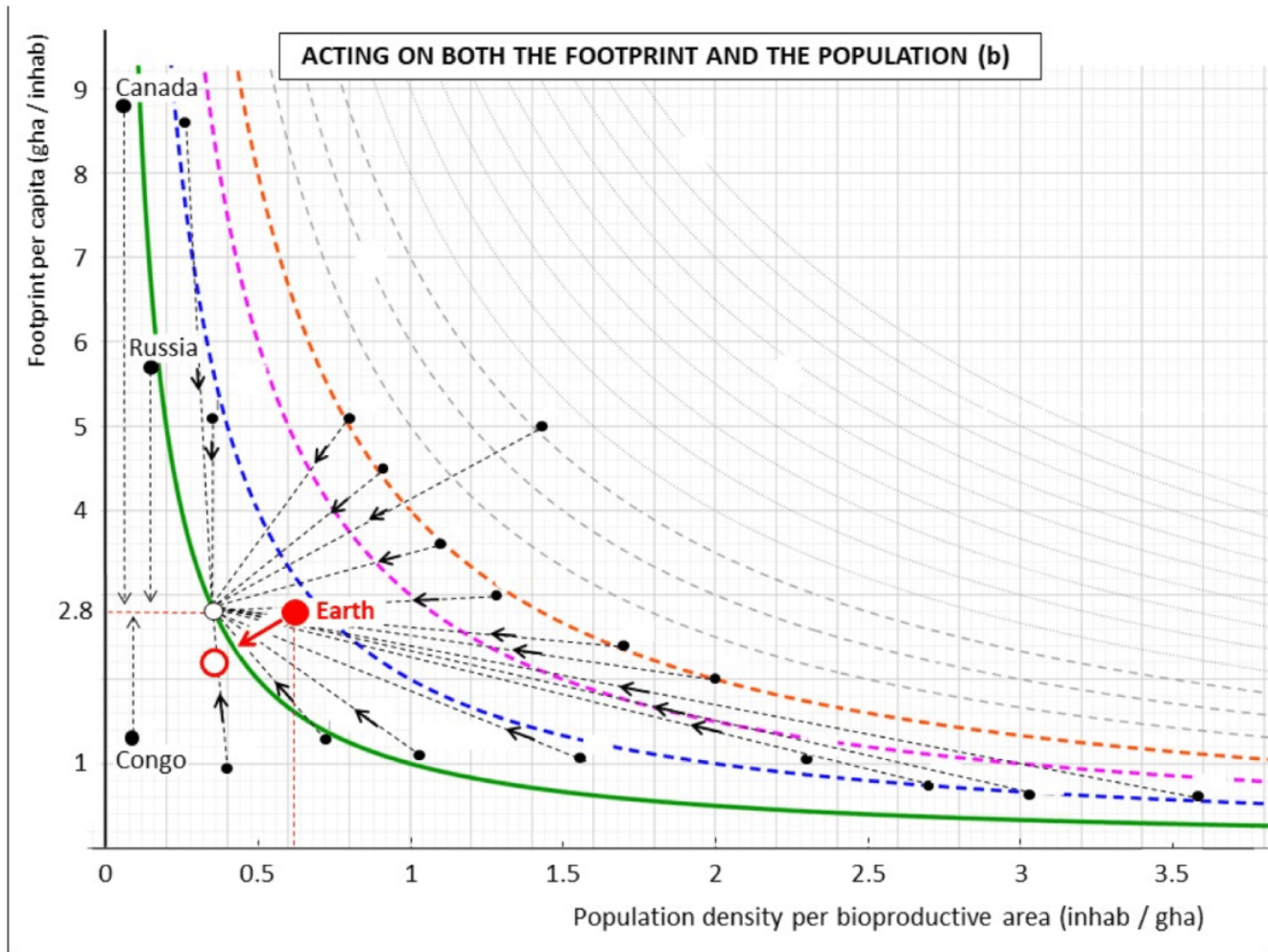
It should be noted in passing that this option leads to a significant drop in the standard of living in countries with a footprint greater than 2.8. For countries with a biocapacity of less than 2.8, this option allows their quality of life to improve but consequently requires an even

greater fall in population than in the previous case [5]. The result is a sustainable population of 4.4 billion.



Population density and per capita footprint of different countries, with lines denoting the level for self-sufficiency and overshoot. Arrows show a combined scenario of how countries would need to decrease or increase both population size and per capita footprint to reach the same level needed for global self-sufficiency.

b) However, as above, it may seem preferable for countries with a biocapacity greater than 2.8 ha per person to remain at the same population level. In this case, the population, using only 70% of the planet's biocapacity, would be 3.1 billion. This assessment, which is the lowest of the four, is explained by the fact that we have chosen a "fairly high" standard of living.



Population density and per capita footprint of different countries, with lines denoting the level for self-sufficiency and overshoot. Arrows show a combined scenario of how countries in overshoot would need to alter their population size and per capita footprint to reach the average for global self-sufficiency, while countries with biocapacity surplus would increase or decrease their global per capita footprint.

CONCLUSION

We have estimated a 'sustainable' world population to lie between 4.9 and 3.1 billion, depending on the strategy used [6]. Based on this, we can estimate that Earth's carrying capacity for humans lies between 3 and 5 billion.

Many scenarios can therefore be modelled based on the GFN database. The idea here is simply to show examples of calculations. It would be in every country's interest and in line with international distributive justice to bring itself into line with its biocapacity by reducing its average individual footprint and/or its population.

If a sustainable population were recommended by the international community at a UN conference, with implementation freely consented to by each state, it would take a relatively long time to achieve. People almost everywhere (including in low-fertility but overpopulated countries) would need to be persuaded that smaller families maximise the future prospects for themselves and their children. Country leaders would need to be convinced that

population decline has more advantages than disadvantages: that it is worth paying a little more of national revenue to pensions and elderly care, to avoid resource scarcity, extreme weather events caused by climate change, and the political instability and warfare that extremes of deprivation tend to trigger. We might assume that restoring global population to a sustainable level will take a couple of centuries. In the meantime, not only must the rich world begin to wind back its high per capita consumption, we need to do everything in our power to protect those productive ecosystems that remain, and use both renewable and non-renewable resources more wisely. In addition, the restoration of natural habitats and species population needs either more resources, or even fewer people than was calculated above, as the ecological footprint does not specifically take biodiversity into account.

Footnotes:

[1] https://www.wwf.fr/sites/default/files/doc-2017-09/12_rapport_lpr2012.pdf

[2] Instead of using densities expressed as the number of inhabitants per square kilometre, this new concept adjusts the area according to the biocapacity of the land compared with the global average. Hence it adjusts the area downward where unproductive or low productivity land exists, and upward where land is very fertile, to calculate the number of inhabitants per hectare on a globally standardised basis (inhab/ha). These are the 'inverses' of national biocapacities per person (expressed in ha/inhab).

[3] The hyperbolic shape of the curves can be explained as follows: for example, if the population density per bioproductive area is 1 inhabitant/ha, equilibrium (for self-sufficiency, the product having to be equal to 1) is achieved with a footprint of 1 ha/inhabitant. If this density is 0.5 inhabitants/ha, equilibrium is achieved with a footprint of 2 ha/capita...

[4] Downwards for countries whose footprint is larger than the Earth's, and upwards for the others. This shift, and those that follow, can be seen graphically here: <https://vu.fr/GaWJD>

[5] For Bangladesh, for example, this would mean an 85% drop in population, which may seem enormous. To mitigate this drastic impression, it should be borne in mind that, in the end, the country would end up with a real population density of 163 inhabitants/km², compared with France's 103 inhabitants/km². This difference is because Bangladesh is even more 'fertile' than France.

[6] The spreadsheets download automatically here: <https://urlz.fr/o9MW> and <https://urlz.fr/o9Nf>