"Grew too much. Consumed too much. Polluted too much"
The Path to Phillips Cay (2021)

DIALOGUE 2: The Global Drivers

Interviewer: Thank you for the coffee and cake. I see you've laid out a new set of figures on the table for our next conversation but before we do that, let me summarise what we discussed earlier - to make sure I've got it right.

You argue that the world has reached a critical point in its development. After many Millenia of expansion, all lands are fully owned and the fully connected. You term this, *the beginning of the **'Full-Up'** stage*. With nowhere to go, the impact of increasing population, rising levels of pollution and depleting resources will, from now on, be increasingly felt across national borders and play a direct role in controlling the shape and direction of human activity.

FN: And to control these Global Drivers and many of the high level Inevitable Consequences - will require Humankind to cooperate.

Interviewer: Global Cooperation is an unavoidable obligation?

FN: I suppose all planets, populated by intelligent life forms, eventually reach this Full-Up stage and are faced with the the same generic problems of population, pollution and resource. Some collapse at this point - and may even disappear; others fragment or limp on - declining slowly – while a fortunate few, adapt and move forward.

Interviewer: And that corresponds approximately to the four outcomes of the 'real' Model: Stagnant, Divided. Anxious and Emergent. So let's look in more detail at the 'real' Model, starting with the status of the Global Drivers in 2021 and an issue that has been a concern for many years: **POPULATION.**

FN: Indeed. The Population Division of the UN has been compiling statistics since the organisation's inception almost eighty years ago.

As this first figure shows, population grew steadily up to 1900, but then rapidly increased from 1950, rising from two billion to just under eight billion today.

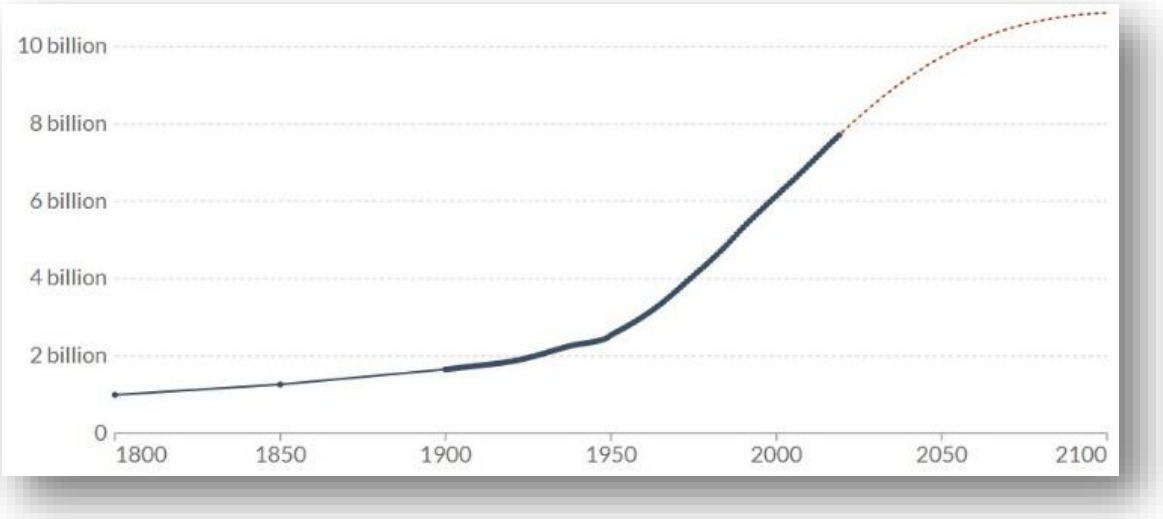

Figure 1: **Population Growth from 1800** *(OWID, 2021)*

Growth rates, however, started to decline from the 1970's.

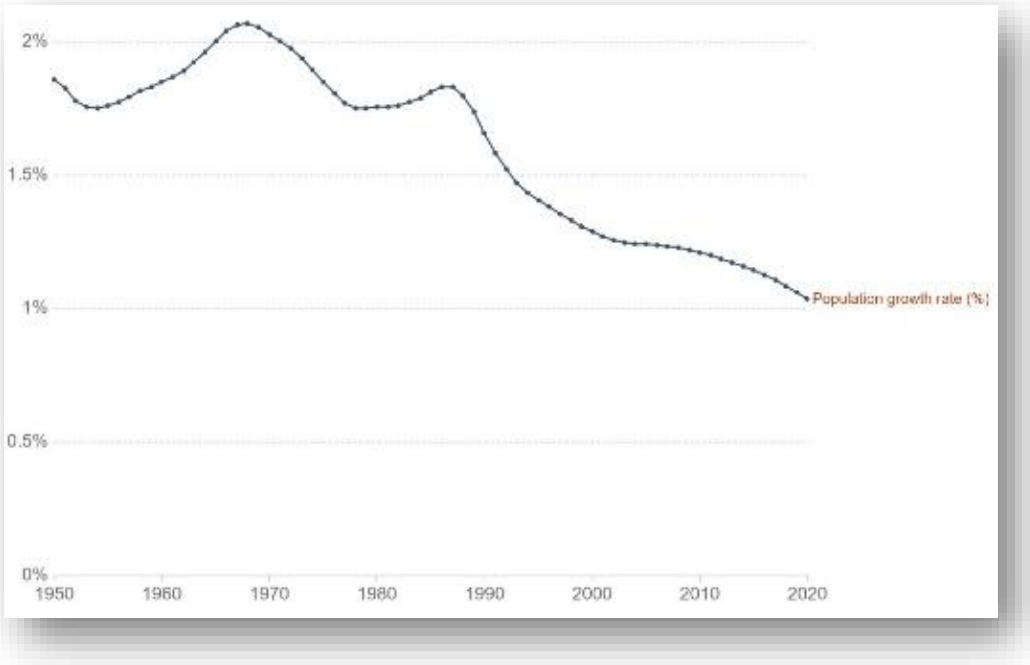

Figure 2: **Annual Global Population Growth Rate** ***(****based on UN Population Division and after OWID)*

The UN has also made predictions on the future growth of global population, producing four fertility-based variants.

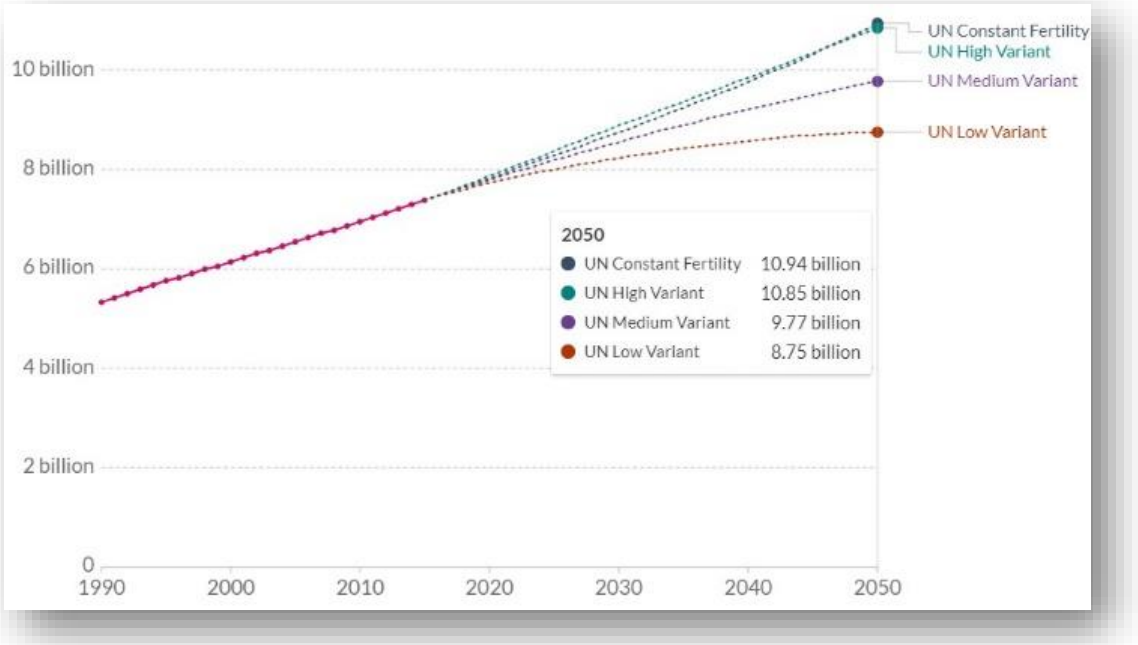

Figure 3: **UN World Population Projections** (*based on UN Population Division and OWID)*

The Median Variant fertility projection predicts a population of 9.77 bn in 2050.

Interviewer: Nevertheless, by 2050, even with the flattening of growth, there will still be, around . . . two billion more mouths to feed from where we are today.

FN: Yes, a very important point. And in the details of that is another important issue that this increase will largely come from impoverished areas of Africa, in particular Sub Sahara, as the next figure shows.

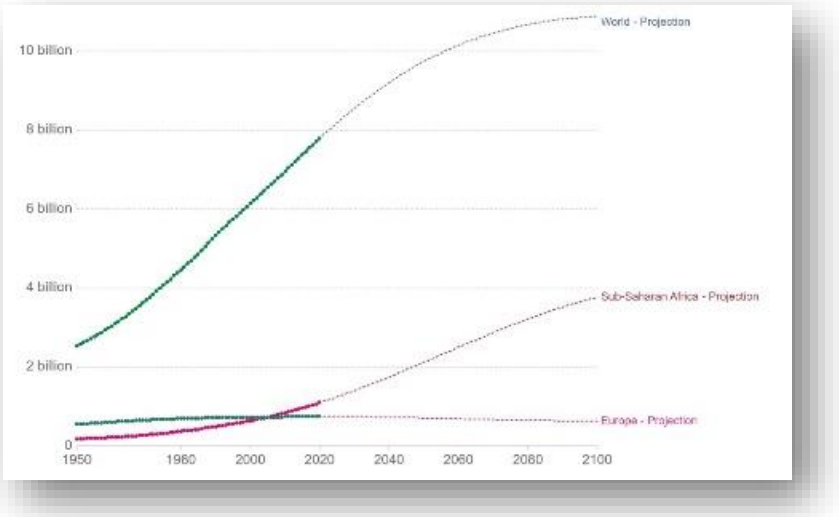

Figure 4: **UN mid-Variant World Population Projection also showing Sub-Sahara Africa and Europe** (*based on UN Population Division and OWID)*

A third point to note, is that by 2100 using the Median Variant projection, the population of Africa *as a whole*, will have increased from just over a billion today, to over four billion - representing 40% of the world's population.

Interviewer: So, why the disparity? How can we account for the overall global slowing down, while in areas such as sub-Sahara, there continues to be high growth rates?

FN: As so often happens in discussing the Global Drivers, we need to go back to human fundamentals – specifically our behaviour and motivation under different living conditions. There is no simpler way to understand that, than by referring to what is called, Maslow's Triangle.

Figure 5: **Maslow's Hierarchy of Needs** *(A Theory of Human Motivation 1943)*

Traditionally, people who have not secured their basic needs (Shelter and Physiological) have had larger families as an insurance policy for their old age. As a nation develops and the population becomes more secure, adults of child-bearing age, begin *looking up the triangle*, diverting some of their resources from large families, towards improving their own lifestyle. This is clearly demonstrated in the next figure (*adapted from OWID*) that plots average income per country against births per woman.

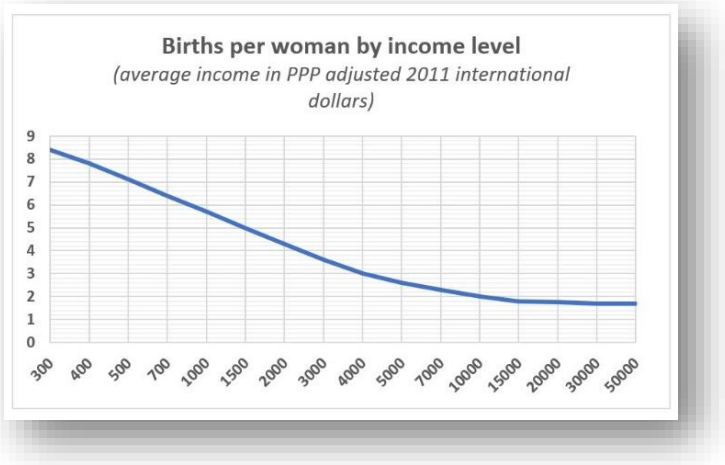

Figure 6: **Average global income against average births per woman** (*based OWID 2020)*

Interviewer: Does that mean in a more insecure world birth rates will pick up?

FN: Probably . . . but not in developed societies where quite the opposite is likely to happen with birth rates falling - even below replacement.

Interviewer: With so many aspects of population documented by the UN, which parameter will you use to represent it, going forward?

FN: For now, I have limited this Global Driver to one parameter: **Population Number** and, as we will discuss in Dialogue 4, the Model employs the UN's fertility-based projections (*Figure 4*) as a basis for forecasting.

Interviewer: The next 'Driver', **POLLUTION**, is a big topic – but for most people it equates with human-induced global warming.

FN: Planetary pollution began to receive attention in the '60's with concerns ranging from toxic water poisoning (e.g. *Minamata disease Guardian 2001 16th October*) to atmospheric pollution by CFC's damaging the Ozone layer (*National Academy of Sciences 1976*). But, undoubtedly, the biggest threat we have today - because it is so pervasive - is the effects of Greenhouse Gas emissions on global temperatures. For many people, this is the greatest threat facing Humankind in the future, But while it is, undeniably, a major problem that requires urgent action, it is part of a much wider problem called WASTE – *the things we no longer have any use* for. To reflect that broader definition, I include two parameters to measure Pollution in this first version of the Model: GHG emissions and plastic waste in surface waters.

Have a look at this figure. It shows annual global **greenhouse gas (GHG) emissions** – expressed in CO_2 equivalent - measured in gigatonnes (billions of metric tons) along with the various pathways that emissions may follow in the future.

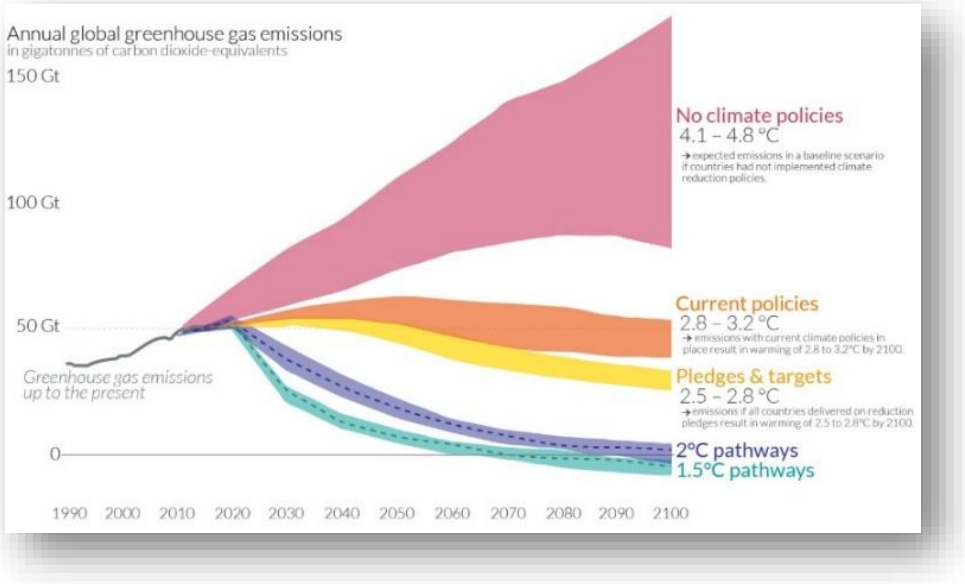

Figure 7: **Global greenhouse gas emissions and warming scenarios** *(after Climate Action tracker and OWID, 2021)*

I'm not going to dwell on this too long. I'm assuming anyone taking the trouble to get involved in the Segmented World Project is in no doubt about the overwhelming role human activity has played in creating the sudden, massive peak in GHG emissions and that the main contributor to that comes from fossil fuels, as this next figure illustrates.

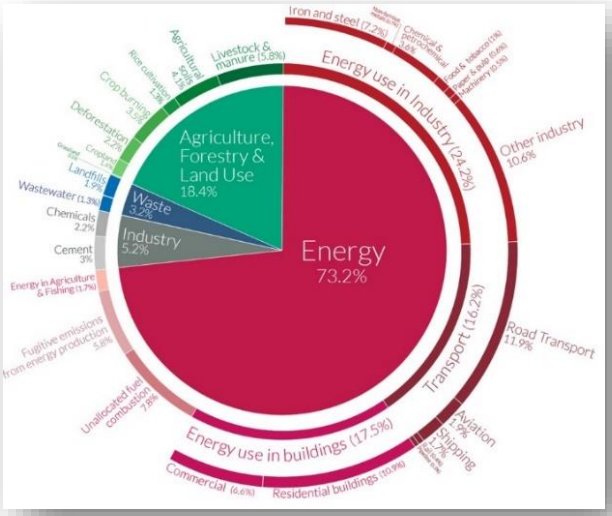

Figure 8: **GHG Emissions by Sector** (*OWID 2016*)

Interviewer: The other pollution parameter you have highlighted is **plastic waste in surface, ocean waters.** Do you have any reason for choosing this one?

FN: Plastics play an essential role in our society – imagine dealing with a pandemic in a world without plastics to safely encase the vaccine. But the side effects of this *plasticised society* are now beginning to be recognised - from minute plastic spherules used in cosmetics that insidiously enter the bodies of much marine life, to possible links between plastic chemicals and the dramatic decline in sperm count across the world. (i.e. phthalates and BPA: see *Shanna Swan, 2021*)

At present, plastic pollution has a strong regional distribution issuing prominently from Asian rivers *(OWID 1/5/21).* But the effects are already widespread, creating, for example, huge, floating litter islands in the Pacific – one being twice the size of NW Europe (*The Great Pacific Garbage Patch*; *theoceancleanup.com*). If the problem is left unchecked, it will eventually have a devastating impact on global marine life that is already having to cope with the challenge of warming seas and overfishing. These two figures demonstrate the problem of macro and microplastics and include projections up to 2050 (from *Lebreton et al 2019)* that have been used to inform the 'real' Model.

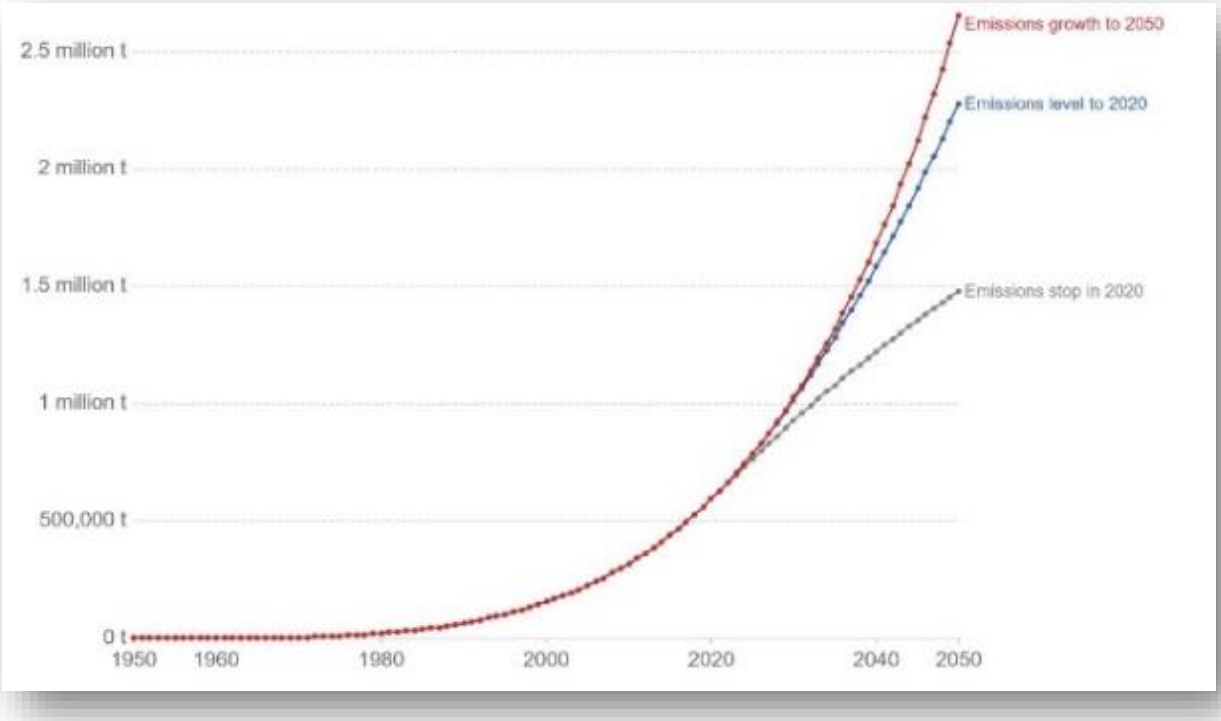

Figure 9: **Global mass budget of Macroplastics (> 0.5 cm) 1950-2020**

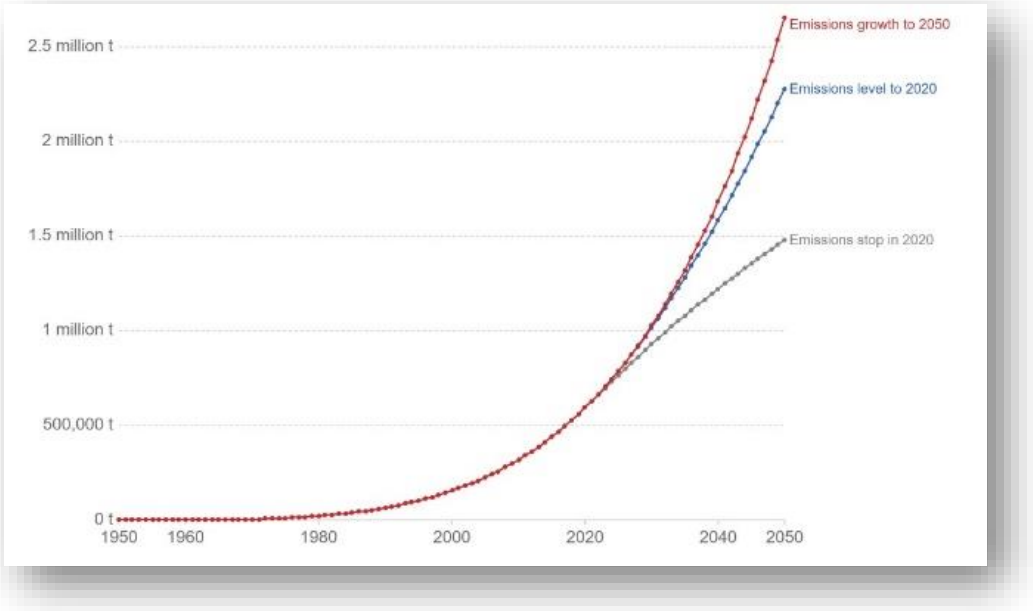

Figure 9: **Global mass budget of Microplastics (< 0.5 cm) 1950-2020**

Interviewer: The final Driver you call **RESOURCE** but looking at the figures you have here, this term has a much broader definition than normally used.

FN: Yes, in the broadest sense, RESOURCE includes all those naturally occurring elements that have not yet been exploited. In the Model, I make a distinction between **INANIMATE** (i.e. solid, liquid and gas substances) and **ANIMATE RESOURCE** – sentient life and its various environments. In the world today, we treat all these resources – as I might add most economists do in their modelling - as if they are infinite. In reality - once extinct - ANIMATE RESOURCES cannot be replaced, while the rate at which INANIMATE is replenished by further exploitation slows with time and eventually halts when the operation is no longer profitable.

Interviewer: But this is a vast topic, how do you decide what should represent this Driver – particularly when so much of RESOURCE is *hidden* from us?

FN: The approach must be one of selecting those RESOURCES that have the most critical impact on human life today.

Interviewer: So, what is the 'most-critical' inanimate resource?

FN: Without any doubt: **Water.** Just before you arrived, we had yet another summer downpour, reminding me how difficult it is, for those of us lucky enough to live in a wet climate, to relate to these concerns. But travel to many parts of the world, and a frightening situation presents itself. Huge communities who cannot guarantee a source of clean water from week to week - with plants and animals all suffering, alike. In addition, industry, agriculture, energy and mineral production also require vast quantities of clean water to

function. Even though we are a planet distinguished by the abundance of water, only around 2% is fresh and of this only 0.78% is available for human and other life forms - the rest locked up in ice.

Interviewer: But how can something like water resources be regularly and reliably monitored on a global scale?

FN: In the past, it has been very difficult but now with remote sensing from sources such as the GRACE (Gravity Recovery and Climate Experiment) satellites, we are beginning to map water resources in great detail.

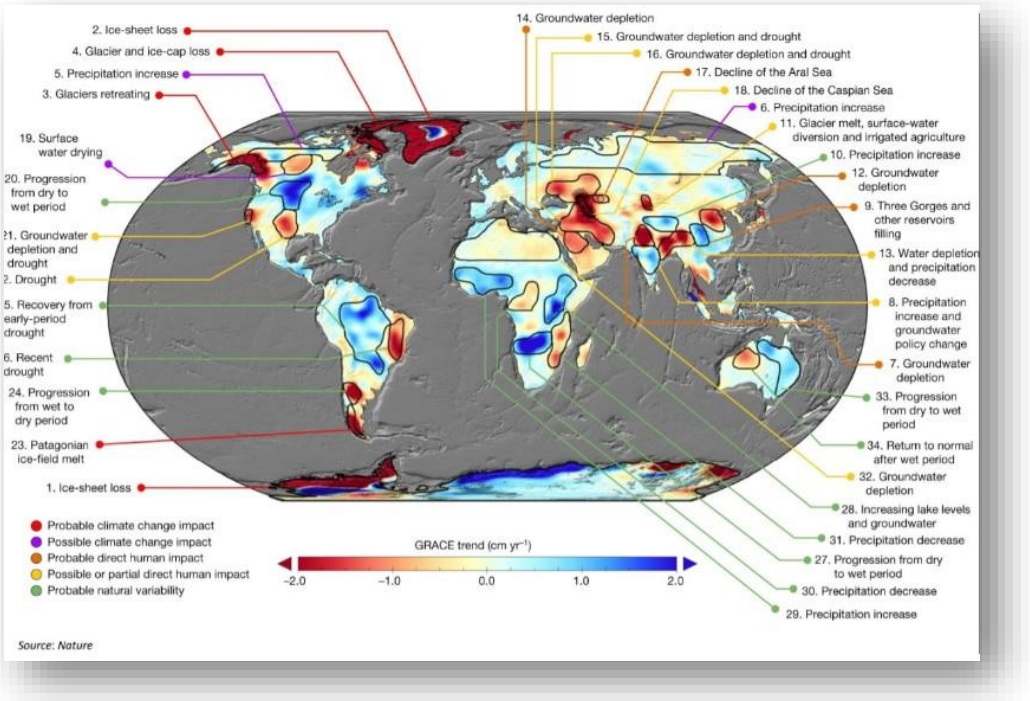

Figure 10: **Global Groundwater changes as indicated by GRACE Satellite sensing 2014** *(Nature 2014)*

Currently the world is ***not*** on track to meet the UN Sustainable Goal 6: *Ensure availability and sustainable management of water for all by 2030.* If no action is taken, then, it has been estimated , 'upto half the world's population by 2050 will no longer have safe water to drink' *(Science News 2018, Alexandra Witze).* Already, in some areas, tough choices are regularly having to be made over what water is used for. This is known as the food-water-energy nexus *(D'Odorico, Review of Geophysics, 2018)* – something that has to be handled with great care. What may sound like a quick fix - such as switching to bio-fuels away from fossil fuels to reduce carbon emissions – takes far more water to grow the crops than is consumed through using fossil fuels. As you will hear me saying throughout our dicussions, there are no easy answers just difficult compromises!

If you want a flavour of this, have a look at this figure which shows the situation in 2040, using a world view not disimilar to the **Stagnant World** we discussed in the previous dialogue.

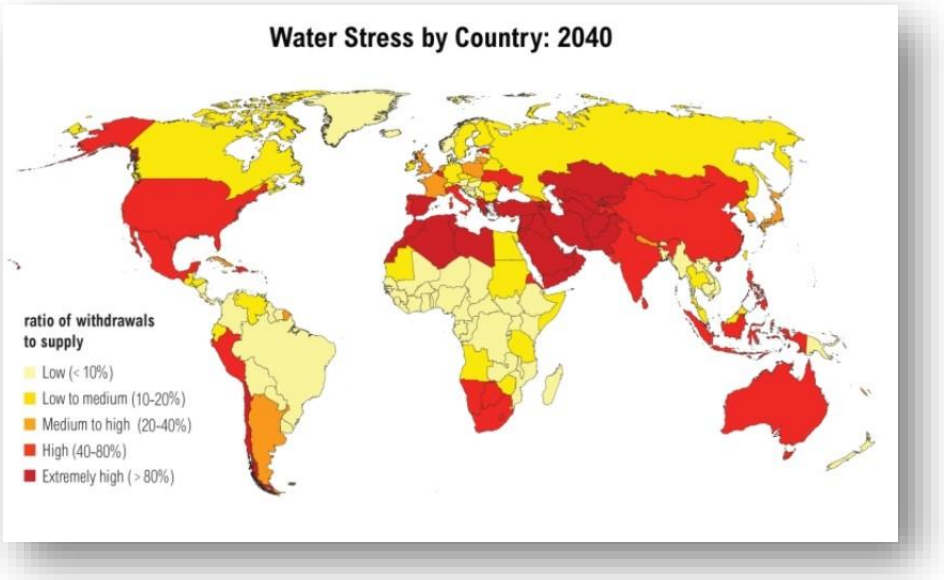

Figure 11: **Global Water Stress projection in 2040** *(Aqueduct Water Projections, The World Resource Institute 2020)*

Interviewer: And this shortage is being exacerbated by climate change, so, it is another borderless issue.

FN: Yes . . . and there is no better way to llustrate that, than a plot of *Drought Cities* – something you may recall Methuen refers to in Book 1.

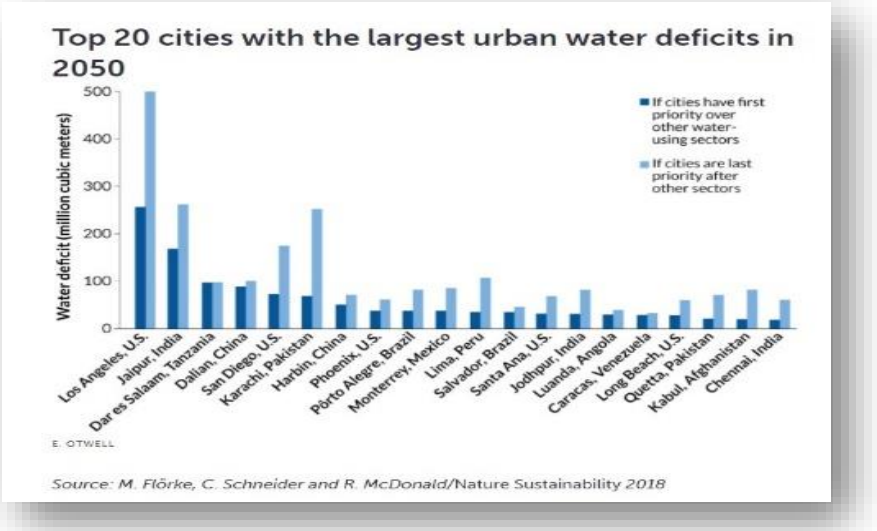

Figure 12: **Drought Cities in 2018** *(M. Florke et al Nature Sustainability 2018)*

Interviewer: Is this RESOURCE parameter used for water?

FN: I would like it to be, because it is a parameter that cuts across the normal wealth divides in our global society. Unfortunately, as in Book 1, I have no yet found a source that is committed to monitpor this long-term. I'm afraid that's often a deciding factor in choosing paramters.

Interviewer: So, what will do you use to monitor water availability?

FN: Direct measurement is not readily available – a common problem with Inaminate Resources. In the case of underground water, the problem is often not presence but supply. The peoples of an area may be dying of thirst but beneath the ground are untapped potable water sources. A recent report from Esri (*van Deusen 2021)* showed that 'most African countries have plenty of stored groundwater and enough regular rainfall to replenish the aquifers, it is just that the investment is not available to drill and produce the water'. I will come back to the issues of 'direct measurement' when we talk about oil and metals but for now, to answer your question, the parameter used to globally monitor the avaialbility of water in Version 1 is indirect through the ***global access to safe drinking water.*** Information on this is readily available linked to the UN Sustainable Goal 6. Have a look at this graph.

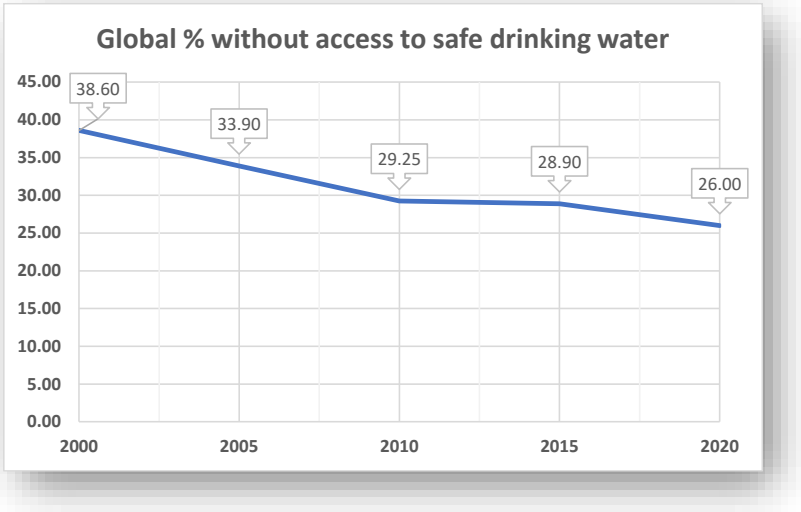

Figure 13: **Global % without access to safe drinking water** (*after WHO/UNHCR and OWID)*

Despite climate change depriving increasing areas of rainfall, the efforts of the UN and the development of China and India have managed to reduce the global percentage without access to clean water by over 30% in the past twenty years. A remarkable achievment!

Interviewer: What is next on your list of critical Inanimate Resources?

FN: After water, the second biggest concern for Humankind is **energy**. It is an emotive subject because of the link between the use of fossil fuels and climate change. However, this

figure from OWID is a sober reminder of how important fossil fuels are to human life on the planet and the relatively small contribution 'renewables' make - even in 2020.

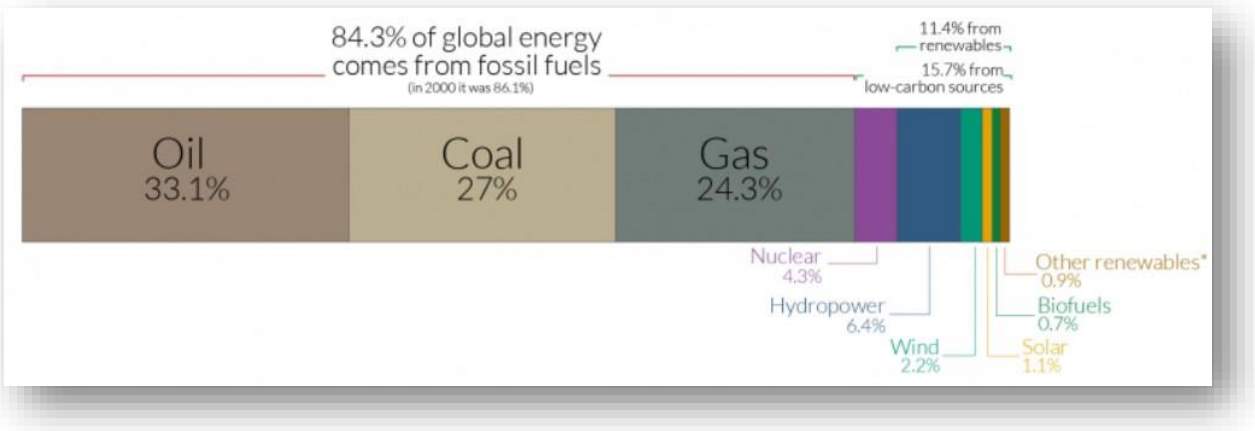

Figure 14: **Global Primary Energy Consumption by Source** *(after OWID 2020)*

Today, just over 80% of our primary energy comes from fossil fuels. In 50 years it has fallen by only 10% - just under 0.2% per year. Even if we were to increase that by five hundred percent in the future, the world of 2050 would still be reliant on fossil fuels for 50% of its energy. Unhooking ourselves from using fossil fuels will not be a quick process as some have demanded.

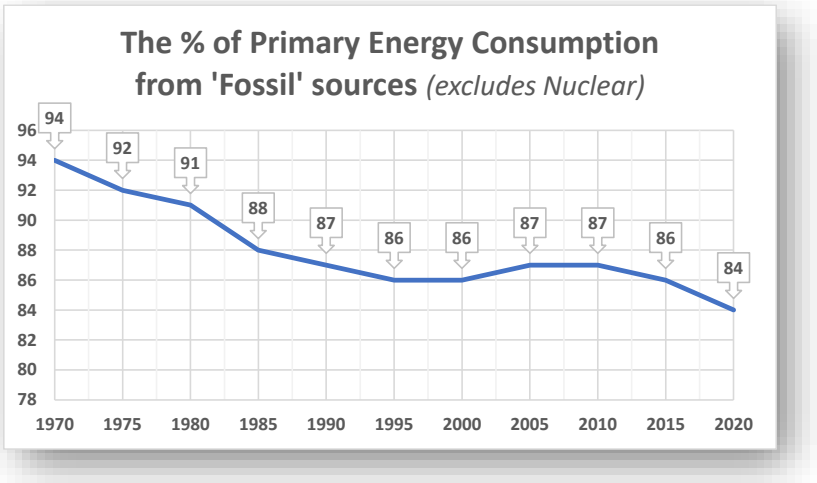

Figure 15: **Change in Primary Energy Consumption from Fossil Fuels** (*after BP Statistical Review 2020)*

A sudden cut-off in energy from oil, gas and coal for example, cannot be covered by existing non-polluting renewables. For the vast majority of countries, such a cut-off would result in even greater environmental and atmospheric damage as they switch to locally available fossil fuels, such as wood and peat (burnt biomass) – as is norm in many poorly developed

rural communities. Have a look at the next figure that shows the curent situation in rural Pakistan.

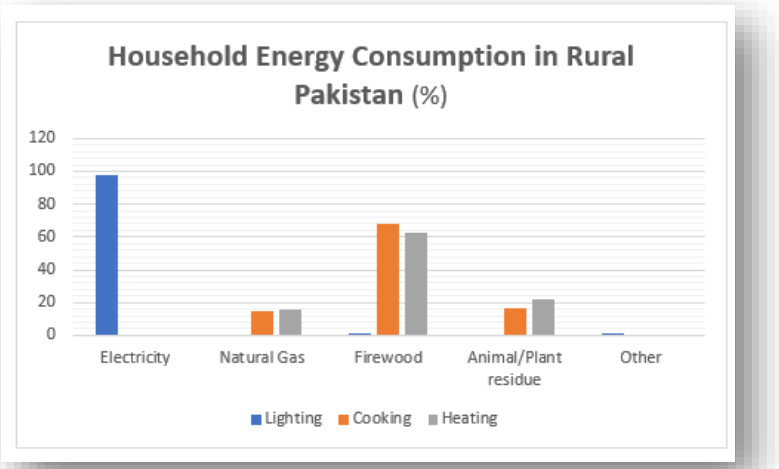

Figure 16: **Household Energy Consumption in Rural Pakistan** (*after www.researchgate.net, Moeen 2016)*

Interviewer: So the ***demand for fossil fuels*** will be the parameter you will monitor? Why not *supply* – if fossil fuels are so critical to the stability of the economic system?

FN: Of course you're right – particularly in the case of oil where reserves of 'cheap' oil *have almost certainly passed peaked production*. Some of the new hydrocarbon provinces - such as the tight oil resource in the US - will rapidly decline through this decade (*Rystad Energy 2021*), but, as with water, oil and gas supply is a complex phenomena controlled not just by the level of accessible reserves but by many other social and political factors. I will have more to say about this when we discuss the *energy transition* later on.

Interviewer: I suppose the supply of important naturally occuring **minerals** is also difficult to monitor but equally, a concern.

FN: Probably more so. Unlike energy that has the IEA globally reporting or the FAO for food and agriculture, there is no international body covering minerals to provide data dissemination or analysis as well, I might add, for setting standards and fostering global cooperation. Over the next thirty years we will also pass through a challenging *minerals transition* that may, in turn, delay the much-discussed energy transition *(IMF BLOG Boer, et al November 2021).*

Interviewer: How do you mean?

FN: The 'green revolution' is creating its own supply crisis for certain **strategic metals**. For example, battery demand is expected to grow 36% every year for the next ten years (*Rystad Energy October 2021*) requiring significant new reserves of lithium and nickel to be

exploited. But, even more significantly, the transition also includes many minerals widely-used today such as zinc and even copper, nickel and tungsten as well as materials used in construction (e.g. sand and gravel) and industry (e.g. salt and barytes). This Table lists the metals currently on the inanimate resource equivalent of an endangered species list!

METAL (mln. metric tons)	Global Production *(USGS 2021)*	Global Reserves *(USGS 2021)*	Reserve Life (Years) (from 2020 / 2050)	Recycling (2020) Sustainable Substitution	Usage and Comments
Antinomy	0.153	1.9	12.5 / **POST PEAK**	Low / Limited	Storage batteries, solders, alloys, flame retardment;
Chromium	40	570	14/ **POST PEAK***2	Low / Limited	Stainless Steel; large undeveloped resource*2
Cobalt	0.14	7.1	25/ **POST PEAK**	Medium (29% in US) / Limited	Superalloys; aircrft, batteries; large resource in seabed nodules
Gold	0.0032	0.053	16.5/ **POST PEAK**	High / Limited	Currency hedge; electrical goods
Lead	4.4	88	20 / **POST PEAK**	High (73% in US) / Limited	non- SLI batteries
Silver	0.025	0.5	20 / **POST PEAK**	Low / Limited	Electrical, photo voltaic cells
Tin	0.27	4.3	16/ **POST PEAK**	Medium (24% in US) / Limited	Tin plate, chemical solder
Zinc	12	250	21 / **POST PEAK**	Medium (33% in US) / Limited	galvanising, zinc-based alloys, rubber, paint - many applications

Table 1: **Global Production, Reserves, Substitution and Usuage of 'threatened' metals** *(after USGS 2020)*

Interviewer: Another dimension to this, is the uneven distribution of INAMINATE RESOURCE that, as availability decreases, will confer geopolitical advantage to some and disadvantage to others.

FN: We will talk about this again when we discuss GOVERNANCE but already the emergence of OPEC to control a significant portion of the world's crude oil production, plays a significant role in shaping global geopolitics today. The next figure shows another politically significant INANIMATE RESOURCE - the alarming concentration in China of the worlds Rare Earth Oxides production – minerals critical to the electronics industry.

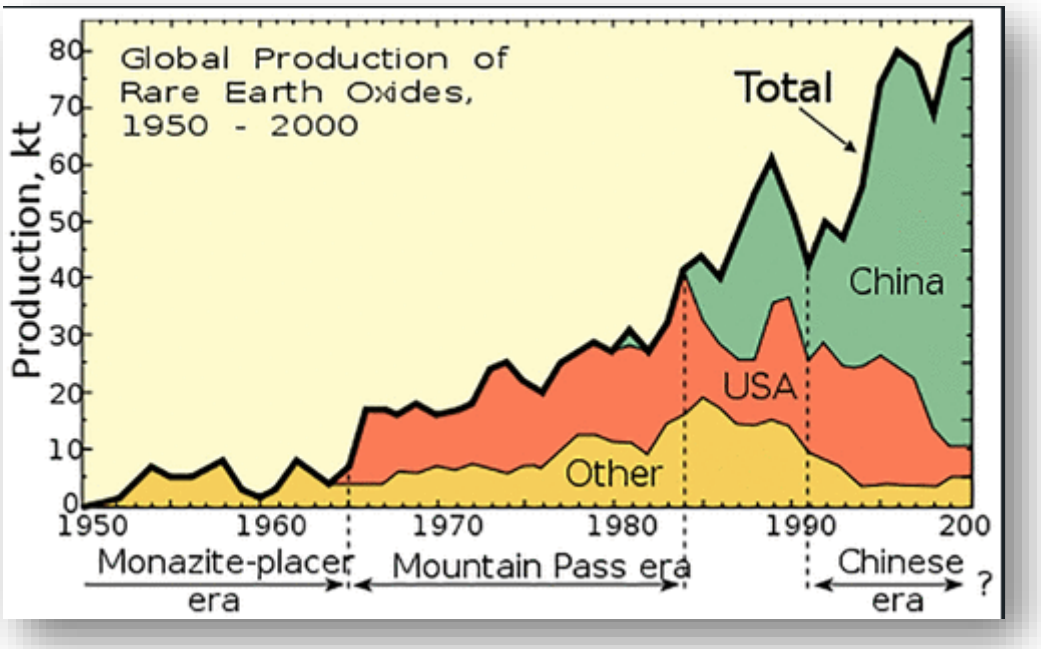

Figure 17: **History of Rare Earth Oxide Production: 1950 – 2000** *(BMacZero 2010)*

Interviewer: According to Table 1, at present, hardly any substitutes for these critical minerals exist.

FN: Yes . . . and that despite the enormous prize that awaits anyone who can invent a cheap substitute for copper, for example. The fact that substitutes haven't been found is because they often fall into the 'very diffcult class' for innovators. This, if you recall, is what afflicts the Anxious and Stagnant Worlds – an inability in the next thirty years to solve the 'very difficult' problems. Easier to focus on space tourism than invest in the basic research required to create new substitutes. (*Please read Prince William's interview with the BBC on 14/10/21 for a more polite version of this view*).

Interviewer: Of course, increasing exploitation to find more fossil fuels and minerals, adds to the threat of what you call, the ANIMATE RESOURCES on the planet. This is another huge topic, and, again, I wonder how it can be sensibly represented by a limited number of parameters?

FN: The answer to that was - at the start of the Millennia – 'not easily'. But now, with growing awareness of the threats to the biosphere, an increasing number of global monitoring programmes are beginning to get a realistic picture of how the natural environment is being affected by the changes that are occurring in the world.

A good example of regular and reliable global reporting is the **Living Planet Index** - compiled by the Zoological Society of London (ZSL) and World Wildlife Fund (WWF). The Living Planet project reports on the state of more than 20,000 wildlife populations from across the world - everything from hedgehogs to buffalo. The headline result is that we have seen an average decline of 68% of wildlife populations since 1970 but, as OWID correctly point out, it is necessary to also look at the data closer – it isn't all bad news!

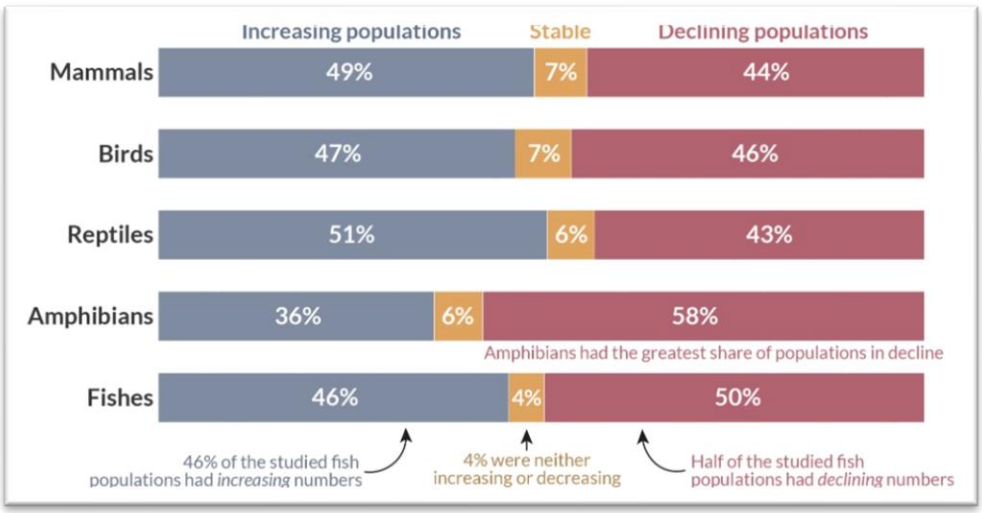

Figure 17: **Global Living Planet Index** *(WWF 2020 and OWID)*

Interviewer: If I could interject here with, what I know is a disagreeable question. If I were living in one of those Fully Segmented Worlds you describe in our first discussion, I might ask: 'What is the utility of wild animal life?' Unlike wild plants, that have clear medicinal benefits for us, the presence of other creatures living naturally alongside us contribute little to our survival.

FN: Whether we live in a city or a jungle, we depend on ecosystems to provide freshwater; to pollinate plants, to raise soil fertility and so on. Animals are an essential part of all these ecosystems. If the ecosystems weaken then those 'services' - if you like - are also weakened. But there's another more subtle but no less profound reason why wildlife is important to us. Allowing wild animal life to go extinct, extinguishes something that has always been important in defining who we are as human beings—

Interviewer: You mean something to measure ourselves against?

FN: Not measure – but something that reminds us, that whatever our ethnicity or different proclivities might be, we are just one sub-species in a highly speciated world. I believe this perspective of ourselves is *so* important, that I've included, in this first version of the Model, a second general biodiversity parameter: the **Mean Species Abundance** (MSA). This is an Index supported by the UN, OECD and others and measures the degree of naturalness. The relative abundance of a species is the % of individuals left in a given ecosystem compared with the past undisturbed situation. The MSA is then the mean of the relative abundance of all species left.

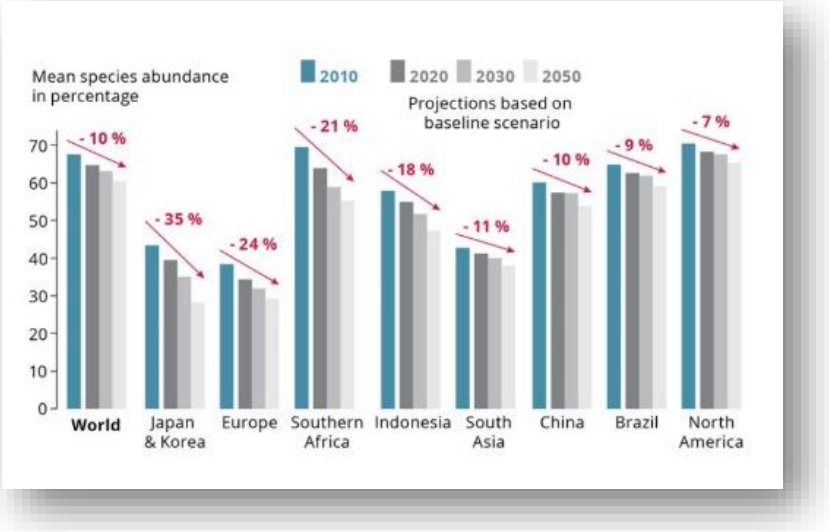

Figure 18: **Mean Species Abundance** *(European Environmental Agency 2015)*

Interviewer: If measuring land-based animals is difficult, the next category, marine life, must be even more underdeveloped and from what the previous figure showed - most threatened!

FN: Unquestionably so, and that despite the critical role marine life plays in maintaining the health of our oceans and the world's carbon cycle. The global population of phytoplankton, for example, that absorb CO_2, may have fallen by as much as 40% since 1950, according to researchers at Dalhousie University in Canada. This is a potentially devastating trend that will be picked up for monitoring here, once reliable tracking of the data is available.

For this section, the measure that will be used is one provided by the Food and Agriculture Organisation (FAO) as part of UN's Sustainable Goal 14 (Life below Water). **The % of wild fish stocks being fished in a sustainable manner as a % of the Total**. It provides a clear indication of the way in which the world is responding to the UN's Code of Conduct for Responsible Fisheries that has been updated every two years since 1995.

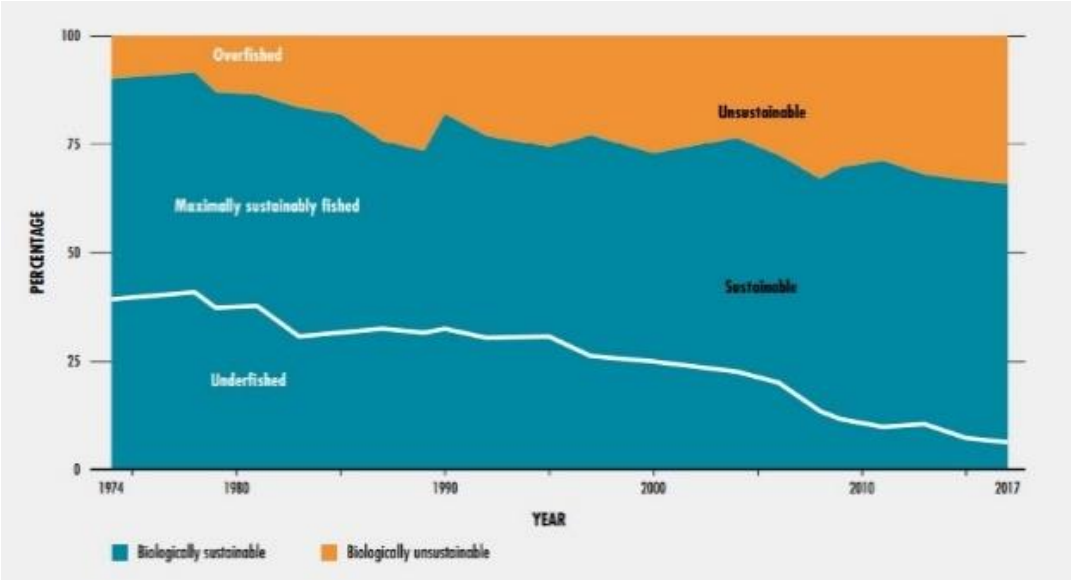

Figure 19: **The global state of wild fisheries** *(FAO 2018)*

Interviewer: I'm surprised to see this plot because, contrary to what I had assumed, fish stocks are not from a global perspective, over exploited.

FN: This is why properly validated *numbers* are important and agencies such as the FAO vital for giving us an objective global picture. Of course, there are some horrific examples of over fishing – the disappearance of cod on the Grand Banks off Newfoundland many years ago is a well documented case - but in 2017, at least, the FAO reported that 66% of monitored fisheries are at biologically sustainable levels accounting for almost 80% of the fish we consume.

Interviewer: Finally, there are plants. I imagine like marine life, global data is poor despite the critical role they play in, not least, keeping us alive by absorbing CO_2 and releasing oxygen.

FN: That's correct abut Again measurement is a limiting factor, so that is why I have chosen chosen **Trees**. They are the most conspicuous plants on our planet that can now be accurately measured from space. It has been established that forests cover around 25% of the world's land surface today, down from just under 50% in the 1800's. Most of this loss is the result of land converted for agriculture. About the same area occupied by forests is, also taken up by grazing land, used for meat production. The 3Tn trees estimated in 2015, play a critical role in the health of the planet as you have mentioned but are also essential in creating the richest habitats for animals and plants. Of the total forest cover, 70% lie in the northen hemisphere predominantly in the Powerblocks (Dialogue 1). In recent years, the area of tree cover has been *increasing* in these areas. Virtually all global forest loss (whether degradation or deforestation) occurs in the southern hemisphere – in the tropical *StaticLands***,** to use the geopolitical parlance of the Segmented World Model. Much of the exploitation occurs in order to provide the Powerblocks with agricultural and forestry products. Deforestation is a topic being followed by OWID who provide this informative historical plot.

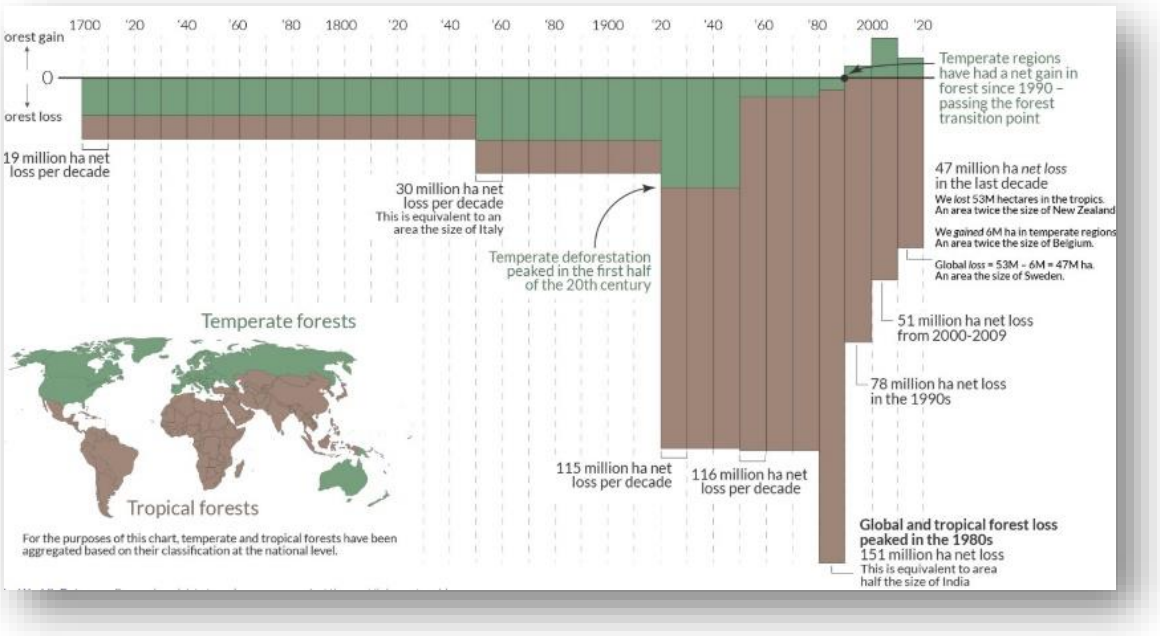

Figure 20: **Global Forest Changes** *(after OWID, 2020)*

Interviewer: I'm trying to imagine how biodiversity is viewed today, let alone thirty years from now. There is undoubtedly a mood in favour of protecting the natural enrionment, spurred on by concerns over climate change—

FN: In comfortably-off western countries, you are correct. Also, the technology - the processes required to re-instate ecosystems and thereby improve global biodiversity - are already well known and, of course, eagerly taken up by nature! Local measures, like the

creation of national parks, marine conservation areas and re-wilding of agriculture land are now creating linked corridors, restoring habitats and raising biodiversity levels. But in much of the world, there is a reluctance to adopt these practices, for economic reasons. A growing population and the demand from affluent countries for cheap food, maintains the rate at which natural ecosystems are converted into sterile environments. The onus is upon us, in the affluent countries of the world, to act, by practicing what we preach and only importing products from countires that adopt similar practices.

Interviewer: So that is your final Global Driver parameter? As we're approaching lunchtime, maybe we stop here for a break and then start again this afternoon with the parameters that you plan to use for monitoring the *Inevitable Consequences* of the Segmented World.