2 STANDING FURTHER BACK

Humans have been getting more powerful, every year, for a very long time.

For millennia, the world was a robust and plentiful place for us, in which we could experiment and expand as far and as fast as we were able. It was a sturdy, bountiful playground, but now it is finite and fragile. In this chapter, we are going to stand right back to look at the *dynamics* of our growth, to see if they can tell us anything new about how – going forwards – we can live well on the beautiful, vulnerable home that we call Earth. It turns out that we will be able to make some fairly simple but widely overlooked observations, whose policy implications are so massive that no climate policy-maker can afford to ignore them.

Why Are Efficiency Gains Adding to the Climate Emergency?

Year-on-year, we get more energy-efficient at just about everything we do. It would be easy to assume that efficiency improvements should lead, by default, to a decrease in the total use of energy, and thereby a general decrease in the burdens on our environment. Indeed, under certain conditions that we *could* bring about, that *could* happen, but the default position, and how things operate right now, is in fact the exact opposite.

Why are our efficiency gains leading to us using *more* energy, not less as many people expect and assume? This

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phenomenon is sometimes known as the 'Jevons paradox', named after William Stanley Jevons, who noticed in the nineteenth century that as the UK became more efficient with its use of coal, it led to rising, not falling, coal demand and usage.[1] But the Jevons paradox doesn't just apply to coal. It describes a much more general and incredibly important principle:

> ***When we find a more efficient way of producing or doing something, we usually increase the amount of it that we do by a bigger proportion than the efficiency gain itself. So the total usage of the resource and environmental burdens associated with it go up, instead of down.***

To unpick how this comes about, let's think of almost any process in our economy. Examples could include oil extraction, flying an aeroplane or making any household item. The process requires inputs (in the case of oil extraction, these include energy, materials to create oil rigs, pipelines, tankers, refineries, labour . . .) and it does things with those inputs to produce the useful outputs (oil) along with some environmental burdens (greenhouse gases, toxins and habitat degradation).

The *efficiency* of the process could be defined as the output per unit of input. So an efficiency improvement happens when someone finds a way of getting more out for any given amount that is put in. Let's see what happens when a process becomes, say, 15 per cent more efficient.

What we find over and over again is that the useful outputs become cheaper to make and to a higher standard. So they become better value for money, which leads to customers wanting more. It takes less energy to make and drive a car these days, but that has led to more and bigger cars being driven further.[2] This is also known as the *rebound effect* (Figure 1).

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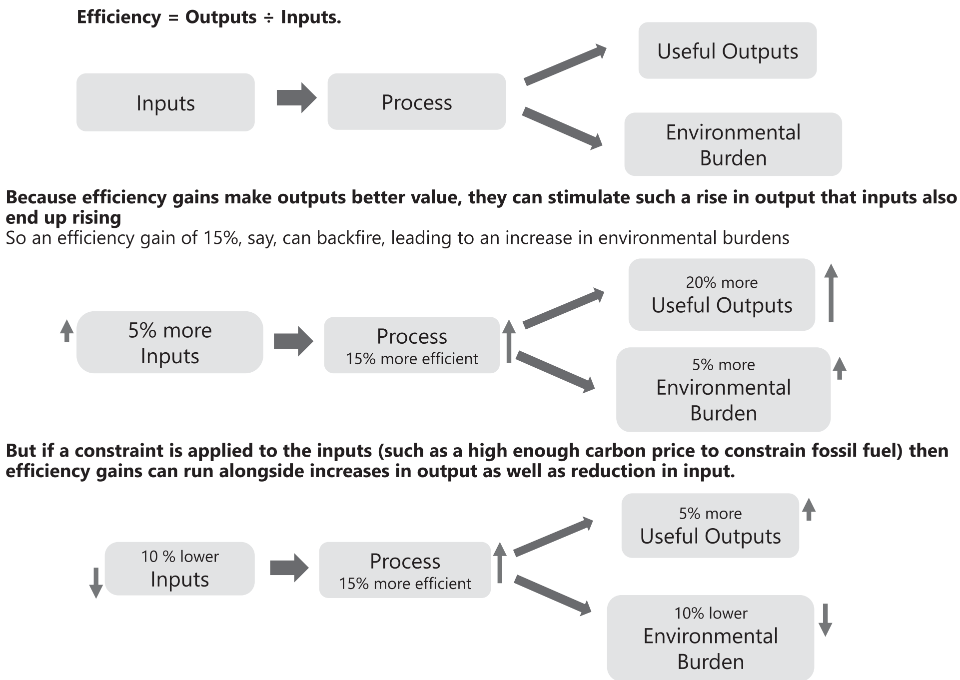

Figure 1 Rebounds and backfires. When a process gets more efficient, many people expect the total inputs and environmental burdens to go down. But unless there is a constraint applied, the increase in outputs usually ends up more than offsetting the efficiency gain. Hence, although humans have become more efficient at almost everything, their impacts have carried on rising.

The rebound effect is one of the most critically important and under-appreciated concepts for all climate strategists and politicians to get their heads around.

So far, I've described rebounds on a simple, single process, but in real life all these processes are part of a complex system that we call 'the global economy', and a myriad of direct and indirect rebound mechanisms take place involving interactions between different processes in the whole system. Let's look at just one of these, the car example: improvements in cars make some people more likely to live in the countryside, and with that comes a likelihood of having a larger home with a larger energy requirement. But these indirect rebound effects are impossible to capture one by one, so to understand their total impact you have to stand back for the macro view. If you don't do that, but instead try to understand rebounds by counting them up one at a time – as happens all too often – you vastly underestimate or even trivialise the enormously important rebound phenomenon.

The reason it matters so very much is that the overall rebound effect of energy efficiency in the global economy is currently, and always has been, *more* than 100%. Efficiency improvements are actually backfiring and leading to an *increase* in our access to, demand for, and use of, energy – including fossil fuel energy. So, coming back to our example, in the case of the global economy, a 15% efficiency improvement leads to something like a 20% increase in demand and therefore a 5% total rise in inputs, and their associated environmental burdens.

This is one way of explaining why global energy use and carbon emissions have been going up, not down, for the last couple of centuries, and continue to do so despite ever-improving efficiency of almost every process humans carry out: transport, heating, communication, data analysis, food production . . . *everything*. (It is sometimes argued that because decoupling between energy and emissions has

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been achieved in some countries, this proves the decoupling concept at the global level. The problem with this argument is that it doesn't work to quantify rebound effects by looking at only one part of the system, such as individual countries.[3])

Here is an example of why you can't make useful decisions as a politician or climate policy-maker without a full grasp of rebounds. One of the outputs of COP28 was to push for a tripling in energy efficiency improvements. But because of rebounds, as things stand, this will lead to an *increase* in total energy demand and usage. And since we won't any time soon have enough renewable or nuclear energy to meet even today's energy use, the greater our energy demand, the more fossil fuel we will burn. The fossil fuel lobby at COP28 will have seen this very clearly. It has a far more sophisticated understanding of energy dynamics than the average politician.

Can Energy Efficiency Be Made to Help Us After All?

Yes. The dynamics don't have to work as I've described them. They can very simply be changed. All you have to do is *constrain the inputs* so that they can't go up. Then what you find is that efficiency improvements lead only to greater outputs and/or a reduction in environmental burdens. How you share out the benefit of efficiency gains between increased outputs and reduced inputs and environmental burdens is another matter, but the key thing is to understand the following:

> ***Only when the inputs are constrained do efficiency improvements stand to make both quality of life and the environment better rather than worse.***

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Many in the fossil fuel industry don't want you to understand this because, in the case of energy efficiency in the global economy, it means constraining energy demand in order that efficiency gains can lead, for the first time, to reductions in carbon emissions. In practical terms, I think that means a high enough and increasingly universal carbon price, applied to the extraction of fossil fuel. More on this later.

Why It Doesn't Work to Add Up the National Climate Pledges

Failure to consider rebounds is also a fatal flaw in the international community's assessment of its carbon-cutting plans. The Paris Agreement resulted in a framework of national carbon-cutting pledges, the so-called Nationally Determined Contributions (NDCs). We hear that they are not enough to keep temperatures within acceptable levels, and that they are not all being implemented. But what is still missing from these assessments – and it is massive – is consideration of systemic effects. It simply doesn't work to think, as the United Nations does in its assessment of the NDCs, of each nation's carbon trajectory being independent of what goes on in other countries.[4] To do so is to assume, for example, that if a coal supplier finds it harder to sell its product to one country because of its carbon-cutting plans, that company will make no attempt to sell to another country instead. And if one country cuts its polluting manufacturing industries, the current modelling assumes this will never stimulate the relocation of those factories to other parts of the world that are less committed to climate action. In reality, if, as is the case in the UK, a country's climate pledges do not include emissions of imported goods and services, the tendency is to shift manufacturing to countries whose energy inefficiency and coal reliance may be higher,

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and in the worst case, actually lead to increasing global emissions.

I'm not saying we shouldn't have NDCs, but I am saying that much of the benefits of actions by individual countries will undoubtably be lost through leakage into other parts of the system, unless, as we will see later, something is done at the global system level to constrain emissions.[5]

How and Why Does the Economy Grow Differently from Trees, Mice, People and Elephants?

Now we are going to look at the growth of global society through a slightly different systemic lens, comparing and contrasting with other kinds of systems that we find in nature and in society. One way of looking at a tree is as a beautiful part of our environment. Another way is to see it as a complex system which carries out lots of processes. Its inputs are water, carbon dioxide, energy from the Sun and nutrients from the soil. It uses them to maintain its leaves, roots and branches and to transport all its nutrients to where they are needed. Its main outputs might include oxygen, fruit, and fallen leaves and branches. If there are any spare inputs after the basic work of staying alive and healthy has been carried out, the tree uses these to grow bigger.

It is a similar kind of story for most living organisms. All mammals eat food, drink water and breathe in oxygen. This gives them the energy to keep warm, move around, find more food, maintain their bodies, do all the things they want to in life and, if there is a surplus, to grow a bit bigger. A bit of physical growth is usually a good thing in children but usually not in adults.

As trees and many other natural systems grow, they find an economy of scale that allows them to keep getting bigger despite the fact that some tasks, such as transporting nutrients from the roots to the leaves, get disproportionately larger. Geoffrey West, former director of and distinguished professor at the Santa Fe Institute, has studied these growth dynamics to find some fascinating patterns.[6] He has identified incredible and uncanny similarities in the growth dynamics of different living organisms. For example, looking between all species of animals, you find that the rate at which they use energy goes up by almost exactly 75% every time weight goes up by 100% (Figure 2). The 25% difference between the weight gain

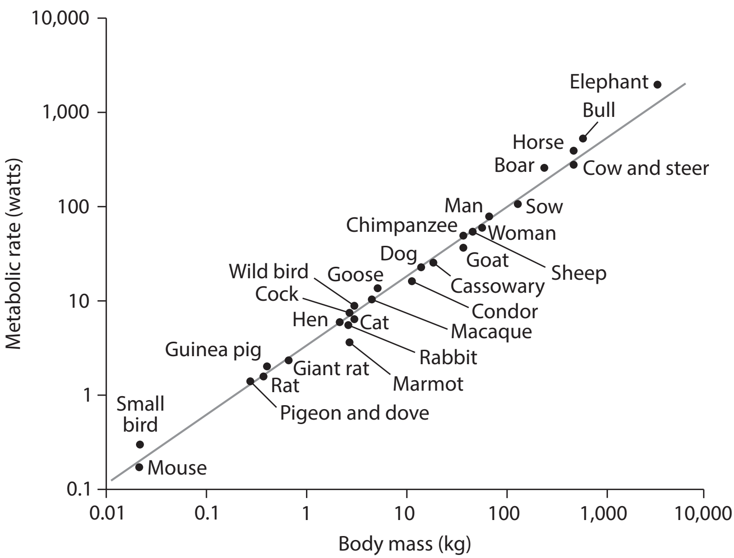

Figure 2 This logarithmic plot of the energy used by different mammals against their body mass is a remarkable straight line and shows that for every doubling in weight, the energy needed to live only goes up by 75 per cent.[7] (That is why the *x* axis increases by a factor of a million – from 0.01 to 10,000 – whereas the *y* axis only goes up by a factor of 100,000). Mammals are more efficient the bigger they are. Figure credit: West, B.J. (2020). *Entropy*, *22*, 1204.

and the energy use is the economy of scale that the larger species is able to find; in order to survive, bigger animals need to use fewer watts per kilogram of body weight. Elephants plod about, living longer but slower lives, with slow heart rates and with each kilogram of flesh needing less power than is the case for mice, who scurry around with heartbeats like drum rolls. Exactly the same ratio of size-to-respiration rate also applies to species of trees. (If you like maths, a ratio of ¾ between energy growth and energy use can be plausibly explained with a simple model in this endnote.[8])

Turning to the individual trees and animals, they also experience an economy of scale as they grow, but it becomes counter-balanced by moderating factors that inhibit growth. And because the economy of scale is a relatively modest 25 per cent, each tree, mouse, elephant or person reaches a point at which there is no longer any spare resource, and healthy growth has to stop (Figure 3). We call this maturity or adulthood and, once reached, the

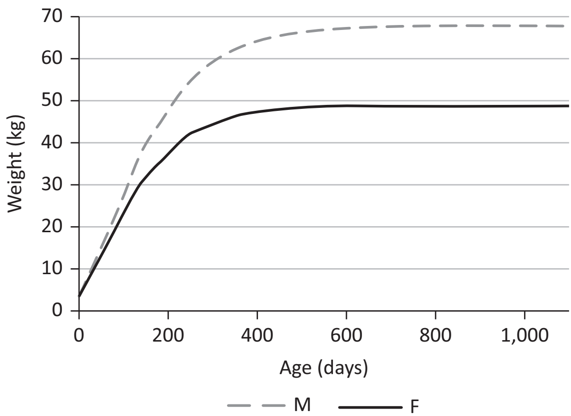

Figure 3 The growth rate of organic systems such as animals (in the graph here, sheep) reaches a stable plateau.[9]
Figure credit: Lupi, T.M. et al. (2015). *Animal*, *9*, 1341–1348.

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organism can continue to thrive for an extended period; perhaps centuries in the case of trees. In the case of humans, we can have many more happy decades, especially if we keep our intake in balance with our energy needs.

But West's work gets even more interesting and relevant to this book when he turns to exploring the growth dynamics of human social systems, cities, businesses and economies. His findings give us another powerful way of understanding the challenge facing humanity right now. In one sense they are alarming, but they also give us insight as to where our best hope may come from.

The key inputs to the global economy are energy, materials and food. We use these to enable all the activities and possessions that make up our lives, including the harnessing of more energy (from fossil fuels, renewables and nuclear sources), materials and food. When there is a surplus, this gets used for growth: growth in infrastructure and population, but also, unlike in trees and other mammals, growth in innovation and new ways of doing things.

Just like with plants and animals, socio-economic systems' growth and efficiency gains go hand in hand. But West found a key difference that has enormous implications for us. He found that in human social systems such as businesses, cities and even the global economy, when the system doubles in size, the rate of energy burn goes up not by a mere 75% but by a much larger and, again, amazingly constant 115%. So, whereas larger animals tend to have slower heartbeats and burn through less energy per kilogram of weight, in larger cities, the people live faster than in villages, and each individual uses more energy, not less.

In cities, compared with villages, people tend to walk and talk faster and, critically, interact with more people. As the global economy grows, it requires an enormous transport and communications effort to keep it functioning as a whole. So why doesn't it just run out of steam or buckle under the burden of such disproportionate energy needs?

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The answer is that we have a whole different way of getting access to a greater energy supply. Trees, mice and elephants can't innovate, but they don't need to in order to grow to a certain size, plateau out and then continue to thrive. However, social systems both can and must innovate in order to find the extra energy that is required for the next stage of growth. In cities and companies, the rate at which ideas can be shared jumps up far faster than the size of the system. The same happens as our society continues to globalise. At the same time, we burn through far more energy per person than is required by a small, self-sufficient tribe.

Whereas trees and mammals naturally reach a point at which growth stops and the size remains constant, in human social systems, the innovation brings the efficiency improvements that power continuing growth. The result is a system-growth curve that – instead of levelling off at a point that we call maturity (in living things) – rises ever-more steeply. Growth begets growth begets growth, at an ever-faster rate. Energy use begets further rises in energy use. Innovation quickens. The more people there are, the more they can share ideas. The more spare resource they have, the more time there is to dream and experiment. It even becomes steeper than exponential. It becomes super-exponential. In other words, whereas in exponential growth there is a constant percentage growth every year, we are talking about that percentage annual growth rate *rising* as the years go by.[10] The more energy and materials we extract, the more we are able to do with them, including extracting ever-larger amounts, ever-more efficiently. The Stockholm Resilience Centre coined the phrases 'The Great Acceleration' and the 'Trajectory of the Anthropocene', to describe the eruption of steeply rising socio-economic trends. Figure 4 shows a whole range of socio-economic trends accelerating in this way. To repeat the phrase with which I started this book, we really are accelerating into a Polycrisis. But is it inevitable? Is there a way out, or are we doomed to failure?

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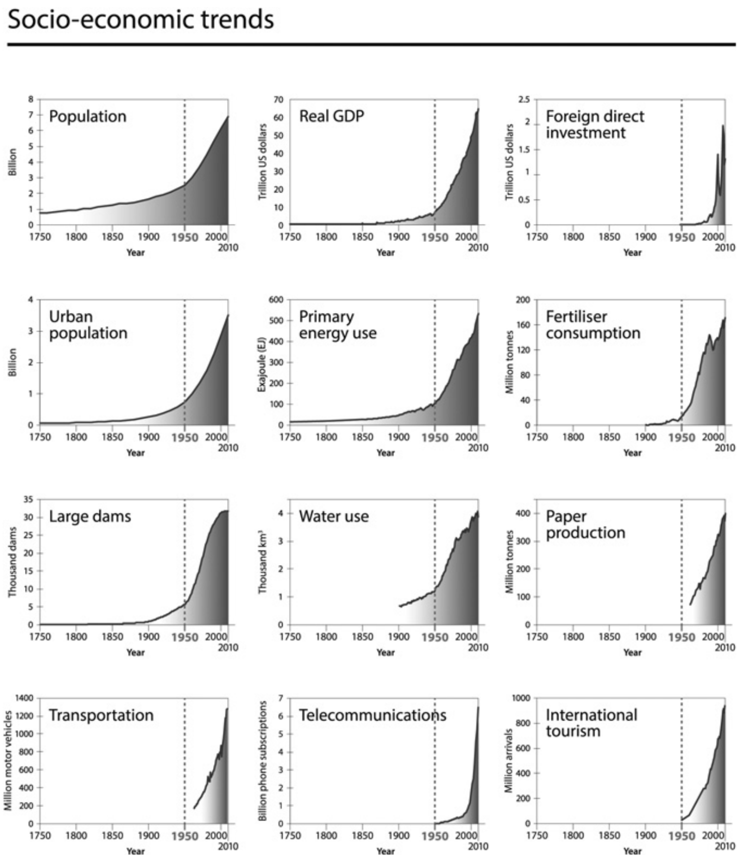

Figure 4 The Great Acceleration, or the Trajectory of the Anthropocene.[11]
Figure credit: Steffen, W. et al. (2015). *The Anthropocene Review, 2*, 81–98.

Do We Have to Grow Until We Pop?

Humanity has been experiencing the same dynamics of growth for millennia. We have been innovating and expanding. Small groups have been coming together into larger tribal units, then countries, unions and collaborations between countries, in a process that can be summarised as globalisation. The energy supply has been growing. The bigger the groups, the more the interaction, and the greater the rate of that interaction. Energy begets energy, and innovation begets innovation. In our market economy, competition has been spurring everything on.

Geoffrey West describes a choice of two possible fates for socio-economic systems, of which global society is the largest and most important, that do not tend by default towards a healthy equilibrium state. The first is that they develop into ever-increasing vicious spirals and positive feedback so that the steepness of growth gets closer and closer to vertical: infinite growth (Figure 5). Because that is physically impossible to achieve (without expansion to

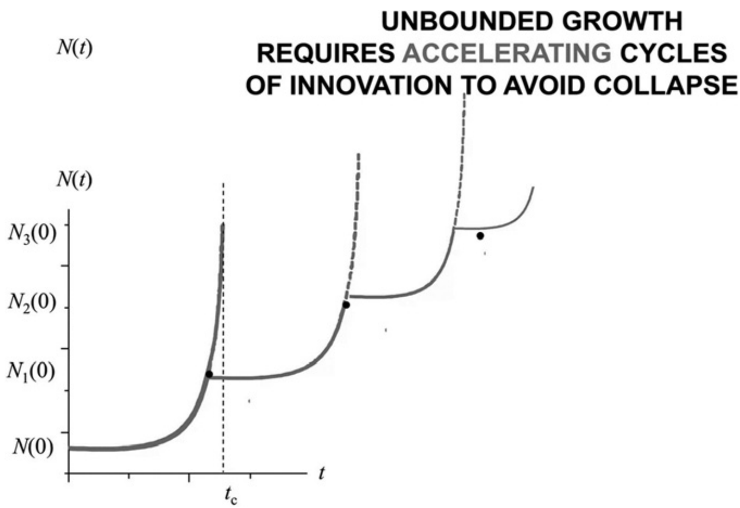

Figure 5 Geoffrey West's slide showing that socio-economic systems, of which the global economy is one, have a tendency to spiral into uncontrolled growth and inevitable crash, unless they undergo periodic resets. The need for these becomes more frequent until a meta-reset is required.
Figure credit: Graph used with permission from Geoffrey West.[12]

other planets, which as I've outlined isn't foreseeably feasible), the system is forced eventually into a dramatic crash, and often complete death.

The alternative, and what this book is arguing for, is that socio-economic systems are able to undergo a system *reset*; they manage to achieve a new mode of operation in which the rules and processes are different, and the growth rate is healthily tamed. Such a reset is one more way of framing the challenge we now face, as we are clearly not far from the asymptotic crash that West predicts.

In West's view, the growth rate eventually starts to pick up again after such a reset, and further resets are required, in fact with increasing frequency, until a meta-reset is necessary to avoid a meta-crash. But some wonderful news for us is that we can worry about this eventual meta-reset in years to come. Maybe by then Planet B really will be an option. In the meantime, we – humanity – need to perform a reset on ourselves – *now* – in order to survive. The alternative is that the planet *imposes* a reset on us against our will, leading to huge population loss, a crash of civilisation, an unthinkable level of collective suffering and untold destruction to the other lifeforms that share our Earth. Those really are the only two options: we either control the reset ourselves, to everyone's benefit, or we allow the reset to be imposed on us.

For now, in this practical book about the very present emergency of our inept and blundering arrival in the Anthropocene, the questions are 'What does that reset look like?', 'Who needs to do what?' and 'What can each of us do right now to help?' That will take us into questions about the ways we make decisions, the ways we think, to our relationship with technology, and for reasons we'll get into later, our relationship with truth. (Don't worry, we can still innovate – in fact we need to – but we need to have a lot more agency over the kind of innovation we embark upon.)

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One of the great mysteries to unpick on our way to understanding humanity's failure so far to deal with the climate emergency is why, despite all the detailed assessments of climate impacts on every scale, there is so little attention paid to big-picture modelling of the system dynamics. This needs to change because even the relatively simple concepts explored here readily yield enormous policy implications. I don't claim to have the full answer, but I suspect it is partly, as we will explore later, because we haven't yet got used to thinking in some of the ways we are going to need to if we are going to thrive in the coming decades. It is partly because the implications are challenging and quickly make clear that minor modifications or sticking plasters on top of a global 'business-as-usual' approach won't be enough. It is also partly because, as we will see, some people are happy for us *not* to understand what it will take, for example, for us to leave the fossil fuel in the ground.

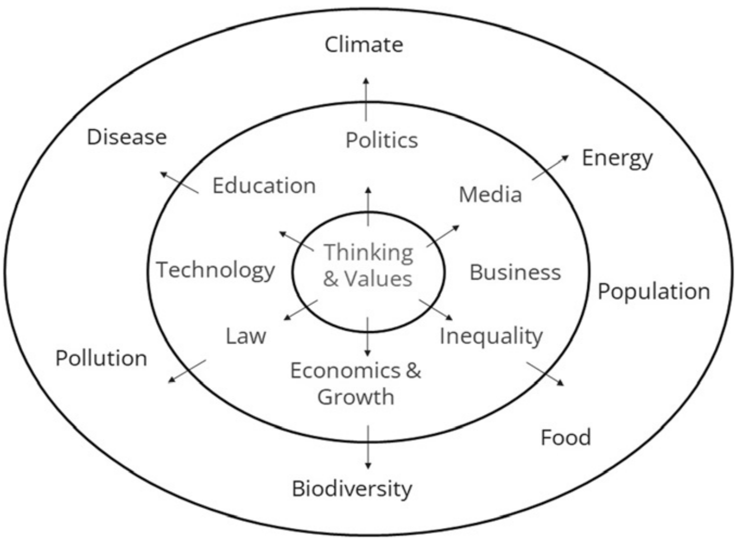

Figure 6 A simple illustration of the full challenge ahead: the Polycrisis.

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The Layers of the Polycrisis

Over the next three chapters, we'll deconstruct the Polycrisis, layer by layer, starting with the outer crust and moving towards the centre (Figure 6). Then we'll look at the single biggest lever for achieving change, and explore very practically what can be done, and what each of us can do, to get things moving right now.

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