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Human Overpopulation Atlas

Volume I

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HUMAN OVERPOPULATION

VOLUME I

JOÃO L. R. ABEGÃO

Acknowledgements

"As if there was much of anything in any human utterance, oral or written, except plagiarism! The kernel, the soul – let us go further and say the substance, the bulk, the actual and valuable material of *all* human utterances – is plagiarism. For substantially all ideas are second-hand, consciously and unconsciously drawn from a million outside sources…"

- Mark Twain, in *Mark Twain's Letters Volume 2 1867-1875* (Clemens, 2012). Letter to Helen Keller about the Myth of Originality (Popova, 2018).

A coalescence and unification of knowledge such as the one that was conducted in this work would not have been possible without the unflagging and indefatigable examination and experimentation of others. First and foremost, this work is an amalgamation of their inquiry, so to all of them I owe a debt of gratitude, since without their clarity and understanding I would never have been able to articulate my thoughts, reflections and rationalizations.

As the reader delves through this work, I would exhort him or her to never lose sight that the scientific method relies on an aggregate and sequence of ideas, concepts and designs. To this end, it can be almost inconceivable to claim any solo authorship of this work, as it must be remembered from Mark Twain's literature: "When a great orator makes a great speech you are listening to ten centuries and ten thousand men – but we call it *his* speech, and really some exceedingly small portion of it *is* his" (Clemens, 2012). To this end, I made sure to properly cite every author and provide links to their works (in-text), so the reader may conduct an independent investigation, on his/her own accord. Regarding any text devoid of citation, it can then be considered my own expostulation, even though I share Twain's reticence and reservations to its *originality* or *authenticity*, and can only allege a *bona fide* intent of not committing intellectual appropriation.

Equally important, this first volume stands as a consolidation of many different disciplines, and individuals with distinct backgrounds, and notwithstanding their commitment to the subject of human overpopulation, they all share an engagement with the constancy and maintenance of human and non-life on this planet (the majority at least) and the conditions to sustain healthy and vigorous ecosystems. Nevertheless, I want to use this section to properly commend the efforts of those researchers, activists, spokespersons, artists, journalists and basically anyone who has devoted a portion of their time on this planet to the subject of the rise of human numbers and what it entails. If the reader isn't among that diverse group just yet, my end in view is that by the completion of this first volume they might be willing to change.

Furthermore, and more specifically now, I would want to show appreciation and praise the Faculty of Sciences of the University of Porto (FCUP), respectively the Biology Department and the Scientific Committee for the broad-mindedness and receptiveness in allowing this work to be used as my thesis for the Masters in Ecology and Environment. At a time when scientific creativity and ingenuity are often stifled and suppressed due to excessive bureaucracy, norms and protocols, it is the people behind the curtains of these institutions, which are willing to bet on unfamiliar approaches while recognizing their merit, that push the scientific understanding a step forward. I feel a sense of obligation and deep indebtedness to the professors in the FCUP for placing their confidence and giving credence to what at first might have resembled a madman’s reverie.

Lastly, I would like to individually thank the advisors that accompanied the development and flourishing of this work and stood by its defence:

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Keywords

Human Population; Overpopulation; Limits; Ecology; Climate Change; Species Extinction; Food Security; Water Stress; Biological Diversity; Immigration; Malthusian; Growth; Diets; Environment; Fertility; Reduction; Projections

Abstract

According to archaeological records, it is realistic to consider that it took the entirety of human history on this planet for our numbers to reach 1 billion, at the beginning of the 19th century. The 2 billion mark was reached in 1927 and after that our human population numbers surged upwards and haven't stopped ever since. Currently, in 2018, our species is estimated to have attained 7.6 billion individuals, with projections for 2050 amplifying this figure to 9.9 billion and close to 12 billion by 2100. The reader is invited to take a moment to ponder and deliberate on this change. By 1927, a date in which most reader's parents or grandparents were arriving on this Earth, the human aggregate was roughly 2 billion. That means that any individual that was born by that time and is still alive today, has witnessed the human population almost quadruple, even if he or she was never aware of that fact.

In this first volume of the Human Overpopulation Atlas, the reader is presented with a compilation of scientific literature, as well persuasive argumentation from an array of experts, with the intent on making the case that many of the symptoms of ecological, environmental, sociological, geopolitical and economic predicaments that have tainted our world, have a root cause or can be, indubitably, linked to our vast and rising numbers. And how could it not? Every new human passenger on this Earth comes equipped with necessary requirements that need to be met to safeguard his or her existence and flourishing. That person will require food, water, shelter, clothing, energy, materials, technology, transport, infrastructure, space and security and will in turn exude residues and waste, alter habitats and pollute the atmosphere, soil and water courses. Even if each human being contributes in an almost imperceptible way, 7.6 billion is a tremendous number that our mind can't even begin to conceptualize, with all of those trivial impacts amounting to profound transformations. The Human Overpopulation Atlas describes those deviations.

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Definitions

Place is a deep attachment to specific geographies fashioned by repeated interactions that provide both the context and content for the construction of personal and cultural identity. Places are those sites that evoke a profound sense of belonging, where values (and virtues) are acquired; sense-of place values include continuity (tradition), reciprocity (enduring cooperation), embodiment (belonging), integrity (obligation) and informed judgments (justice) (Chapman, 2006).

Ecological niche is the position occupied by an organism in relation to other organisms and to the environment. Also, a particular part of an ecological environment in which a singular plant or animal species prospers. It is the set of terms, in relation to food and water supply and relationship with predators and disease and with competitors, by which the organism achieves its full biological potential (The Free Dictionary, 2018)

Refugee are defined as those who "owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion" have had to flee their country of origin are protected by International law with the "right of non refoulement" that forbids forced repatriation (UNHCR, 2018).

Climate refugee, persons or groups of persons who, for reasons of sudden or progressive climate-related change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes either temporarily or permanently, and who move either within their country or abroad (EJF, 2017).

Human Carrying Capacity, equals the maximum human population *equipped with a given assortment of technology and a given pattern of organization* that a particular environment can support, without life-supporting-reducing habitat damage (Catton, 2012).

Urban: There is no general agreement on a definition of what is urban. In Europe and North America, the urban landscape is often defined as an area with human agglomerations and with >50 percent of the surface built, surrounded by other areas with 30-50 percent built, and overall a population density of more than ten individuals per hectare. Urbanization can be defined as a multidimensional process that manifests itself through rapidly changing human population and changing land cover (Seto, Pernell & Elmqvist 2013).

Net migration, for a given country and time period, refers to the difference between the number of immigrants and the number of emigrants. If more people immigrate than emigrate, the country gains population due to positive net migration, or net immigration; when more people emigrate than immigrate, the country loses population through negative net migration, or net emigration (Business Dictionary, 2018).

Relative Decoupling: "Put very simply, relative decoupling is about doing more with less: more economic activity with less environmental damage; more goods and services with fewer resources inputs and fewer emissions. Decoupling is about doing things more efficiently. And since efficiency is one of the things that modern economies are good at, decoupling has a familiar logic and a clear appeal as a solution to the dilemma of growth (Jackson 2011)".

Absolute Decoupling: It refers to the ability of an economy to grow without corresponding increases in environmental pressure. In many economies, increasing production (GDP) raises pressure on the environment. An economy that is able to sustain GDP growth without having a negative impact on environmental conditions, is said to be decoupled (Wikipedia, 2018). Needless to say, no such state has been attained as say: “Growth in GDP ultimately cannot plausibly be decoupled from growth in material and energy use, demonstrating categorically that GDP growth cannot be sustained indefinitely” (Ward et al, 2016).

Ecojustice: “a general set of attitudes about justice and the environment at the center of which is dissatisfaction with traditional theories of justice. With few exceptions (notably a degree of concern about excessive cruelty to animals), anthropocentric and egocentric Western moral and ethical systems have been unconcerned with individual plants and animals, species , oceans, wilderness areas, and other parts of the biosphere , except as they may be used by humans. In general, that which is non-human is viewed mainly as raw material for human uses, largely or completely without moral standing.” More in (Encyclopedia.com, 2018).

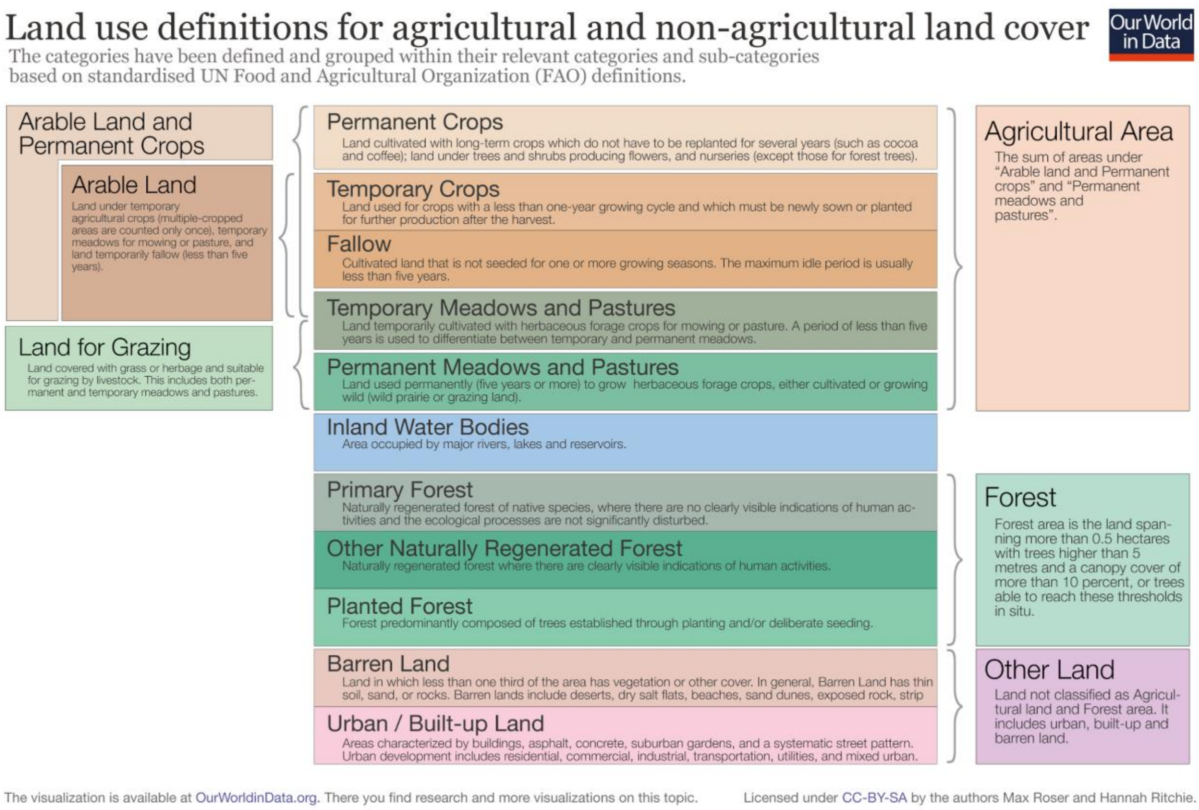

Figure 0.1: Land use definitions for agricultural and non-agricultural land cover. Retrieved from Roser & Ritchie, 2018.

Acronyms and Abbreviations

1. [CO_2] – Carbon Dioxide Concentration
2. AAAS – American Association for the Advancement of Science
3. BAMS – Bulletin of the American Meteorological Society
4. BCE – Before Common Era
5. CCC - Climate Change Committee
6. CCEI – Climate Change Exposure Index
7. CCP – Comprehensive Conservation Plan
8. CE – Common Era
9. CO_2 – Carbon Dioxide
10. DfT – Department for Transport
11. DRC – Democratic Republic of Congo
12. DTT – Demographic Transition Theory
13. EF – Ecological Footprint
14. EJF – Environmental Justice Foundation
15. EU – European Union
16. FAO – Food and Agriculture Organization
17. FARC – Revolutionary Armed Forces of Colombia
18. GDP – Gross National Product
19. GHGs – Greenhouse Gases
20. GISS - Goddard Institute for Space Studies
21. GNI – Gross National Income
22. GRID – Global Report on Internal Displacement
23. HANPP – Human Appropriation of Net Primary Production
24. HDI - Human Development Index
25. HIPPO – Habitat Destruction, Invasive Species, Population, Pollution and Overharvesting
26. IDMC – Internal Displacement Monitoring Centre
27. IDP – Internally Displaced Person
28. IFPRI – International Food Policy Research Institute
29. IOM – International Organization for Migration
30. IPBES - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
31. IPCC – International Panel on Climate Change
32. IPO – Interdecadal Pacific Oscillation
33. IUCN – International Union for Conservation of Nature
34. LDCs - Least Developed Countries
35. LECZ – Low Elevation Coastal Zones
36. MDGs - Millennium Development Goals
37. MPA's - Marine Protected Areas
38. NASA – National Aeronautics and Space Administration
39. NDCs – National Determined Contributions
40. NOAA – National Oceanic and Atmospheric Administration
41. ODI – Overseas Development Institute
42. OHC – Ocean Heat Content
43. ONS – Office of National Statistics
44. PA's – Protected Areas
45. PEG – Political Ecology Group
46. PETM – Palaeocene-Eocene Thermal Maximum
47. PNAS – Proceedings of the National Academy of Sciences
48. SDGs – Sustainable Development Goals
49. SOFIA – State of the World Fisheries and Aquaculture
50. TFR – Total Fertility Rate
51. UN – United Nations
52. UNCCD – United Nations Convention to Combat Desertification
53. UNEP – United Nations Environment Program
54. UNFPA – United Nations Population Fund
55. UNHCR – United Nations Refugee Agency
56. UNICEF – United Nations International Children's Emergency Fund

57. UNPD – United Nations Population Division
58. WAD – World Atlas of Desertification
59. WMO – World Meteorological Organization
60. WWF – World Wildlife Foundation
61. RCEP – Royal Commission on Environmental Pollution

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Foreword

- The Atlas' Burden -

"The student of population growth, and its consequences finds himself compelled, whether he likes it or not, to assemble information from the diverse fields of biology, medicine, mathematics, archaeology, history, nutrition, agriculture, geography, sociology, politics, economics, town planning, and traffic engineering - to say nothing of questions of morals and religion."

- Colin Clark, *in Population Growth and Land Use (*1977)

Before we embark on this journey through the countless realities that our numbers touch and impinge upon, I would like to take a moment to clarify and elucidate the reasoning behind my choice to name this work Atlas and create the art that stands at its cover. To the reader who is unaware of Greek mythology, Atlas was a Titan condemned by Zeus to shoulder the sky (later the image of Atlas holding the Earth was adopted) for all eternity as punishment for defying the gods of the Olympus. Unlike the fables of past ages, this chronicle is no figment of the imagination or enterprise of the mind, moulded by allegories or parables, although I expect that throughout this work some moral reasoning might indeed percolate and occupy the reader's attention.

Beyond the old myths, there were attempts to decipher the etymology of the name Atlas and its symbolism. In particular, the Roman poet Virgil associated the Atlas narrative with an emblem of endurance and resilience. Conversely, I have begun to formulate a different interpretation. What if the meaning behind the infliction of "shouldering" the globe is instead a metaphor for overseeing and safeguarding this planet during its brief existence? Following this rationale, one could even assert that the most accurate castigation given to Atlas was to be forever cognizant and knowledgeable of the maladies brought upon this celestial body. In a sense, Atlas could have been condemned to act as the guardian of this planet, with its affliction being the perpetual awareness of the many threats inflicted on this Earth.

Translating this myth into our everyday life and to the context of this work, I could impute the role assigned to Atlas to any individual who is aware of and alert to the threats imposed on this planet, and in a way, cursed with knowledge and foresight. During the process of assembling information for this work, I would find myself probing and dissecting one specific event or scenario with a causal link connected to our vast human numbers, and immediately be aware of its links to other causes. For instance, considering water stress in Pakistan, the related issues rapidly become apparent, for example, species extinction, habitat loss resources, appropriation of land, degradation of soil, excessive livestock, ocean acidification, extreme meteorological phenomena, excessive tourism, food security, morality of procreative decisions, rise in per capita affluence and excessive consumerism, and an economic model that is lifting the tide for everyone who owns a boat, while deluging the natural world in the process. It was an *overwhelming* barrage of occurrences, and in reality, all of these factors eventually are exacerbated by our rising numbers. In essence, this unbounded load of problems and issues – that embodies the study of human overpopulation –conceived of this little twist in Greek mythology.

For the last two years, as I have been amassing literature, articulating thoughts and composing the narrative that gave rise to this book, I began to realize that I was only scratching the surface of my understanding of the innumerable mechanisms operating in tandem with the expansion in numbers of our species. It might be reasonably plausible to assert, that population studies are conceivably one of the most multidisciplinary and integrative areas of study out there. Simply put, it encompasses such a sweeping latitude of disciplines that the reader will find him or herself invariably interchanging among different branches of knowledge as Colin Clark put it in *Population Growth and Land Use* (1977) (mentioned above).

Due to the overwhelming magnitude of issues contemplated in *The Human Overpopulation Atlas*, I decided to divide it into several volumes, each reflecting upon distinctive matters of contention that end up being deeply intertwined. As a result, this first volume is bisected into two parts, comprised of eight particular chapters. Part I incorporates three chapters:

- The first chapter The Root of All Evil & the Evil Twin introduces the reader to the issue of human overpopulation and the extensive ecological damage perpetrated by the explosive surge in the number of *Homo sapiens* roaming the planet. By making use of the latest reports, trends and projections in demographic data, the reader will be quick to catch up to the fact that never before has such a numerical experiment been carried out on this planet, and that we are not fully aware of its many consequences. Moreover, this chapter introduces the dispute and synergy between human overpopulation and overconsumption, and unveils from the get-go, the exigency of ceasing population growth as well as the imperative and urgency of contracting our human aggregate to a sustainable figure, due to constraints of a finite planet with finite resources.
- The second chapter Prometheus is meant to illustrate how fears of overpopulation and resource overshoot have always permeated human history. By making use of ancient and classical writings, that were preserved to our days, the reader will soon recognize that population issues are not just trepidations and anxieties of a few contemporaneous alarmists, but instead, that many individuals throughout human history foreshadowed its occurrence and consequences.
- In the third chapter Judas and the Elephant in the Room, two main issues are characterized: the disinclination to discuss, debate and include population issues in the many realms of dialogue, be it the media, politics, *academia*, environmental groups, human rights activists, journalists, artists among others, as well as the state of discourse that revolves around those that attempt to broadcast and disseminate those ideas. That silence explains the Elephant in the Room, while the Judas is an allegory to the dishonesty and betrayal from those who are best suited to come to the defense and

endorse the criticalness of human population growth, but instead, opt to disregard or just scorn and despise those who do.

These three chapters complete the first part of this book. After roughly 100 pages, the reader will be much more informed regarding the past, present and future prognostications with respect to demographic tendencies. Comparatively, the second part of this book, which is comprised of four distinct chapters will burrow into some of the ecological, environmental, and sociological aspects of unrestrained population and consumption growth. Part II integrates these four chapters:

- The fourth chapter Where the Wild Things Were encases the ecology nucleus of this book. Since not every reader will be well-rounded and experienced in concepts and terminology, I made sure to properly clarify and illustrate any necessary jargon and nomenclature that is used frequently. The chapter itself is a memoir of loss. But one that is dedicated to the non-human passengers on this planet that have sustained the worst offences. From time immemorial, when our ancestors first walked upright and spread to every corner of the world, they carried with them a torch of dispossession and wreckage. That flame burns stronger than ever in our modern days, to each all-new human passengers brought to this Earth are complicit in some way (some more than others, evidently).
- Hunger Games is the fifth chapter in this series, and as the name implies it deals with scarcity, namely, water and food insufficiency. This is also the chapter with the highest amount of unique segments, each one imparting distinct consequences of human population growth regarding food security. Examples range from living space and land allocation; soil degradation, climate change on food security; water stress; diet and affluence; livestock, food waste and the nutrient deficit, among others.
- The sixth chapter Category: Chaos, delves into anthropogenic climate change, and how human activities and the number of participants are magnifying and aggravating its effects. The chapter starts with an overview of climatic science to put everyone on the same page. It is followed by a segment that scrutinizes the so-called efforts by the international community to restrain the progression of this human-made monstrosity. Furthermore, I explore how the effects of global warming are affecting ecosystems, as well as the acidification of the ocean. Equally important is the segment that probes into the escalation and intensification of natural phenomena, which is the aspect of anthropogenic climate change that is less abstract and more immediate. Moreover, and uniquely in this first volume is the segment that deals with procreative ethics in a rapidly changing world under the effects of climate change. Lastly, I navigate through the theme of internal displacement and climate refugees due to the widespread repercussions of climate change.
- The seventh chapter, Exodus is a preliminary attempt to understand immigration and how excessive human fertility is inducing ever more people to relinquish their homes and propel migratory movements. The chapter encompasses a literary review that migration has always been a part of human history, but also examines the arguments made by scientists, scholars and philosophers that migration should be restrained in order to reduce the escalation of ecological deterioration while proposing a policy to

humanely deal with this circumstance. Besides improving on these points in the upcoming volumes, I will also explore the socio-economic, political and cultural backlash derived from extensive migratory movements.

- The last chapter, The Sword of Damocles, brings the narrative back to the parables of old, which bestow us with ancient knowledge while helping us make sense of the present. Moreover, this chapter embodies an amalgamation of reflections and deliberations that I discern to be paramount to the many questions that might arise in the mind of the reader, in the interim of studying this document.

To the best of my abilities, I paraphrased and reworded the whole body of content present, so allow me to apologise in advance to any author if by any means I misrepresent their views through the process of rephrasing and interpretation. If by any chance that happens, feel free to contact me directly since I will continue to revise this work and update revised versions.

Regarding the sources used throughout this work, these cross several disciplines, with the essential ones being ecology, demographics, geodemography, history, sociology, natural sciences, geography and to some extent, economics and politics. I also analysed numerous fundamental texts written by scientists, intellectuals, scholars, activists, non-profit organizations, think tanks, UN agencies, international bodies, national governments as well as various articles by journalists. With respect to the pertinence of using these sources, this stems from an intention of making this work more flexible and manageable for the reader. My stance on this is that by merging scientific knowledge with journalism and abounding interventions from experts on the media, one gets to perceive the disposition and personal viewpoints that generally are not reproduced in scientific papers, as a result, this gets to humanize science. Coupled with this, I was assisted by online subscriptions to a considerable number of newspapers and a legion of news digests from a myriad of entities and collectives.

Together with this, throughout the research period, I attempted to invalidate parochial and insular views, and instead exerted myself to provide a global scope of phenomena, by monitoring and illustrating scenarios on an international scale, in the hope that I could portray how human overpopulation and the threats it multiplies can pervade every nation. Although that was my aspiration, it becomes unavoidable to focus on particular countries that first, are more affected than others, and second, because someone is writing about it, therefore more data and literature can be found. Henceforth, the countries that are put under the spotlight are China; India; the United States; the UK; several countries in the African continent; South America to a certain extent, the EU, and South-East Asia, among others.

Finally, it needs to be stated that the words expressed in this work are the result of a transitory state of knowledge, and since the acquisition of insight and wisdom translates into a cumulative process that does not signify an immutability of my convictions. This isn't to say that my views expressed here are volatile and elusive in their nature, it just manifests a malleability in intellectual reflection. It reminds me of John Maynard Keynes quote: “When my information changes, I change my mind. What do you do sir?”

This becomes even more pressing when we take into account the interconnected age we are living in, when all content made available online can follow and ruin an individual's life in a matter of days. One just needs to be aware of how a photo, a *tweet* or an essay on a theme such as human population growth, reproductive rights and procreative ethics, that invites so much controversy, can be taken out of context or simply directly quoted if the moral *zeitgeist* changes dramatically. In other words, one can't really anticipate how in a few years or decades some expostulation presented here - contemporaneously many are already considered taboos - does not end up becoming a scientific and cultural no-go field, such as race and IQ (if the reader is not familiar with the case of Charles Murray and his book "*The Bell Curve*: *Intelligence and Class Structure in American Life*" (1994) I would prescribe listening to Sam Harris podcast *Waking Up* (Harris, 2017)], or the case of the online shaming of the philosopher Rebecca Tuvel surrounding her paper *In Defense of Transracialism* (2017).

Nevertheless, as this long-format thesis is printed, defended in front of a scientific jury and made into the book you are currently reading, I stand by every conviction, statement and assertion that made into paper.

João L. R. Abegão
September, 2018

PART I

CHAPTER I

THE ROOT OF ALL EVIL & THE EVIL TWIN

"Of all the interconnected problems we face, perhaps the most serious is the proliferation of our own species."

- Sir Crispin Tickell

"The pattern of human population growth in the 20th century was more bacterial than primate. When Homo sapiens passed the six-billion mark we had already exceeded by perhaps as much as 100 times the biomass of any large animal species that ever existed on the land. We and the rest of life cannot afford another 100 years like that."

- Edward O. Wilson

"We are living through the Great Acceleration – a unique event in the 4.5 billion-year history of our planet – with exploding human population and economic growth driving unprecedented planetary change through the increased demand for energy, land and water."

- Owen Gaffney (WWF, 2018)

Figure 1.1: Human population in Lagos, Nigeria. Retrieved from Nigerian Finder, 2018

In the early 90s, more than seventeen hundred of the world's scientists, including the majority of Nobel Laureates in the sciences, signed a "Warning to Humanity" (Union of Concerned Scientists, 1992). The warning identified a range of planetary boundaries that were being breached, such as the atmosphere, water resources, oceans, soil, forests, species, and ecosystems, and declared an utmost urgency to stabilize human population numbers in order to mitigate the pressure exerted and avoid potentially grave harms to people. Henry Kendall, chair of the Union of Concerned Scientists wrote at the time, "If we don't halt population growth with justice and compassion, it will be done for us by nature, brutally and without pity – and we will leave a ravaged world." The report continues:

> The Earth is finite. Its ability to absorb wastes and destructive effluents is finite. Its ability to provide food and energy is finite. Its ability to provide for growing numbers of people is finite. And we are fast approaching many of the Earth's limits. Current economic practices which damage the environment, in both developed and underdeveloped nations, cannot be continued without the risk that vital global systems will be damaged beyond repair.
>
> Pressures resulting from unrestrained population growth put demands on the natural world that can overwhelm any efforts to achieve a sustainable future. If we are to halt the destruction of our environment, we must accept limits to that growth.
>
> No more than one or a few decades remain before the chance to avert the threats we now confront will be lost and the prospects for humanity are immeasurably diminished.
>
> Destructive human activities may so alter the living world that it will be unable to sustain life in the manner that we know and so if human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated, human behavior must change.

It concludes: "We the undersigned, senior members of the world's scientific community, hereby warn all humanity of what lies ahead. A great change in our stewardship of the Earth and the life on it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated" (Union of Concerned Scientists, 1992).

This warning was sent out more than twenty-five years ago. All of those involved asserted apprehension regarding prevailing and impending deterioration on planet Earth involving ozone depletion, freshwater availability, marine life depletion, ocean dead zones, deforestation, biodiversity eradication, climate change, and continued human population growth (Ripple et al, 2017).

The authors of the 1992 declaration displayed uneasiness regarding how humanity was syphoning and straining, for its convenience, the Earth's ecosystems beyond their measures to support the web of life (Ripple et al, 2017). The scientists submitted and urged for a halt on human population growth, specifying how our substantial numbers - enlarged by 2 billion since their writing, a 35 percent increase - exert tension on the Earth's systems, overwhelming other efforts to bring about a sustainable future (Crist, Mora & Engelman, 2017).

In view of this reality, with the exception of stabilizing the stratospheric ozone layer, humanity has fallen short of the necessary commitments in solving these foreseen environmental challenges, and perilously, most of them are reaching a ghastly and deleterious condition (figure 1.2). Especially exasperating is the current trajectory of potentially catastrophic climate change due to rising greenhouse gases (GHGs) from burning fossil fuels (Hansen et al, 2013), forest loss (Keenan et al, 2015), and agricultural production - notably from farming ruminants for meat consumption (Ripple et al, 2014). Likewise, we have unleashed a mass extinction event, the sixth in roughly 540 million years, wherein many current life forms are experiencing disquieting population decreases or committed to extinction by the end of this century (Ripple et al, 2017).

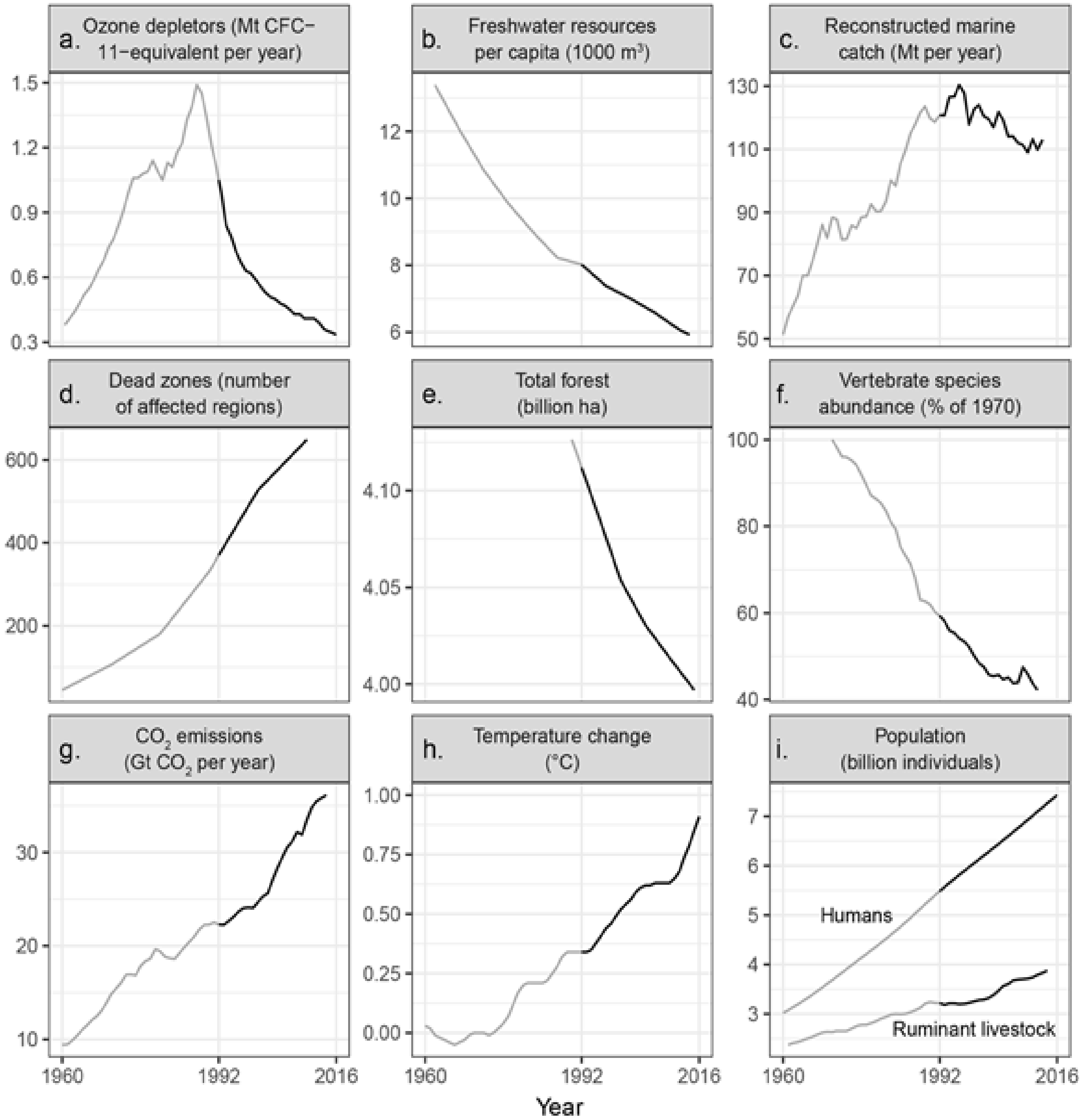


Figure 1.2: Trends over time for environmental issues identified in the 1992 scientists' warning to humanity. The years before and after the 1992 scientists' warning are shown as gray and black lines, respectively. Panel (a) shows emissions of halogen source gases, which deplete stratospheric ozone, assuming a constant natural emission rate of 0.11 Mt CFC-11-equivalent per year. In panel (c), marine catch has been going down since the mid-1990s, but at the same time, fishing effort has been going up. The vertebrate abundance index in panel (f) has been adjusted for taxonomic and geographic bias but incorporates relatively little data from developing countries, where there are the fewest studies; between 1970 and 2012, vertebrates declined by 58 percent, with freshwater, marine, and terrestrial populations declining by 81, 36, and 35 percent, respectively (file S1). Five-year means are shown in panel (h). In panel (i), ruminant livestock consist of domestic cattle, sheep, goats, and buffaloes. Note that y-axes do not start at zero, and it is important to inspect the data range when interpreting each graph. Percentage change, since 1992, for the variables in each panel are as follows: (a) –68.1%; (b) –26.1%; (c) –6.4%; (d) +75.3%; (e) –2.8%; (f) –28.9%; (g) +62.1%; (h) +167.6%; and (i) humans: +35.5%, ruminant livestock: +20.5%. Retrieved from Ripple et al, 2017.

Under the circumstances delineated in figure 1.2, one gets a sense that Humanity is being given a second notice, as illustrated by these disquieting trends. We are imperilling our future by not governing our uneven material consumption and not being conscious that rapid population growth is the main driver behind many ecological and societal threats (Crist et al, 2017).

For this reason, if we do not devote ourselves to adequately limit population growth, reassess the role of an economy rooted in growth, reduce greenhouse gases, incentivize renewable energy, protect habitat, restore ecosystems, curb pollution, halt defaunation, and stifle the colonization of invasive alien species, humanity is not taking the urgent steps needed to shield our endangered biosphere (Ripple et al, 2017).

Efforts have been made to name and tackle the root of the problem so that a public conscience could arise, and so, in 2000, Worldwatch Institute issued the following assessment, in hopes of conveying the seriousness of the problem:

> "The projected growth in population over the next half-century may more directly affect economic progress than any other single trend, exacerbating nearly all other environmental and social problems… the accelerating extinction of plant and animal species… As human population grows… at some point we will face wholesale ecosystem collapse… The risk in a world adding more than 80 million people annually is that ... thresholds will be crossed in a short time … the consequences will become unmanageable" (Brown et al, 2000).

Important to realize, is that for the short time that humans have inhabited this planet, their numbers have dwindled and soared in multiple occasions, depending, mostly, on the availability of resources. A brief explanation regarding this population dynamic history is informative, to better understand the uniqueness of our current predicament.

Five thousand years ago the Earth most likely contained fewer than 20 million people; at the beginning of the common era the total was about 200 million; a millennium later it had risen to about 300 million, the one billion mark was hit shortly after 1800. In 1900, the total was about 1.6 billion, in 1950 2.5 billion, in 2000 6.1 billion, and in 2010 it neared 7 billion. To put it differently, there has been a 350-fold increase in 5,000 years, more than a 20-fold gain during the last millennium, and roughly a quadrupling between 1900 and 2010 (Vaclav, 2011). So explosive has been the recent rise in the human population, that roughly 14 percent of all the human beings that have ever existed are still alive today (Westing, 2010).

Accordingly, and as figure 1.3 demonstrates, the current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.9 billion in 2050 and 11.2 billion in 2100, according to the most recent estimates (PRB, 2018;UNDESA, 2017). Provided that roughly 83 million people are being supplemented to the world's population every year, the upward trend in population size is expected to continue, even assuming that fertility levels will continue to decline (UN News Centre, 2017).

In view of the results of the 2017 Revision from the United Nations Department of Economic and Social Affairs (UNDESA, 2017) (Table 1.1) sixty per cent of the world's people reside in Asia (4.5 billion), 17 per cent in Africa (1.3 billion), 10 per cent in Europe (742 million), 9 per cent in Latin America and the Caribbean (646 million), and the remaining 6 per cent in Northern America (361 million) and Oceania (41 million).

These projections include some conspicuous findings at the country level. China (with 1.4 billion inhabitants) and India (1.3 billion inhabitants) continue to be the two most populous countries, amounting to 19 and 18 percent of the total global population. In roughly seven years, or around 2024, the population of India is foreseen to surpass that of China. Among the ten largest countries worldwide, Nigeria is growing expeditiously. Henceforth, the population of Nigeria, currently the world's 7th largest, is estimated to surpass that of the United States and become the third largest country in the world proximately before 2050 (UNDESA, 2017).

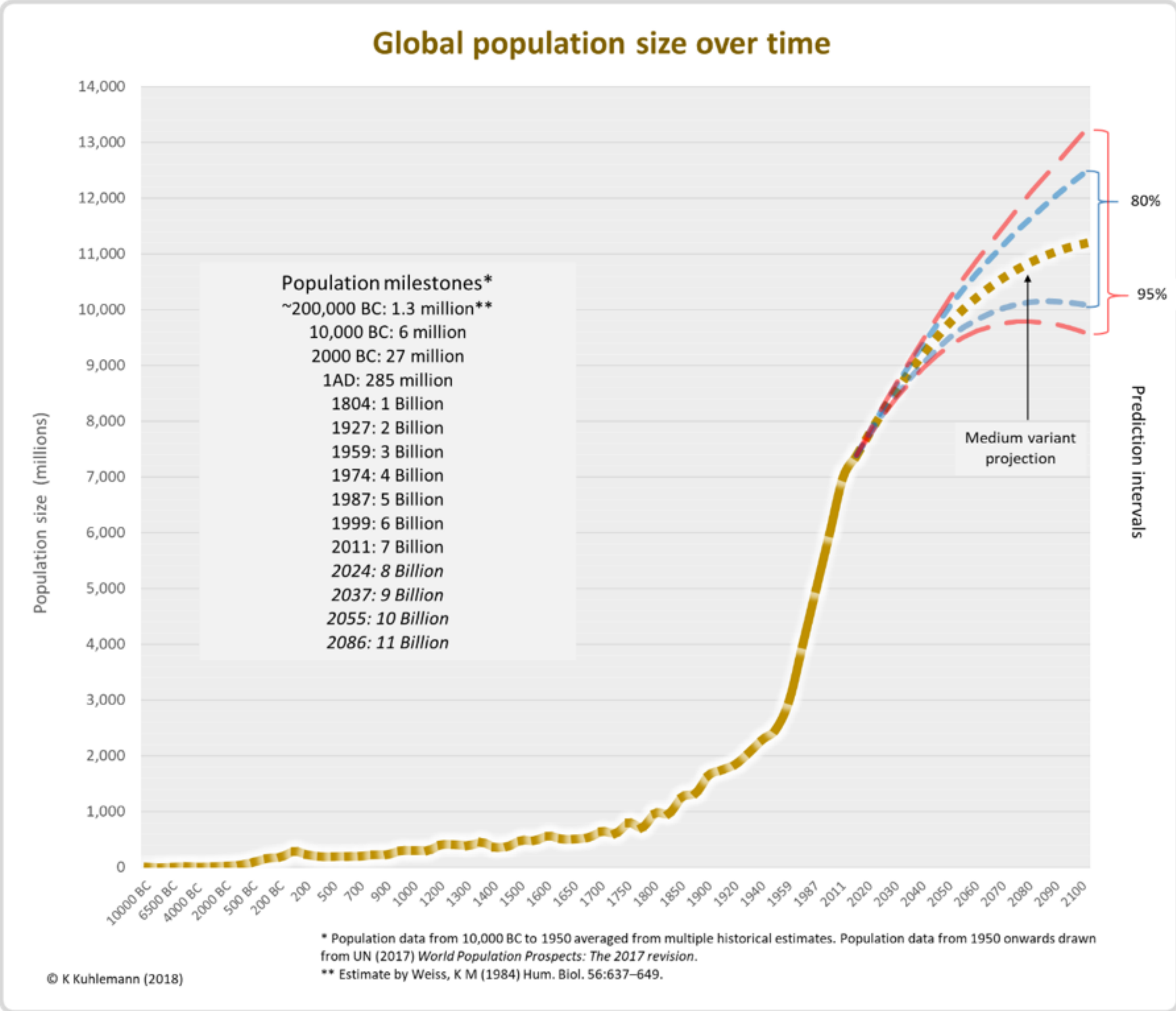


Figure 1.3: Human population in the last ten millennia. Projections until 2100 are based on the estimates from the United Nations World Population Prospects 2017 Revision. Image retrieved from Kuhlemann, 2018.

As it is portrayed in figure 1.4, Asia has been and will continue to be the most populous region in the world (Roser & Ortiz-Ospina, 2017). Although only Nigeria and Ethiopia occupy the top 10 most populous countries one could be under the impression that this wouldn't translate into considerable population expansion, then again, by reviewing Table 1.1 the reader can quickly perceive that Africa's population is envisioned to quadruple in less than a century under the *medium* scenario (which has consistently been proven to err on the side of conservatism). As I intend to demonstrate throughout this work, this and the remaining population growth will materialize into a plethora of complex, interconnected and labyrinthine repercussions.

Region	*Population (millions)* 2017	2030	2050	2100
World	7 550	8 551	9 772	11 184
Africa	1 256	1 704	2 528	4 468
Asia	4 504	4 947	5 257	4 780
Europe	742	739	716	653
Latin America and the Caribbean	646	718	780	712
Northern America	361	395	435	499
Oceania	41	48	57	72

Table 1.1: Population of the world and regions, 2017, 2030, 2050 and 2100. According to the Medium- Variant Projection. United Nations, Department of Economic and Social Affairs, Population Division (2017). *World Population Prospects: The 2017 Revision.* New York: United Nations.

Under these circumstances, the size of the global human population has often been contemplated as unsustainable in terms of its current and future impacts on the Earth's functioning systems. There have been countless claims for action from those who admonish this plight (Pimentel, Harman, Pacenza, Pecarsky & Pimentel, 1994; Daily & Ehrlich, 1992; Ehrlich, Kareiva & Daily, 2012; O'Neill et al, 2012; Murtaugh & Schlax, 2009; Potts, 2009; Butler, 2012; Sen, 1983, Cafaro, 2012) emphasizing the Earth's limits to distribute food production equitably, population and species extinctions, the provision of adequate ecosystem services, disruption of natural cycles such as nitrogen and phosphorus, the economic, sociological, and epidemiological well-being and anthropogenic climate change, to name just a few, which are being imperilled by an ever-growing human population.

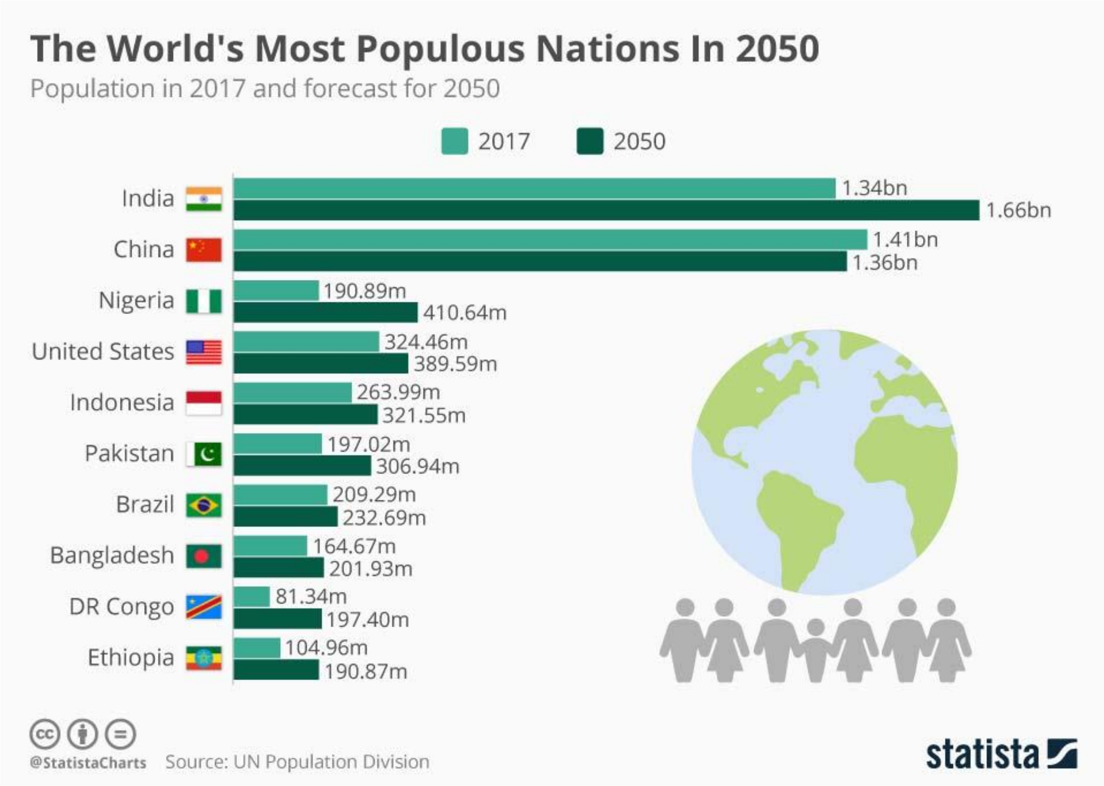


Figure 1.4: The World's Most Populous Nations in 2017 and 2050. Source Data: UN Population Division, 2017. Created by Statista.com. Retrieved from Sadhguru, 2018

Equally important is the fact that these natural frontiers are being breached by human economic and demographic growth (Cafaro, 2012). More people consuming more goods and services *per capita* bring about more pollution. We use more of the biosphere and other resources, leaving less suitable habitat and natural capital for other species (Meffe, Ehrlich & Ehrenfeld, 1993; Olden, Poff & McKinney, 2006). Ever increasing requirements tend to degrade the key ecosystem services that human and natural communities need to flourish since we too are committed to its existence and perpetuation (Cafaro, 2012). All over the world, environmental conditions are threatened primarily because of human-driven operations in the form of land conversion (agriculture, logging, urbanization), direct exploitation (fishing, bushmeat), and their synergistic interactions (Brook, Sodhi & Bradshaw, 2008). As the *Living Planet Report* from the World Wildlife Foundation (WWF) concludes, 'with the world already in ecological overshoot, continued growth in population and per person footprint is clearly not a sustainable path' (WWF, 2008).

In the *Peak Prosperity* podcast, in the episode *Dealing With The Elephant In The Room: Overpopulation* (2018), the host Chris Martenson opens up the discussion with the following:

"You live in a world surrounded by exponential charts. Some good, but mostly bad. Rainforest is disappearing at an increasing rate, and if charted (put into a graph), the chart looks like a hockey stick. It starts out slowly back in the early 1900s, then rises slowly until that line turns the corner, and it shoots upwards. The number of airline miles flown is also a hockey stick. Energy consumed, ditto. Freshwater use, again, we have a hockey stick. Underneath all of this, driving every one of these exponential charts and a thousand more not named here, is human population."

Nowhere is this more noticeable than with anthropogenic climate change. Every new person added to the planet wields a personal carbon footprint through all our daily activities as individuals and as part of a civilization, such as transport, food, waste management, buildings, energy etc, which each and every one of us brings to bear, just by the sheer act of survival.

In figure 1.5, a graph composed of atmospheric CO_2 (carbon dioxide) on the left and world population on the right, relates these two variables. It is reasonably obvious to the naked eye that CO_2 and population seem to move in lockstep. To show this in more analytical terms, we can superimpose a trend line, which is simply a mathematical curve which fits the data. In statistical terms, the R^2 value for this curve is more than 0.999, which indicates that it correlates with the data to an accuracy of closer than 99.9 percent (Graves, 2016).

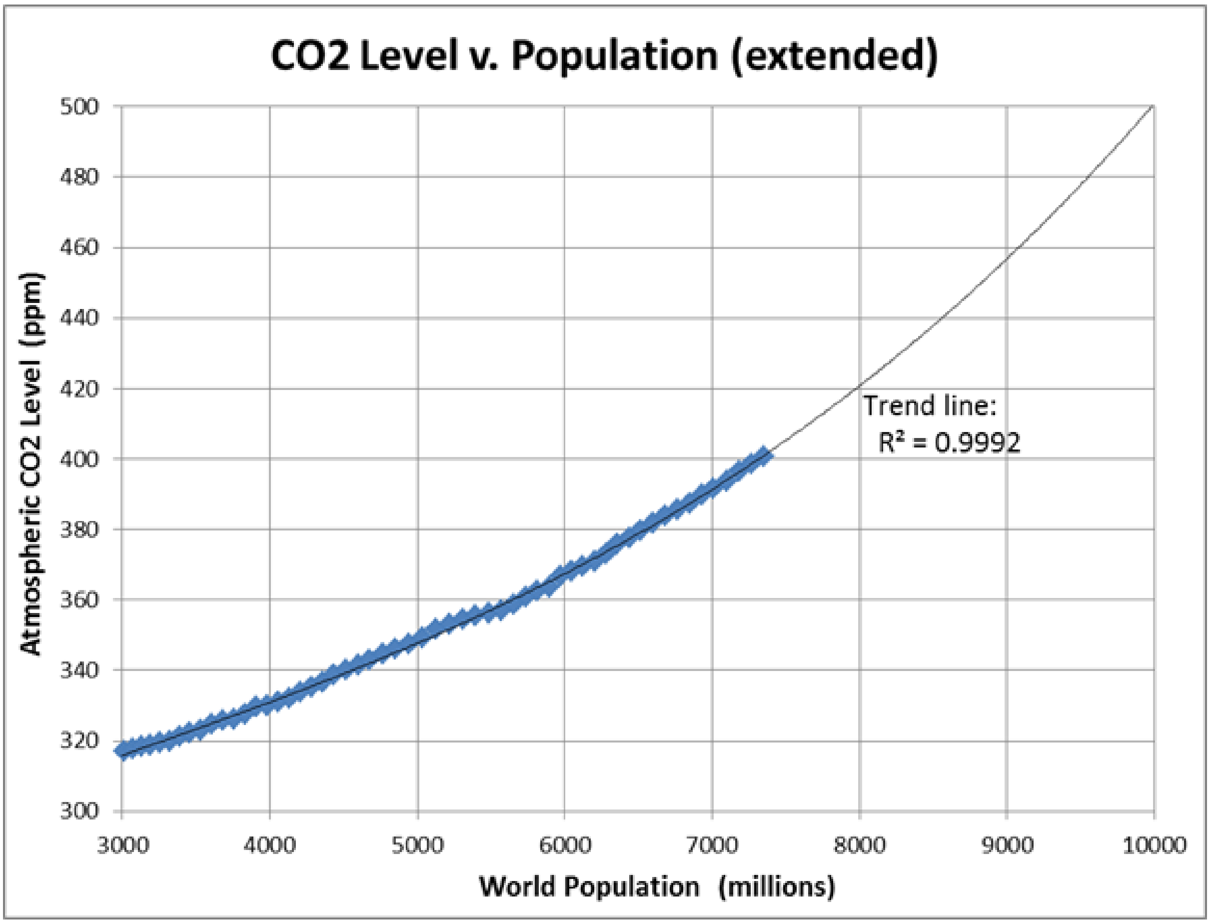


Figure 1.5: Graph plots CO_2 levels as a function of world population, encompassing the period 1960 to 2015. Although each data point represents an individual year in sequential order, time is not explicitly represented on this graph, which merely shows how CO_2 levels are related to overall world population. Retrieved from (Graves, 2016).

Even with a correlation of almost 1, the old adage of "correlation does not necessarily mean causation" continues to be opportune and admissible, so let us take this chance to dissect that claim. The reasoning behind this correlation is that every new individual added to the planet will have an amalgamation of distinct needs. Surely, our objective is that everyone will be provided with a dignified way of life, namely, to afford housing, energy, transportation, food, waste management, consumer goods and the list goes on. The intricacy arises when we start piling up all of these needs and realize that every action has a ‘reaction,’ which in the case of anthropogenic climate change is most fittingly portrayed as ‘carbon footprints’. Thomas Wire (2009) as well as O’Neill and colleagues (2010) agree that the compounding of relatively small but expanding ecological footprints in poor countries, plus the larger ones supplemented by the richer individuals are collectively responsible for aggravating phenomenon like climate change.

With climate change now being a pressing and emergent threat on everyone’s minds, population is infrequently connected to the acceleration of climate change (Götmark, 2018). In *Global warming policy: Is population left out in the cold?* Published in the journal *Science,* John Bongaarts and Brian O’Neill (2018) put forward the question:

> “Would slowing human population growth lessen future impacts of anthropogenic climate change? With an additional 4 billion people expected on the planet by 2100, the answer seems an obvious “yes.””

The chapters in Part II will expand on all of these human activities, their implications and consequences.

A survey of 50 Nobel laureates has found that many recognize population growth to be among the greatest threats to humanity today. A survey carried out by *Times Higher Education* (Grove, 2017), in association with the Lindau Nobel Laureate Meetings, drew responses from Nobel Prize winners for chemistry, physics, physiology, medicine and economics. Nobel Laureates were asked to respond to the questions: “What is the biggest threat to humankind, in your view?”

As it can be seen in figure 1.6, one in three respondents declared population growth and environmental degradation as the major menace facing humanity, making this the highest-ranking peril in comparison to all other responses. “Climate change [and providing] sufficient food and fresh water for the growing global population… are serious problems facing humankind,” says one US laureate, and in the same fashion, for Sir Richard Roberts, feeding the world’s growing population is the biggest problem facing humanity (Grove, 2017) as we shall see in the chapter Hunger Games.

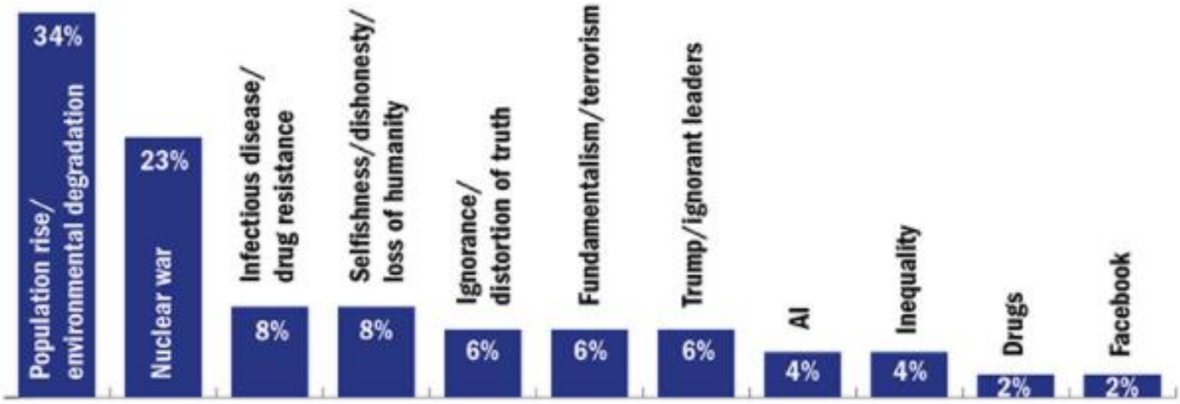


Figure 1.6: Survey on 50 Nobel Prizes with the question, "What is the biggest threat to humanity, in your view?" Source: Grove, 2017.

In conjunction with these results, a Pew Research Center survey (Funk & Rainie, 2015) has demonstrated that a chasm exists between the concerns of scientists and the general [American] public, in regards to being concerned about human overpopulation and population growth. To this extent, when asked if the expanding human population will stand as an important problem, 59 percent of U.S. adults inquired answered yes, with 82 percent of U.S.-based members of the American Association for the Advancement of Science (AAAS) also agreeing with the statement. On the other hand, 17 percent of AAAS scientists and 38 percent of Americans claimed population not to be an issue, and that humanity will find a way to stretch the natural resources in which it relies on (Gao, 2015).

In the spirit of what is to come in the Atlas, regarding the complex web of interconnected problems that arise as the human population expands and acquires more material wealth, it is worth examining the words of Bradford Hatcher (2017):

> "Even if we assume that Earth and its web of life nothing more than a kit of raw materials with which to build a human civilization in order to maximize our numbers, and that any value nature may have must be cast in the economic terms of the environmental services it provides, it really takes an utterly delusional species, with no vision at all beyond a single generation, to fail to see that we are already well over the limit. We have, in no particular order: biodiversity loss, habitat fragmentation, global fisheries collapsing, overgrazing, ocean acidification, reef destruction, accelerating global warming, methane releases from permafrost and clathrates, waterway siltation, soil salinization, over-paved agricultural lands, aquifer draw-downs, groundwater pollution, ozone depletion, glacial melt, growing fresh water shortages, grain deficits for fuel production, mass extinctions, bio-invasions, pollinator losses, heavy metals in the food chain, plastics pollution, eutrophication, algal blooms, malpredation with its genetic pollution, pandemic vulnerability, environmental refugees, hypertrophy or overextension into geo-hazardous regions, peak oil, peak fertilizer, Ponzi economics, and increasing per-capita food consumption at the third trophic level."

Given these points, population growth is surely a problem that needs to be addressed and fully understood, so that the percentage that argues for its harmlessness might be inclined to change their minds. Hopefully, the ensuing chapters might act as a vessel for that intellectual transition.

Projected growth of the global population

"Growth for the sake of growth is the ideology of the cancer cell."
- Edward Abbey

"It is difficult to make predictions, especially about the future."
- Karl Kristian Steincke (1948)

Today, the world's population continues to increase, albeit more slowly than in the recent past. In the 1950's the annual growth rate reached its apex of 2.1 percent per annum, and it has been slowing down ever since, sitting below 1.2 percent. Although annual growth has decreased in the last half-century, by no means has this translated into a reduction in the absolute population, which the most compelling evidence is shown in the figure 1.7, which associates the two trends. Important to realize from the graph is the world's population projection to increase by slightly more than one billion people over the next 13 years, reaching 8.6 billion in 2030, and to increase further to 9.9 billion in 2050 and 11.2 billion by 2100 (UNDESA, 2017; PRB, 2018).

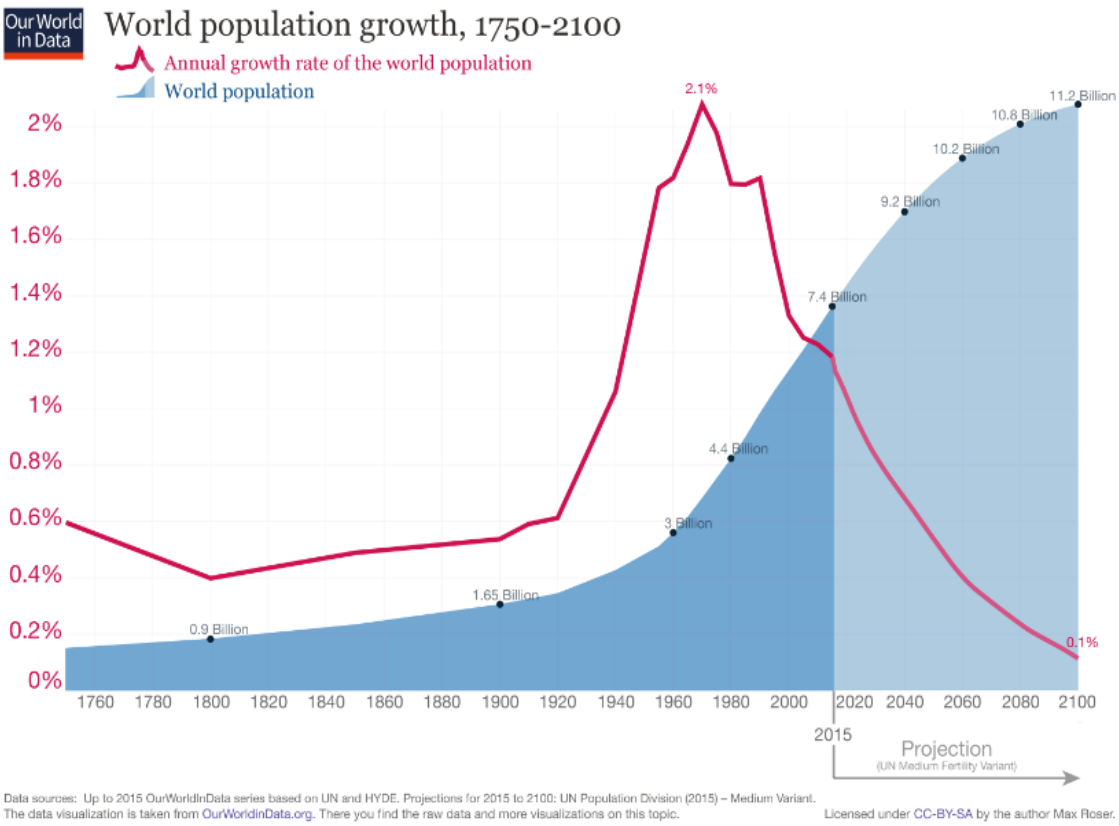


Figure 1.7: Annual growth rate of the human population plotted against world population, 1750-2100. Retrieved from OurWorldinData (Roser, Ortiz-Ospina, 2018).

In effect, population growth is unevenly distributed, with some countries undergoing explosive and possible unsustainable population growth. According to the Population Reference Bureau, Niger with 19.7 million, in late 2016, could hit 68.9 million in 2050, and Afghanistan could grow from 33.4 million to 62.4 million. For instance, in 1950, Sri Lanka had the same population as Afghanistan, but it carried out a realistic set of fertility regulation choices, and as a result, the population will remain at replacement rate from today till 2050, with 21.2 million, one third of what is expected in Afghanistan. Additionally, in 1970, there were 5 million more people in Bangladesh than on Pakistan, but Bangladesh focused on making family planning available in culturally acceptable ways, while Pakistan did not. As a result, by 2050 Pakistan will have 344.0 million people and Bangladesh 202.2 million (Campbell, 2012).

Meanwhile, from 2018 to 2050, the United Nations Population Division (UNPD) foresees that half of the world's population growth will be concentrated in just nine countries: India, Nigeria, the Democratic Republic of the Congo, Pakistan, Ethiopia, the United Republic of Tanzania, the United States of America, Uganda and Indonesia (ordered by their expected contribution to total growth) (UNDESA, 2017).

In the long run, the concentration of global population growth in the poorest countries poses an appreciable test to governments in implementing the 2030 Agenda for Sustainable Development, which pursues an end of poverty and hunger, broadening and refurbishing health and education systems, attaining gender equality and women's empowerment, curtail inequality and ensure that no one is left behind (UNDESA, 2017). As Bill and Melinda Gates accentuate in *The Goalkeepers Report* (2018):

> "To put it bluntly, decades of stunning progress in the fight against poverty and disease may be on the verge of stalling. This is because the poorest parts of the world are growing faster than everywhere else; more babies are being born in the places where it's hardest to lead a healthy and productive life. If current trends continue, the number of poor people in the world will stop falling—and could even start to rise."

It must be remembered that it all comes down to fertility (figure 1.8). In order to reach the 2030 Agenda for Sustainable Development, a widespread population awareness and commitment to grant women the possibility to have a say in their reproductive choices would go a long way (discussed in the chapters Access and Suffrage, featured in the upcoming Volume II). For the African continent it is paramount that such a mission is reached. The continent's population could quadruple over the next century, surging from 1 billion inhabitants in 2010 to an estimated 2.5 billion in 2050 and a soaring over 4 billion in 2100. While, globally speaking, one person in six currently lives in Africa, the proportion will probably be more than one in three a century from now (Pison, 2017a). This upsurging should be especially rapid in sub-Saharan Africa, where the population may rise from just over 800 million in 2010 to 4 billion in 2100 (Pison, 2017b).

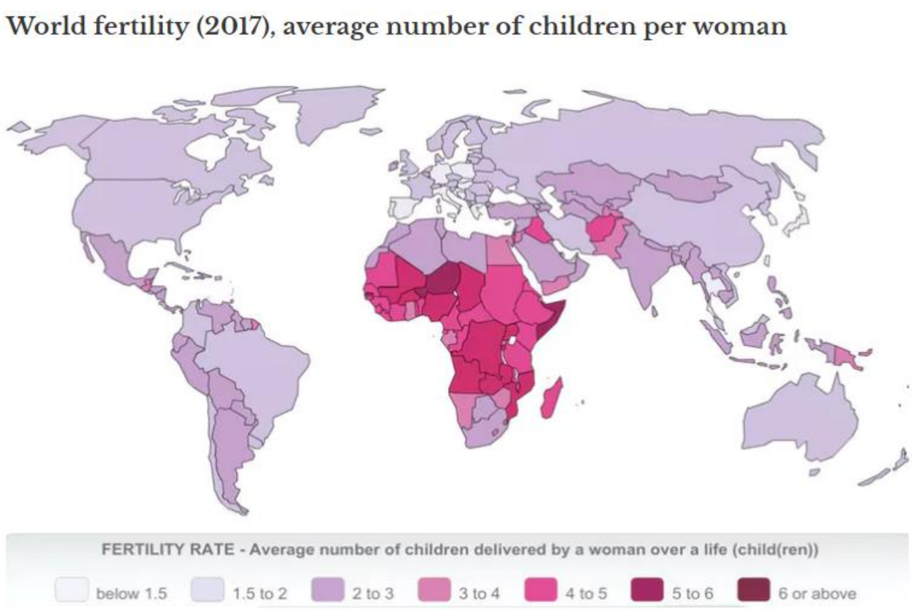


Figure 1.8: World fertility (2017), average number of children per woman. Gilles Pison (2017b), based on United Nations data, CC BY-SA.

The reasons for Africa's rapid growth stem from births outnumbering deaths four to one (Pison, 2011). Even though African mortality stands as the highest in the world, it has decreased in recent decades, succeeding a pattern already observed on other countries. Fertility has also dwindled. African women have 4.5 children on average - shattering the 6.5 forty years ago and 5.5 twenty years ago. Here too, the same trend has been incorporated on other continents. Women in Asia have 2.1 children on average, in Latin America 2.0 children, in North America 1.9 and in Europe 1.6 (Pison, 2017c).

This mixture of declining mortality and relatively high fertility is the catalyst for rapid population growth in Africa. Even if fertility proceeded to recede, as assumed by the United Nations medium scenario (UNPD, 2004), it will not drop the growth rate in the near future, let alone cease population growth (Pison, 2017c). This is because of "demographic inertia," which translates to, even if the African fertility were to dwindle to European or Chinese (1.6 children per woman) - an almost implausible scenario - the population would still continue to inflate for many decades, reaching 1.6 billion in 2050 (Institut National D'Études Démographiques, 2018). This is due to the elevated cohorts of young adults of reproductive age (15-49) (UNDESA, 2017), which, if all were to bear few children, the number of births would still be elevated (Pison, 2017c).

The group of 47 least developed countries (LDCs) continues to have a relatively high level of fertility, which occupied 4.3 births per woman in 2010-2015. As a result, the population of these countries has been dilating, at around 2.4 percent/per year. Furthermore, the combined population of the LDCs, roughly one billion in 2017, is projected to increase by 33 percent between 2017 and 2030, attaining 1.9 billion persons in 2050. Similarly, the populations of 26 African countries are projected to expand to at least double their current size, before 2050 (UNDESA, 2017).

Notwithstanding these figures being projections they can be thoroughly reliable for forecasting population size over the next 10, 20 or 30 years. This is because most of the people who will be alive in 2050 have already been born, their numbers are known and estimations of the proportion among those currently alive and those who will die can be rigorously predicted. Likewise, the women who will bear children over the next 20 years are alive today, thus being easily counted. By estimating their potential fertility, the number of future births can be determined with relative accuracy (Pison, 2017b).

The forecast of a global population of 11 billion circa 2100 is established on the two latest UN population projections (UNDESA, 2015; 2017), but it could result in being an optimistic underestimate. Population projections for countries experiencing high fertility are notably uncertain, thus, even slightly slower-than-anticipated fertility declines could result in a much larger population size. The UN's 'high' variant projection (figure 1.8) assumes fertility rates will remain half a child higher, on average, than the 'medium' variant. This will bear a 2100 population of over 16 billion. Surprisingly, the high variant still builds in a substantial reduction in fertility rates relative to today's levels. A straightforward extrapolation of current fertility rates would generate a population of over 25 billion by 2100 (Kuhlemann, 2018).

One just needs to ponder on the population projections published by the United Nations in 1981 (figure 1.9), predicting that the world population would attain a 10.5 billion in 2100, under its medium scenario. Projections from 2017 determine a figure of 11.2 billion - 0.7 higher. Even if the world total is only slightly larger than expected, it conceals a radical shift in population distribution across the continents (Pison, 2017c).

In 1981 the population of Asia was envisaged to reach 5.9 billion by 2100, but in 2017 the figure was amended downward to 4.8 billion. For Latin America, similarly, the figure of 1,187 million in

2100 was modified to 712 million (a 40 percent decrease). For Africa, however, the 1981 projections forecasted a population of 2.2 billion, while in 2017 this figure has doubled, to 4.4 billion (figure 1.10) (Pison, 2017c).

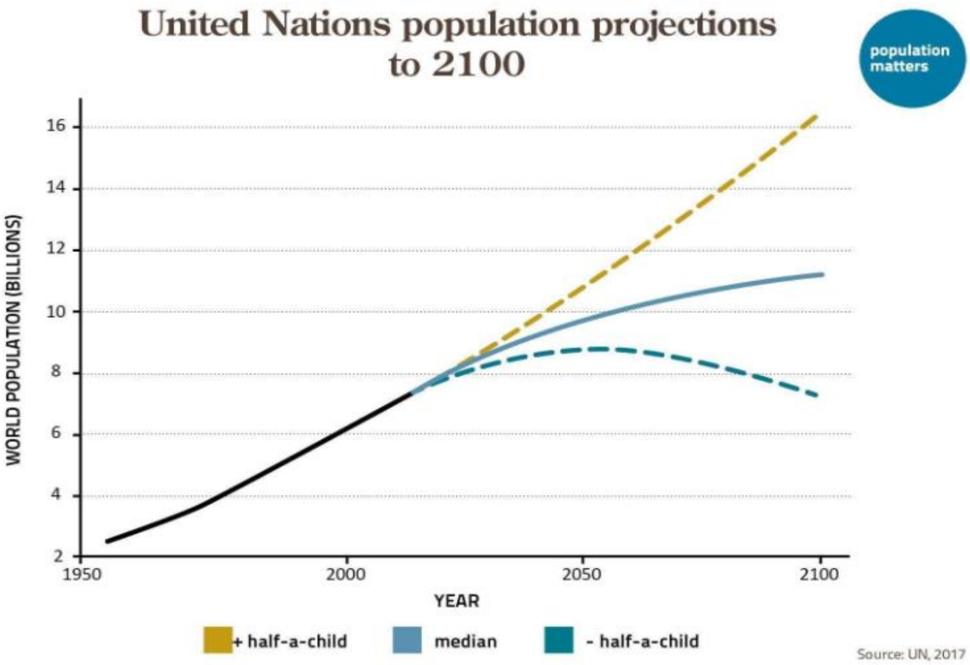


Figure 1.9: United Nations human population projections for the XXI century. The high and low estimates vary from the median projection by a difference in "half-a-child." Retrieved from populationmatters.org.

Generally speaking, most of the developed world has stabilized its population (Oceania and North America being exceptions due to elevated levels of immigration), and as a consequence, there is almost zero population growth. On the contrary, if the less developed world, and according to the current data and statistics, nearly all future population growth will take place in the poorest and less advanced parts of the world (Patterson, 2017).

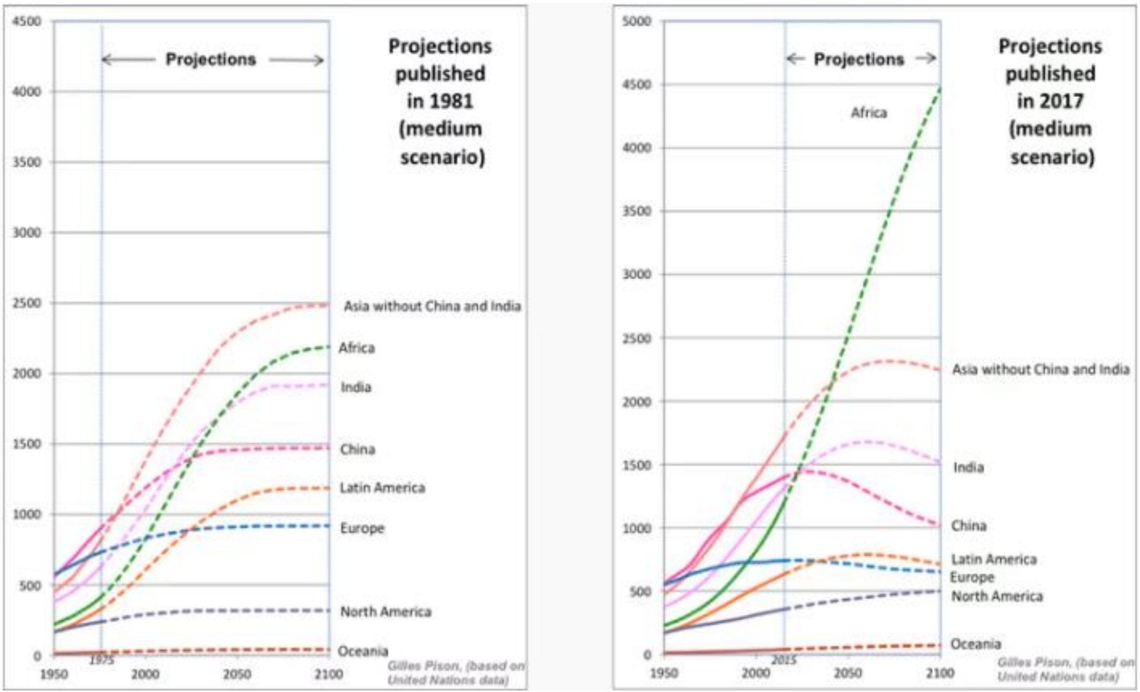


Figure 1.10: Comparison of population projections published in 1981 and 2017. Pison, 2017d (based on UN data)

While a multitude of individuals remains assured about the likelihood of feeding 11 billion humans, having long, healthy and dignified lives with the possibility of ambitions and aspirations in a climate-changed world with over-used soils, deficient water resources and ecosystems extirpated of non-human life, no such credible proposal has been presented for a world of 16 billion humans - let alone one of 25 - most likely due to the sheer infeasibility and unattainability of such an undertaking (Kuhlemann, 2018).

It would be unrealistic to imagine that population trends could be altered on a limited timescale. Gilles Pison offers a short commentary, “Depopulation is not an option. Indeed, how could it possibly be achieved? Through increased mortality? No one hopes for that. Through mass emigration to Mars? Unrealistic. Through a drastic and durable decrease in fertility to below replacement level (2.1 children)? This is already taking place in many parts of the world, as couples decide to have fewer children so as to give them the best chances for a long and fulfilling life. But for reasons of demographic inertia, this does not result in an immediate population decline. Even if world fertility were just 1.6 children per women, as is the case in Europe and China, the population would continue to increase for several more decades; there are still large numbers of adults of childbearing age who were born when fertility was still high, so the number of births also remains high.” (Pison, 2017b).

Given the points accessed throughout this chapter, the reader is now in a position to grasp and apprehend the pivotal changes that the human population has undergone up until this moment. Likewise, future scenarios (projections) are crucial in this analysis, since they reveal to what extent the challenges imposed by an ever growing population will intensify. Therefore, it is paramount that we discuss early-on, the urgency and obligation to scale down consumption and population, through the most humane approaches we can devise.

A Good Life for All?

Why we need policies for population and consumption reduction

"Can you think of any problem, in any area of human endeavour, on any scale, from microscopic to global, whose long-term solution is in any demonstrable way aided, assisted, or advanced by further increases in population, locally, nationally, or globally?"

- Albert Allen Bartlett

"The slogan used to be 'Populate or perish.' We can now see that it is more like 'Populate and perish'. A sustainable future has to be based on stabilisation of both population and consumption."

- Ian Lowe

"I have been at any number of conferences where people talk of various dangers that we are facing, such as water and environmental conservation, but what pains me is, no government wants to address the most fundamental problem - population."

- Jaggi Vasudev "Sadhguru" in World Population Day 2018

The Global Footprint Network (2018) data reveals that humanity exploits the equivalent of 1.7-1.8 planet Earths to provide the renewable resources we wield, as well as assimilate our waste (World Population Balance, 2017). Furthermore, the researchers at the Global Footprint Network appraise that presently, our planet has enough biocapacity for each and every one of us to appropriate about 1.8 global hectares per year. Anything above this line translates into a degree of resource consumption that the Earth cannot restock, or waste that it cannot assimilate, which ultimately materializes in ecological breakdown (Hickel, 2018).

For perspective sake, 1.8 global hectares is in the neighbourhood of what the average person in Ghana or Guatemala expends. At the same time, Europeans monopolize 4.7 global hectares, while in the US and Canada that average rises to about 8 (Hickel, 2018). Comparatively, if the entire humanity were to enjoy a European standard of living - which is about half the consumption of the average American - the Earth could sustainably maintain only about 2 billion people (World Population Balance, 2017).

Evidence of unsustainable resource use is apparent and unambiguous. Global aquifers are being pumped 3.5 times more rapidly than rainfall can commonly recharge them (Gleeson, Wada, Bierkens & Ludovicus, 2012). In the event that they will run dry, hundreds of millions will undergo an untold misery. Topsoil is being squandered 10-40 times faster than it is formed (Pimentel, 2006). Feeding all 7+ billion of us will become increasingly strenuous. Oceans are being overfished, and a primary protein source for over 2 billion people is in a precarious situation (United Nations, 2016).

The *World Wildlife Fund* (2016) asserts that "Worldwide, we have lost half the vertebrate species in the air, water, and land since 1970." How many more species can we lose and how many more ecosystems can we destroy before humanity's own existence is threatened? (This is the anthropocentric view that analyzes the degree to which environmental degradation and ecological collapse gets in the way of our survival. It is a crucial view to get support and conscious awareness of people to the problem, but it's incomplete and a morally indefensible stance since we share this planet with many other non-human species. The philosophical ramifications of this are discussed in the segment Anthropocentrism, in the upcoming volumes).

Inasmuch as it is axiomatic that a smaller human population would reduce most of the menacing processes facing every species on the planet (Laurence, Sayer & Cassman, 2014), divorcing consumption rates and population size per se is a strenuous task (Ehrlich & Holdren, 1971) due to their connected repercussions on the loss of biodiversity and non provisioning natural capital (Ehrlich et al, 2012; Bradshaw, Giam & Sodhi, 2010; The Royal Society, 2012), as well as the discrepancy in consumption patterns among regions and socio-economic classes (Krausmann et al, 2008; Butler, 1997).

Sustainability demands an eventual stabilization of Earth's human population on account of resource demands and living space escalating with population size, and proportional ecological impairment surges even when consumption patterns stabilize (Davidson & Andrews, 2013; Davidson, Andrews & Pauly, 2014). Overall, it is indispensable that scenarios for future human population dynamics are scrutinized critically if we are to plan for a prospective healthy society (DeLong, Burger & Hamilton, 2013).

Notwithstanding, there is a clash, and division, among environmentalists about the relative roles of population size and per capita consumption in causing environmental adulteration. In the past two centuries, both factors have partaken roughly equally, to humanity's assault on its life-support systems. Reducing this incursion while transitioning to a sustainable society will entail action on *both* factors (Ehrlich & Ehrlich, 2012, foreword).

In the colossal treatise of literature *Natural Resource Conflicts: From Blood Diamonds to Rainforest Destruction,* Max Lu writes a chapter denominated *Overpopulation Stresses Resources, Which In Turn Stresses People* (2016) and formulates the following:

> "Arguably, population size still matters, but it is no longer considered the dominant factor affecting the planet's ecosystem. A bigger threat to sustainability is the rising consumption of people in many parts of the world. As people's income levels rise, they usually eat less grain-based food but more meat and dairy products. They also tend to buy more consumer goods. Urban residents generally also consume more than their rural counterparts. Not surprisingly, wealthy countries use many times more resources per capita than poorer nations and have a bigger environmental impact. With 5 percent of global population, Americans consume a quarter of the world's energy and emit about 16 percent of the world's CO2."

Although this may be true, the focus of the discussion has shifted away from the influence of population, to the fact that a growing number of humans, many equipped with resource-ravenous technology, have abused a widening array of natural resources, both renewable and nonrenewable (Catton, 2012).

As William R. Catton Jr. (2012) so eloquently articulated:

> "Carrying capacity limits, too often unrecognized, mean that in any environment there is a rate or amount of resource use that cannot be exceeded without reducing the subsequent ability of that environment to sustain such use. Much human use of planet Earth has been in defiance of this principle, so twentieth-century population growth - and technological advances that enabled some *Homo sapiens* to develop huge resource appetites and impacts - turned the past human carrying capacity surplus into the present carrying capacity deficit."

As a result*, carrying capacity* can be surmised as the means to a population of a given species, on a specific environment, to be supported indefinitely, which is to say, without causing habitat deterioration that would dwindle that environment's future life-supporting capacity. Each singular habitat will have various carrying capacities for different species, by virtue of each species having a characteristic way of depending on its environment, in terms of the resources it needs to withdraw and the metabolic end products it necessarily puts back into it.

William Catton Jr. contends in his book *Overshoot* (1982) that:

> "Throughout the essay Malthus was referring to human population, and by subsistence he meant food… these conceptions were unduly narrow. But the really basic Malthusian principle is so important that it needs to be restated in the more accurate vocabulary of modern ecology. It states a relationship of inequality between two variables: The cumulative biotic potential of the human species exceeds the carrying capacity of its habitat."

In the case of humans, however, different societies have diverse lifestyles. So we have to take into account the significant divergences contrasting the consumption patterns of different human populations. The definition thus, requires some clarification and once again William Catton can help:

> "Human carrying capacity equals the maximum human *equipped with a given assortment of technology and a given pattern of organization* that a particular environment can support indefinitely - without causing damage to the habitat."

In light of this definition, one can notice the strict focus on human carrying capacity customarily does not undertake the query of whether it is decent and ethical toward other species to augment human numbers. If we acknowledge that other species have a right to extend their existence on Earth, then we must balance our expansion *well short* of human carrying capacity (Catton, 2012).

Max Lu (2016) again:

> "Here lies the main problem. One thing we know for sure is that the world will continue to industrialize and urbanize. More and more people will enjoy higher incomes and live in cities. According to the World Bank, more than 1 billion people in the developing world will be in the middle class by 2030, compared with just 400 million in 2005. Only about 3 percent of the world's population was urban when Thomas Malthus [more on the next chapter] published his notable essay on population growth. The proportion of urban population stands at just over 50 percent now, and is projected to reach 69 percent in 2050. This means that in the next few decades, a significantly larger number of people worldwide will be consuming more. All the consumption translates into a higher demand for natural resources, from minerals and water to land for food production. If humans are already stressing Earth's finite resources as it is, can the planet take the strain in the future, particularly if people in developing countries all emulate the way Americans and Europeans live today, eating more meat, driving cars, and living in single-family homes?"

One thing is certain, these trends and data foment some crucial questions. What is the relationship between consumption [(determined by the Ecological Footprint (EF)] and development (Hickel, 2018)? Is it achievable and practicable to reason that 7.6 billion humans (plus 83 million/year) can aspire to live as any individual in the West or any developed nation? What will transpire when the creed of economic growth and free trade comes across the reality of ecological limits? Can we hope to continue to advocate for the inviolable and sacrosanct human rights for an ever-growing and more affluent human population in the face of ecological meltdown?

Reality speaks an entirely different language, and in her book *Collision Course – Endless Growth on a Finite Planet*, Kerryn Higgs (2014) quotes Tim Jackson's remark (2011) that there can be:

> "No credible, socially just, ecologically sustainable scenario of continually growing incomes for a world of nine billion people."

Manifestly, augmentations in EF's are closely tied to GDP (Uddin, Alam & Gow, 2016; Feng & Wu, 2011; Galli et al, 2012; Al-mulali, Weng-Wai, Sheau-Ting & Mohammed, 2015), which is the same as saying that as humans acquire wealth, their scope of possible ecological repercussions expands rapidly. But what about *human development* indicators? And what about well-being? Is it conceivable for a nation to live in reach of the threshold for biocapacity while at the same time possessing high standards of living?

The graphic below (figure 1.11) portrays a coherent relation between the Ecological Footprint of nations against their score in the Human Development Index (HDI). The results are telling since a pattern clearly emerges from them. They demonstrate that as HDI rises, so too does EF. Actually, the two seem to be tightly entwined, meaning that attaining higher levels of HDI customarily translates into vastly transcending biocapacity. Few outliers seem to appear: countries that achieve "high" HDI (above 0.7) while still remaining within biocapacity. Nevertheless, all nations that consummate "very high" HDI (0.8) overtake the biocapacity limit. To say nothing of the disheartening conclusion that there are no nations that are encapsulated within the box for sustainable development at very high HDI (Hickel, 2018).

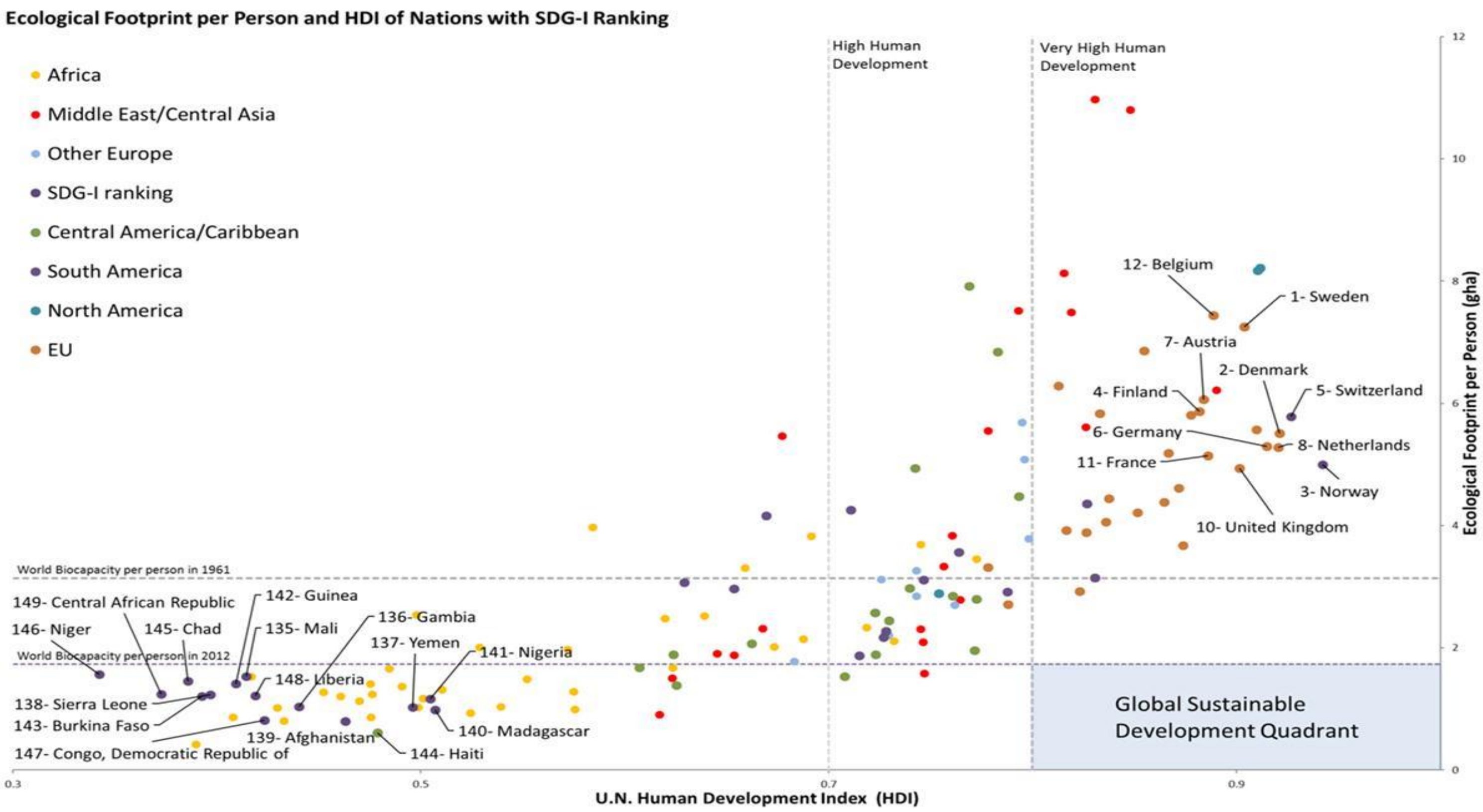


Figure 1.11: Ecological Footprint per person and HDI by country indicate how closely each country is to basic global sustainable development criteria (high human development, within resource requirements that are globally replicable). Each number indicates the country's ranking on the Sustainable Development Goal (SDG) index (only top and bottom 10 are marked here). Source: Global Footprint Network, 2017.

HDI is gauged as the average of three contrasting indicators: **life expectancy** index, **education** index, and **income** (where 1 = Gross National Income (GNI) per capita of $75,000, on a logarithmic scale)**.** By all means, it makes perfect sense to study life expectancy and education against EF, but analyzing the comparison between income with EF is incongruous. This is due to the fact, that income, just like Gross National Product (GDP), is indistinguishably associated with EF. Even though it is quite possible to achieve tremendous gains in life expectancy and education with somewhat little expense of ecological footprint, it becomes impossible to raise average incomes up to $75,000 without overtaking biocapacity (Hickel, 2018).

Despite the fact that some relative decoupling of GNI from EF (with rapid technological innovation and vigorous taxes on carbon and resource extraction) has been enacted, no such thing has occurred with absolute decoupling (Hickel, 2018). By decoupling, the economists anticipate: severing economic growth from the use of materials. How well is that going? A paper in the journal *Plos One* uncovered that while, in some countries, relative decoupling has occurred, "no country has achieved absolute decoupling during the past 50 years" (Ward et al, 2016). This translates into the volume of materials and energy linked with each increment of GDP possibly declining but, as growth eclipses efficiency, the total use of resources keeps augmenting. More decisive still, the paper divulges that, in the long term, both absolute and relative decoupling from the use of essential resources is unattainable and contrary to reason, by virtue of the physical limits of efficiency (Monbiot, 2017a).

On account of this dissenting and sometimes discordant theme that is the role which income and consumption have, the team at the Overpopulation Podcast (2018) sat down and discussed:

> "Morally, for people who say it's all about consumption, they need to look at, realistically, what is *that* level of consumption that would create a sustainable planet, if it was shared completely equally. What I often think about is that income is the best proxy for consumption of resources, and if you look at the World Bank's purchasing power parity (PPP: provides a measure of price level differences across countries) income is $17,000 per person, around the planet. So, if you take global footprint analysis which says we are in 70 percent overshoot, which means that the $17,000 is 70 percent too high. So the global equal income all over the world would have to be $10,000 a person […] That is a lot lower than anybody in developing countries is willing to consider, since the poverty line in the US is 12-13,000$. So that $10,000? How many of our listeners and the people saying that is all about consumption would be willing to live on 10,000$/year? This leads to hypocrisy and laziness in the discourse, when people don't realize that if they really want to look at the level of consumption that brings us even in the ballpark of sustainability, it is so low compared to how you and I are living right now, and if people don't drill down on this reality they aren't being honest, and especially not if they are dismissing population as part of the equation."

In other words, it seems as though income cannot reach $75,000 while EF goes down to 1.8. It is physically infeasible and insurmountable (Hickel, 2018).

Under these circumstances, it becomes straightforward that the HDI resolution is entirely self-defeating. Forasmuch as income is an integral part of the HDI (roughly 33 percent), consummating a high HDI *by definition* will demand growth to the point that it surpasses biocapacity. Therefore, if all nations in the world were to pursue the highest HDI (which is the present plan), humanity would "develop" itself into ecological meltdown (Hickel, 2018).

As Jason Hickel (2018) asserts:

> "We need a better measure, one better suited for the Anthropocene. Average income does not tell us very much about well-being. There are a number of countries with relatively low income that nonetheless have high levels of human well-being. Costa Rica, for example, has a higher life expectancy than the US and happiness indicators that rival those of Scandinavian nations. But its average income is only $11,000, less than one-fifth that of the US. If we take income out of HDI, then Costa Rica qualifies as having "very high" human development. Many other countries are also in the very high category with even lower EF, including Serbia, Romania, and Albania. Cuba qualifies as very high, with an EF of only 1.95, extremely close to today's biocapacity limit. And Georgia qualifies as very high with an EF of only 1.58."

And of course, Hickel (2018) hits the nail on the head when he puts forward that:

> "Consider this thought experiment. Let us say that rich nations choose to follow post-growth and degrowth principles, slowing down ecologically harmful and socially unnecessary economic activity (fracking, advertising, McMansion building, SUV production, beef farming, single-use plastics, food waste, planned obsolescence and so on) in order to reduce their ecological footprint [...] At the same time, they introduce pro-human policies, that would make average income go down, but with no theoretically drop in quality of life - indeed, quality of life might even improve."

A pro-growth stance was composed in the research paper *Decoupling global environmental pressure and economic growth: scenarios for energy use, materials use and carbon emissions* published in the *Journal of Cleaner Production* by Heinz Schandl and colleagues (Schandl et al, 2016) who advance:

> "In recent decades economic growth and increased human wellbeing around the globe have come at the cost of fast growing natural resource use (including materials and energy) and carbon emissions, leading to converging pressures of declining resource security, rising and increasingly volatile natural resource prices, and climate change."

The authors set out to examine and investigate if well-designed policies can reduce global material and energy use, and carbon emissions, concluding that:

> "A global transition to a low carbon and resource efficient economy is not only possible - if strong and appropriate policies are put in place - but could be achieved with little or no impact on economic growth. This suggests that economic growth, per se, is not the main problem for environmental pressures and impacts but that the focus should rather be on the quality of growth. There is hence no real contradiction in achieving the economic and environmental goals of the Social Development Goals."

Fortunately Manfred Lenzen and colleagues were on the lookout and put a respectable and proper retort in writing (Lenzen, Malik & Foran, 2016):

> "Herein lies our analytical quandary: taken simply, the authors find that emissions targets can be met by large-scale bio sequestration and substantial technological innovation applied universally [...] We believe it is illogical to expect technological progress to stretch to unprecedented limits in order to let populations enjoy unchecked growth in numbers and affluence [...] We need to include curbing affluence and population into our strategic response mix, and to initiate a public discourse about more sustainable levels of personal consumption."

Although this may be true, there is something deeper lurking in the shadows of modern societies. The current system operating in developed nations is set to transform every citizen into a consumer the sooner the better, and it doesn't stop there since income is an inextricable part of it. As a citizen learns his or her place in society s/he is bombarded with the dogma that to be "successful" in life one should strive for an even bigger paycheck, which will allow for the acquisition of more stuff. Additionally, developed nations have promoted rich celebrities, entrepreneurs and generic individuals who wear their wealth on their sleeve to role models, while themselves promote a "cult of affluence" through social media that inculcate the doctrine that happiness, quality of life and well-being are parallel and on the same wavelength as having a rising income or an abundance of wealth. However, we need a reality check. The planet has a finite biocapacity that won't permit the desired state of equality for an ever-growing population - everyone being rich, and probably, not even acquiring a middle-class status, without a widespread ecological meltdown.

In an opinion piece on *The Guardian,* George Monbiot (2017a) writes how:

> "Everyone wants everything. The promise of economic growth is that the poor can live like the rich and the rich can live like the oligarchs. But already we are bursting through the physical limits of the planet that sustain us. Climate breakdown, soil loss, collapse of habitats and species, the sea of plastic, and population and species extinction: are all caused by rising consumption. The promise of private luxury for everyone cannot be met: neither the physical nor the ecological space exists. But 'growth must go on' - it's the political imperative everywhere, and it's destroying the Earth. But there's no way of greening it, so we need a new system."

Monbiot (2017a) interconnects the previous pronouncement with a critique of his own on the green delusion:

> "Green consumerism, material decoupling, and sustainable growth: all are illusions, designed to justify an economic model that is driving us to catastrophe. The current system, based on private luxury and public squalor, will immiserate us all."

The attendant assurance is that, through green consumerism, we can harmonize perpetual growth with planetary continuance. Then again, research continues to emerge, which reveals that there is no significant distinction between the ecological footprints of individuals who consider themselves "environmentally friendly" and those who don't (Tabi, 2013; Akenji, 2014). As a matter of fact, a study published in the journal *Environment and Behavior*, Moser and Kleinhückelkotten (2017) divulged that people who identify as conscious consumers dissipate more energy and carbon than those who do not. The reason behind this is because of environmental awareness tending to be higher among wealthy individuals. **The reality is that it is not attitudes that guide our impact on the planet but income. The richer we are, the more considerable is our footprint,** despite every good intention. Furthermore, those who see themselves as green consumers, the research found, mainly concentrated on behaviours that had "relatively small benefits" (Monbiot, 2017a).

The picture below (figure 1.12) from another research (Wynes & Nicholas, 2017) clearly portrays the tremendous discrepancy between the low and moderate impact behaviours such as upgrading light bulbs and recycling, or the higher and meaningful impact behaviors such as avoiding air travel, living car-free, and of course, something that will be thoroughly discussed in this work, "having one fewer child."

Monbiot (2017a) describes the cognitive dissonance that embeds itself in this:

> "I know people who recycle meticulously, save their plastic bags, carefully measure the water in their kettles, then take their holidays in the Caribbean, cancelling any environmental savings a hundredfold. I've come to believe that the recycling licences their long-haul flights. It persuades people they've gone green, enabling them to overlook their greater impacts. None of this means that we should not try to reduce our footprint, but we should be aware of the limits of the exercise. Our behaviour within the system cannot change the outcomes of the system. It is the system itself that needs to change."

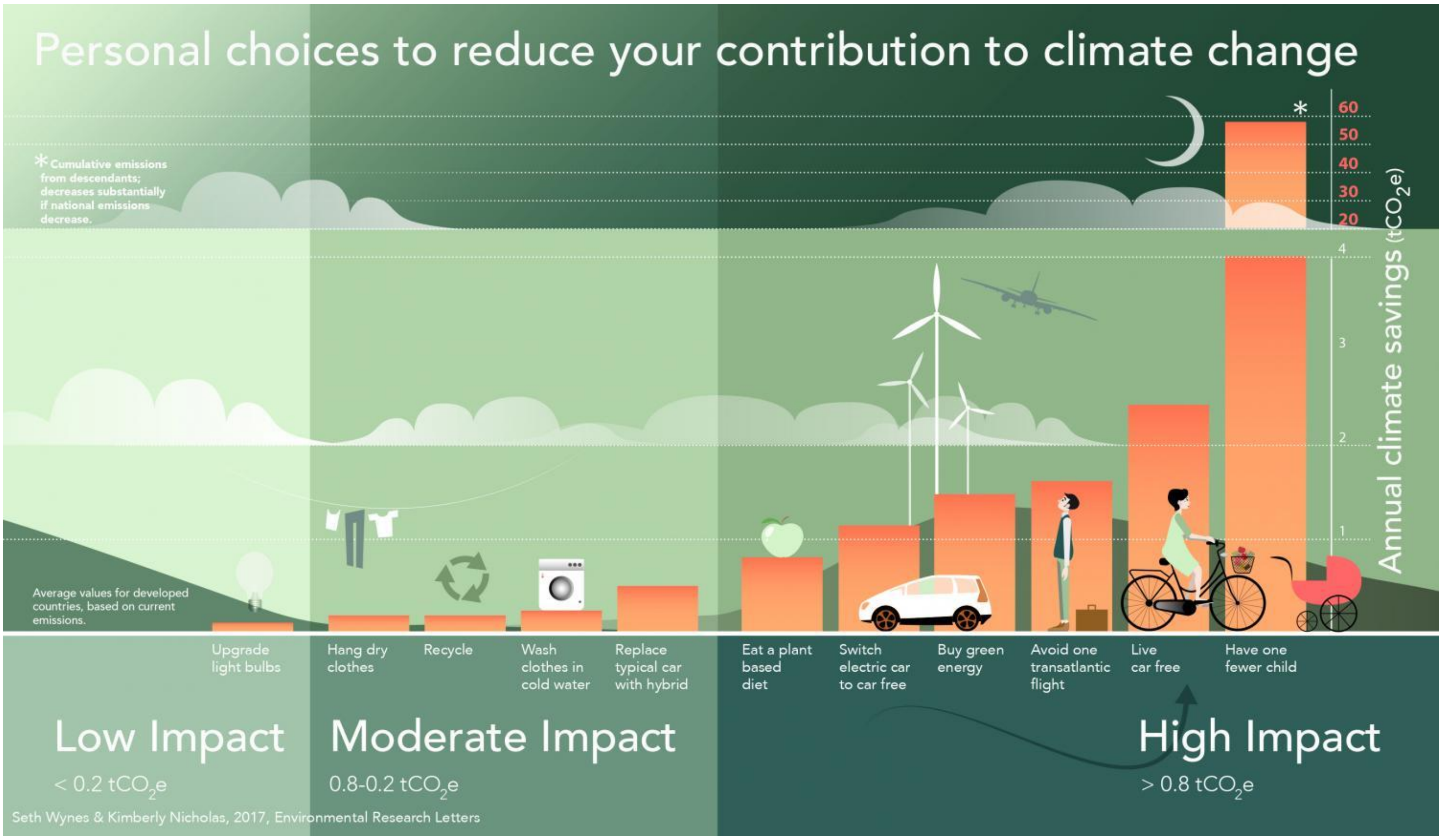


Figure 1.12: Personal choices to reduce one's carbon footprint. Source: Wynes & Nicholas, 2017. Retrieved from Institute of Physics, 2017.

One thing is clear, human overpopulation and overconsumption cannot be dissociated from each other since our expanding populace aims and aspires to achieve and retain a certain level of consumption and material possession. The problem arises when we have to step back and be pragmatic in the reasoning that a finite planet, with finite resources, cannot possibly provide for the hedonistic whims of billions of over-voracious individuals. In the same fashion, solely focusing on contracting consumption patterns while the population is allowed to keep on augmenting is asinine and short-sighted. The solution and the dialogue moving forward will have to always contemplate both sides of the coin.

Overpopulation is causing a massive disservice to millions of people – specifically, to those who are already in a deprived status. By the same token, climate change engulfing the islands of

Kiribati and the Maldives furnishes the moral reasoning not to make (especially carbon-expensive) new people. As a result, we ought not to engage in behaviours partly responsible of overpopulation. One might contemplate the concept that only procreating past "replacement" will reinforce the problem, forasmuch as the affair is not making new people, but generating individuals at a rate that increases the population. So perchance, our commitment should go into having no more than two children per couple. Regrettably, due to the current population being already unsustainable, each couple creating two children might actually still lead to overpopulation. Thereupon, we can conceivably be under a duty of having no more than one child, since that fertility rate would be compatible with reducing the population to a sustainable level (Rieder, 2016).

Admittedly, each of the more than 7 billion inhabiting the Earth contribute at some level to climate disruption, extinctions, ecosystem transformation and pollution as it is depicted in figure 1.13. The actual contributions fluctuate with the prevailing pattern being a much larger per capita footprint in highly industrialized, wealthier countries, and a lower per capita footprint in developing, poorer countries. Although each individual contribution can be insignificant in the larger picture, when multiplied by billions, the effect becomes remarkably substantial (Barnosky et al, 2014). Likewise, regular environmental wisdom would have it that overconsumption is the transgression and misconduct of the affluent, as if their numbers were inconsequential, while overpopulation has been regarded as the deadlock and quandary of the poor as if they did not deplete and expend resources in ecologically unsustainable ways. As humanity has bloomed in both affluence and numbers, the natural world has equally receded apace, squabbles have erupted over whether the surge in consumption or the expansion of population is most culpable (Crist & Cafaro, 2012).

Important to realize is that calls for rapid action to reduce the world population in a humane way over the coming decades to centuries have been echoed (Pimentel et al, 1994; Ehrlich et al, 2012), with lay advocates objecting that sustainability enthusiasts ignore the "elephant in the room" of human overpopulation (Bailey, 2011; McMichael, 1995).

Professor Paul Ehrlich of Stanford University and author of the *The Population Bomb* (1968) states in an interview for *The Guardian* (Carrington, 2018a), commemorating the 50 years of the publication of the book that the world's optimum population is less than two billion people - 5.6 billion fewer than on the planet today.

Ehrlich divulges:

> "Population growth, along with over-consumption per capita, is driving civilisation over the edge: billions of people are now hungry or micronutrient malnourished, and climate disruption is killing people."

He maintains that civilisation is at a risk of shattering collapse and:

> "It is a near certainty in the next few decades, and the risk is increasing continually as long as perpetual growth of the human enterprise remains the goal of economic and political systems. As I've said many times, 'perpetual growth is the creed of the cancer cell."

It is a combination of high population and high consumption by the rich that is destroying the natural world, and the solutions are tough, he asserts:

> "To start, make modern contraception and backup abortion available to all and give women full equal rights, pay and opportunities with men. I hope that would lead to a low enough total fertility rate that the needed shrinkage of population would follow. [But] it will take a very long time to humanely reduce total population to a size that is sustainable."

But afar from unconscionable wars and global pandemics, the only humane way to curtail the proportion of the human population is to embolden lower per capita fertility (Bradshaw & Brook, 2014). This downsizing has been proceeding in general for decades (Lee, 2003; Bongaarts, 2009), mainly as the aftereffect of thriving levels of education and empowerment of women in the developed world, the swelling affluence of developing nations, and the one-child policy of China (Bongaarts, 2009; Myrskylä, Kohler & Billari, 2009; Ebenstein, 2010; Cohen, 2003). Despite this revolution, the status of the environment has aggravated on the grounds of the overcompensating effects of rising affluence-linked population and consumption quotas (Ehrlich et al, 2012; Bradshaw et al, 2010). One colossal obstacle is that a large unmet need for more expansive and effective family-planning aid, which has been previously hindered by conservative religious and political opposition, still lingers, albeit premature claims that rapid population growth has ended, which has translated in the reallocation of resources toward other health issues (Bongaarts & Sinding, 2011).

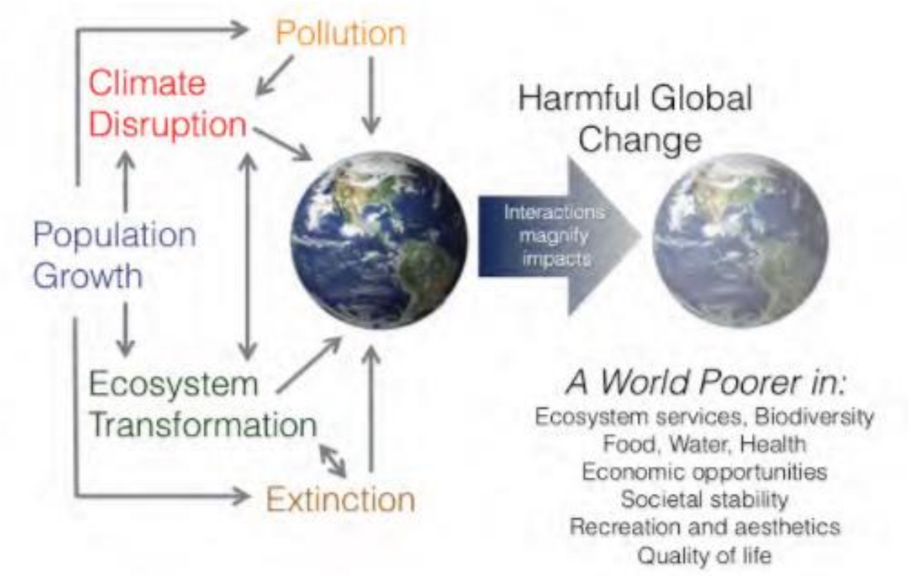


Figure 1.13: The interactions between climate disruption, population growth and consumption, ecosystem transformation, pollution, and extinction greatly magnify the potential for undesirable global change. Retrieved from Barnosky et al, 2014

Nevertheless, these growth trends cannot continue for long. The pivotal motions are, first, whether the nations of the world can decide and embrace a stabilization and reduction of their populations to a sustainable level; and, second, whether we can restrain resource consumption and waste generation to levels that grant us to not just live, but live well, and share resources munificently with the other human and nonhuman inhabitants of Earth (Bartlett, 2012). Ceasing growth used to be the solution, but now we have an *over*population problem. Only abbreviating our growth is not the solution anymore (Shragg, 2015).

To that effect, an international full-fronted campaign to bring the full spectrum of modern contraceptive methods, safe abortion, professional counselling, and sex and health education throughout the world - and especially to the places where they are most indispensable - would make a difference of billions within this century (Potts, 2009). Stabilizing and then reducing our numbers, *globally*, presses for a proactive system, enforced at the grassroots level so as to reach people in all places and walks of life. These measures concern two aspects: delivering services that enable people to arrange their childbearing choices and erase obstacles that hamper people from accessing such services (Crist, 2012). (Chapters Suffrage; Access and "Be Fruitful and Multiply, Fill the Earth and Subdue it", will approach these topics in lengthy detail, in Volumes II & III).

Furthermore, with population size not being benign in itself and presenting considerable hazards to human beings and wildlife alike, the intent must be to reverse population growth rather than merely decelerating it or locking it in some arbitrary, unsustainable size. Elevated fertility rates are broadly speaking the produce of social norms. Equally, social norms can change, and this is a powerful argument for an active and honourable engagement with the problem of population growth by scientists, activists and policy-makers (Kuhlemann, 2018).

Be that as it may, devising population stabilization as a policy goal is bound to produce difficulties of its own. The predominant narrative relies on the premise that populations must not wither; that whatever erratic size a population expands to must be secured and accommodated somehow. The angst and dismay of population 'decline' or 'ageing' is primal and tribal, echoing anxieties of a bygone era where survival hinged on a continuous supply of young men for waging war or fighting off invasions. Of course, in today's world, it amounts to a preposterous doctrine, where the main perils to the long-term viability of human societies are ultimately grounded in our proclivity to procreate - men and women, young and old - simply impairing the world by peacefully leading their own lives (Kuhlemann, 2018).

Provided that we follow up on these solutions, humanity is still, heedlessly, trying to identify how many people can be supported in the short term, without cognizance of the impact on future generations or the repercussions for other species. It is unequivocal that our life-support systems are being drained, otherwise, and has William Ryerson poignantly describes: "we would not have rising CO_2 levels, rising global temperatures, falling water tables, falling grain production per capita, degrading soils, disappearing forests, collapsing fisheries, growing energy shortages in many countries, and massive species extinctions." As Ryerson veraciously denoted as the title of his essay, in fact, "Population: [is] The Multiplier of Everything Else." (Ryerson, 2010).

In like manner, William Rees (2002), co-creator of the concept "ecological footprint" ardently depicts the assault on our existence:

> "From an ecological perspective, the techno-industrial society is already fundamentally unsustainable – the human enterprise is on a collision course with biophysical reality... humans are literally consuming the material basis of their own survival... [this] simple biophysical reality: all 7.5 (and rising) billion people on Earth plus the entire stock of manufactured "capital" – all our homes, cars, stereos, computers, cell phones, furniture, toys, offices, factories, infrastructure, etc. – are made from natural capital (resources) extracted from nature and the maintenance and further growth of the human enterprise requires the continuous extraction of ever greater quantities of energy and materials from the same source."

By all means, all of us want an attainable, sustainable global home. Provided that overpopulation and overconsumption extend into the future, a case can be made that billions will suffer and that we will leave future generations a much arduous, austere life. A smaller global population can be accomplished tomorrow by enacting a dramatic reduction in births today (World Population Balance, 2017). Gretchen Daily, Paul and Anne Ehrlich (1994) estimated a global population of roughly 2 billion - this number emanates from a calculus of how many can be accommodated while granting protection and a secure high-quality life for all people while sustaining a globally interconnected civilization. The Ehrlichs elucidate the rationale for this figure as the following in their book *One With Nineveh: Politics, Consumption and the Human Future* (2004):

> "[A]n optimal population size would be one for which the minimal physical necessities of a decent life could be guaranteed for everyone… and basic human social and political rights could be ensured for all… [P]opulation should be large and dispersed enough to encourage maintenance and development of humanity's cultural diversity and to provide critical mass in numerous areas of high density so that intellectual, artistic, and technological creativity would be stimulated. But the population should be small enough to permit the preservation of natural ecosystems and biodiversity at a level that could sustain natural services."

In effect, Richard Vernon (2018) provides a straightforward solution in dealing with population growth:

> "Benign and non-coercive means to reverse that growth, to achieve something like the 2.5 to 3 billion that experts estimate the planet could sustainably support, are well known. They include the much wider and free provision of reproductive health services, including family planning, to all who need them, and of both general and health education especially to the large number of the world's girls currently denied them."

On balance, Malthusian and deep ecology prospects postulate that depopulation is a decisive asset. Yet, the expectations regarding its environmentally restorative outcomes remain broadly unperceived (Matanle, 2018), while public attention has been concentrated on demographic ageing as the leading confrontation, despite marching social and environmental crises impelled by population growth (Götmark, Cafaro & O'Sullivan, 2018).

A point often overlooked is that the economic and demographic literatures indicate that the issues identified with ageing societies are both overestimated, embellished and amendable, when in fact attempting to ward off ageing by encouraging birth rates or immigration is, to some extent, relatively inadequate and generates even greater problems (Götmark et al, 2018). As the authors of *Aging Human Populations: Good for Us, Good for the Earth*, published in the journal *Trends in Ecology & Evolution* profess:

> "A range of social, economic, and environmental benefits are associated with older age profiles and stable or declining populations, which more than compensate for any economic imposts to support the elderly. Ecologists should study and communicate the negative impacts of human population growth and excessive population density and should not be deterred by misguided economic arguments favouring continued population growth. As the nations of the world grapple with the task of creating sustainable societies, **ending and in some cases reversing population growth will be necessary to succeed**." (Bold added by author)

Japan, which has been undergoing unprecedented demographic change, due to rapid ageing and, since 2008, population contraction, can be a good place to start a 'Depopulation Dividend.' First, this term refers to the achievement of positive benefits that contribute to socio-cultural, political-economic and environmentally sustainable living standards through amiable and non-coercive methods. Namely, environmentally dividends might encompass contractions in resource consumption, ecosystem and biodiversity restoration, and lessened pollution. Social perks could comprehend a more appropriate living space, enhancements to workplace opportunities, less crime and others we currently do not fully grasp. In any event, the depopulation dividend is not *yet* materializing on Japan (Matanle, 2018) (the reader can uncover more information following the given in-text citation) mostly due to national, international and supranational inaction and unwillingness to discuss and implement strategies to counter-act the dominant narrative of more growth (be it populational or economic) that equals better quality of life and environmental integrity. I will come back to this theme of the silence regarding population in the third chapter, Judas and the Elephant in the Room, and in an upcoming volume in Democratic Limits, as well diving deep into the sociological implications of population growth.

Ultimately, those readers that are concerned about the "why?" might wonder how did anything about this came to be, and when one asks why, there is a suggestion that all this had a cause, that someone or some group of people are partly accountable for the ecological mess humanity has created (Patterson, 2017).

One might impinge a faulty behaviour on the early farmers who invented agriculture. Or in the early industrialists like James Watt or Thomas Edison, or Fritz Haber and Carl Bosch that advanced the human enterprise by orders of magnitude and generated this disarray? No, it was none of these people. It was no one person or no group of individuals. It was not even any revolution like the industrial revolution, the medical revolution or the green revolution. There is no one to blame and there is nothing to blame for the 'twins evils' of overpopulation and overconsumption (Patterson, 2017).

After all, agriculture empowered the very modest early population to swell and expand. The industrial revolution and later the green revolution endowed more people to be fed. The medical revolution enabled more babies to survive and people to extend their lives with more quality of life. The human population has erupted simply because it could. Humanity has always lived to the limit of its existence and always will. It is just a part of human nature and life in general (Patterson, 2017). As Bradford Hatcher (2017) points out, humans are still bound by the same influences which restrain and control other animal populations:

> "When the wild animal populations crash […] eventually, populations restabilize, with numbers usually oscillating first above, then below capacity, but at a lower capacity until the long-term damage has been repaired by seral succession. This is where humankind has been headed, to diminished carrying capacity and a population crash to levels below that. If we're going to avoid this, we're going to need to conduct what amounts to a controlled population implosion. Our best alternative is rapid deceleration of growth and eventually a decline to below replacement levels."

Hatcher (2017) contends that:

> "This seems to be occurring as a matter of course in certain local populations, but this developed-world phenomenon also requires a higher standard of living, hence a larger ecological footprint, and education, particularly women's education. If we cannot manage to do this prior to reaching first-world levels of development, it will need to be done nature's way, and every number in a population crash means real people dying younger than they would in a better world, the suffering and premature death of living individuals."

Hatcher's argument is one hard to overlook. As it stands, even our best 'weapons' to counter-act the explosive rise in our numbers have side-effects, but the alternative of doing nothing to stop population growth will lock humanity and the natural world into a much more deleterious and injurious future.

To conclude, if an endeavour to reduce the human population is not attempted, there is no resolution. Ecological, land and water conservation are not going to materialize as long as the kind of impetus that dominates, in the form of science and technology, is making every human being hyperactive. A point often dismissed is that we cannot cap human activity, which translates to human aspirations and ambitions; on the other hand, human numbers can be lowered - by reducing fertility rates - without infringing on anyone's rights. Providing that life for everyone cannot be entertained with the current levels of population (Vasudev, 2016).

CHAPTER II

PROMETHEUS

"If you don't know history, then you don't know anything. You are a leaf that doesn't know it is part of a tree."

- Michael Crichton

"The past is never dead. It's not even past."

- William Faulkner

"We have met the enemy and he is us."

- Featured on the cartoon *Pogo*, created by Walt Kelly

If the reader can recall the clarification I give in the Foreword regarding the decision to name this work 'Atlas,' you will remember that Atlas was a Titan that revolted against Zeus' command in the war named Titantomach»y. Although Atlas was considered Zeus' greatest adversary during this war there were many more Titans like him that opposed Zeus, and eventually lost the war. There were also those who had the clairvoyance and foresight to fight alongside Zeus, and against their own kind. Prometheus was considered to have headed this perceptive decision, and so the words 'prescience' and 'forethought' have reached our day an age, which come from this Titan. In the interest of this chapter, I dive deep into how the excess of human numbers have permeated societies since the dawn of recorded history, and present here their thoughts and expostulations, so we may invigorate and reinforce the interpretation that human overpopulation is not just a perturbation and puzzlement of the infamous Malthus and a few other delirious individuals.

Shortly before 1600 BCE, a junior scribe in what is now Iraq transcribed (Clines, 1988) a Babylonian history of humankind. In the poem, the Babylonian gods designed humans on the Earth to do the arduous endeavours of the lesser gods. But the gods promptly experienced a predicament:

"Twelve hundred years had not yet passed
When the land extended and the people multiplied.
The land was bellowing like a bull,
The god got disturbed with their uproar.
Enlil heard their noise
And addressed the great gods:
"The noise of mankind has become too much for me,
With their noise I am deprived of sleep.
Let there be a pestilence (upon mankind).""

The story continues with the gods exacting plagues to rid the Earth of the surplus of humans. When all else failed, they flooded the Earth with the mightiest rainstorm ever. Only Atrahasis, the hero of the epic, survived. Afterwards, the gods repented and tolerated human flourishing once again. However, to avoid their peace and tranquillity from being breached by too many people in the future, the gods promulgated religious obligations of infertility on priestesses and forged a demon to ravage humanity's infants and children (Cohen, 1995).

> "Furthermore, let there be a third group of people. (Let there be) fertile women and barren women. Let there be the "Eradicator" (a name of *Lamashtu*) among the people and let her snatch the child from the lap of the mother. Establish *ugbabtu*-women, *entu*-women, and *igisitu*-women and let them be taboo and cut off [from] childbearing" (Leichty, 1971).

This Babylonian epic, recognized by contemporaneous scholars as the Atrahasis epic, is perhaps the earliest surviving account of human overpopulation and the primaeval interpretation of catastrophes as a reverberation to overpopulation (Cohen, 1995). But it wasn't the last.

Overpopulation arose again as a dilemma for the gods in the lost post in the almost forsaken post-Homeric epic *Cypria*, attributed to Stasinos. The *Cypria* is part of the Epic Cycle written in the period 776-580 BCE in which, Zeus's first response to overpopulation was to concoct the Theban War, which razed countless lives. But again, the problem endured. After contemplating the universal destruction of humans by flood or thunderbolts, Zeus was impelled to engineer the birth of the beautiful Helen to provoke a war between the Greeks and the Barbarians (Cohen, 2008).

> "There was a time when the countless tribes of men, though wide-dispersed, oppressed the surface of the deep-bosomed earth, and Zeus saw it and had pity and in his wise heart resolved to relieve the all-nurturing earth of men by causing the great struggle of the Ilian war, that the load of death might empty the world. And so the heroes were slain in Troy, and the plan of Zeus came to pass" (quoted in Bacci, 2017).

The conception that gods institute war and plague to prevent the Earth from becoming permeated with people lingered at least another two millennia and persists in the minds of some people even today. But going back to Iraq in 300 BCE, Han Fei-Tzu expostulated:

> "People at present think that five sons are not too many and each son has five sons also, and before the death of the grandfather there are already 25 descendants. Therefore people are more and wealth is less; they work hard and receive little" (quoted in Meadows, Randers & Meadows, 2004).

Some centuries later, around 200 CE, Quintus Septimus Florens Tertullianus wrote in *De Anima* (Tertullien & Waszink, 1933):

> "Indeed it is certain, it is clear to see, that the earth itself is currently more cultivated and developed than in early times. Now all places are accessible, all are documented, all are full of business… everywhere there is a dwelling, everywhere a multitude, everywhere a government, everywhere there is life. The greatest evidence of the large numbers of people: we are burdensome to the world, the resources are scarcely adequate to us; and our needs straighten us and complaints are everywhere while already nature does not sustain us. Truly, pestilence and hunger and war and flood must be considered as a remedy for nations, like a pruning back of the human race becoming excessive in numbers (quoted in Cohen, 1995).

With the world witnessing the scientific method gaining speed and the Enlightenment in the making, in 1688, an anonymous author published in London a 24-page booklet of six "Curious enquiries." The fifth one was entitled "*Of Europes being too full of people*." The author criticized the tremendous rates of unemployment:

> "How many miserable people lie up and down, begging and starving; and I am not so uncharitable to think, that all do it out of idleness, some there are, no doubt on't, that would work, and cannot get it" (quoted in Cohen, 1995)

In 1758, 40 years before the English Reverend Thomas Robert Malthus (1766-1834) wrote his distinguished essay on population, the Reverend Otto Diederich Lütken, rector of a parish on the island of Fyn, Denmark, published an article in *Danmarks og Norges Oeconomiske Magazin (Danish-Norwegian Economic Magazine)* entitled "An enquiry into the proposition that the number of people is the happiness of the realm, or the greater the number of subjects, the more flourishing the state." The article commenced as such:

> "Since the circumference of the globe is given and does not expand with the increased number of its inhabitants, and as travel to other planets thought to be inhabitable has not yet been invented; since the earth's fertility cannot be extended beyond a given point, and since human nature will presumably remain unchanged, so that a given number will hereafter require the same quantity of the fruits of the earth for their support as now, and as their rations cannot be arbitrarily reduced, it follows that the propositions "the the world's inhabitants will be happier, the greater the number" cannot be maintained, for as soon as the number exceeds that which our planet with all its wealth of land and water can support, they must needs starve one another out, not to mention other necessarily attendant inconveniences, to wit, a lack of the other comforts of life, wool, flax, timber, fuel, and so on. But the wise Creator who commanded men in the beginning to be fruitful and multiply, did not intend, since He set limits to their habitation and sustenance, that multiplication should continue without limit" (Saether, 1993).

At the edge of the nineteenth century, Reverend Thomas Malthus contemplated the logic of natural limits, and the relentless expenditure of infringing them, to humanity. He envisioned that as the population grows faster than food production, human numbers would overtake the available food supply and people would reap the woes of famine, disease and war (Malthus, 2007, original 1798, published under his name in the 6th edition (1826)).

Malthus challenged the orthodoxy of his age, asserting that while the means of subsistence develop in a linear manner, population grows exponentially. The disparity between these tempos reaches a perilous threshold as productive land is depleted; a plight of disequilibrium he connected with more developed countries like Britain. Either population growth must thenceforth be reduced through rational means, notably by sexual abstinence, or, if these 'preventive checks' fail, more painful 'positive checks' will ensue as the unsustainable excess falls victim to famine, disease or war, whence restoring equilibrium (Malthus, 1826).

In *An Essay on the Principle of Population* (Malthus,1826), Malthus said:

> "Through the animal and vegetable kingdoms Nature has scattered the seeds of life abroad with the most profuse and liberal hand; but has been comparatively sparing in the room and the nourishment necessary to rear them. The germs of existence contained in this earth, if they could freely develop themselves, would fill millions of worlds in the course of a few thousand years. Necessity, that imperious, all-pervading law of nature, restrains them within the prescribed bounds. The race of plants and the race of animals shrink under this great restrictive law; and man cannot by any efforts of reason escape from it."

The twentieth century witnessed the liberation from medical and resource constraints, which became effortless to govern and regulate due to the emergence of the Green Revolution, which permitted humans to manufacture (and dispose of) much more food than Malthus could have envisioned (Kopnina & Washington, 2016). To this effect, Childe (1951) appreciated population growth as intrinsically contingent on subsistence, cognizant of the fact that foragers were acutely restrained by a low carrying capacity. Correspondingly, the emergence of farming practices increased the carrying capacity and made a "population explosion" possible (Netting, 1977 quoted in Hicks, 1980). Coupled with this, the economist Ester Boserup (1965, in Boserup, 2005) has accentuated that population growth creates a higher carrying capacity by obliging people to use land more intensively and to embrace technological innovations that make more intensive land use feasible (Kopnina & Washington, 2016).

Yet, the negative side of population growth was materializing into a concrete threat. Inspired on the writings of Malthus (1826), that there is a need for particular "checks" on population expansion, emanating "from the difficulty of subsistence," including, among other things, the struggle for resources, diseases, and famine. Since land and resources are finite, checks of growth must be in place to avoid Malthusian "controls." The apprehension that the world has more people than it can shelter, and that raising human numbers will result in agonizing corrective disasters marked the 20th century and continues to our present days. In 1992, Walter J. Karplus (Karplus, 1992), an engineer at the University of California, summarized what he called "The Scientific Prediction of Catastrophes in Our Time" and asserted:

> "Overpopulation is the fountainhead of most of the other catastrophes… If only the world population were to become stable at, say, 50 percent or 75 percent of its present level, most environmental and public health problems would become more easy to manage… if the world population continues to grow at its present rate, a plethora of catastrophes, including those represented by the Four Horsemen of the Apocalypse, will be certain to overtake us sooner or later. Ironically, these catastrophes will serve as feedback mechanisms to limit the population, albeit at a terrible cost in human suffering. For this reason, I believe that overpopulation is the most crucial global problem we face today."

In short, an expanding population can become a menace to humanity itself, as it cripples its own resource base, in due time prompting the reassertion of "natural" controls. The acclaimed anthropologist Gregory Bateson noted in *Steps to an Ecology of Mind* (1972), how when meeting with challenges of altered natural conditions, humans tend to converge on altering their environment rather than themselves. Bateson asserted that these basic causes of environmental crisis manifest in the *combined* action of (a) technological advance, (b) population expansion, and (c) traditional (but wrong) ideas about the "nature of man" and his relation to the natural world. While technological advance has engendered unplanned but exceptionally destructive repercussions on the environment, population increase has aggravated the challenges (Kopnina & Washington, 2016).

With the publication of *The Population Bomb* (Ehrlich, 1968; for an update see Ehrlich & Ehrlich, 2009 and *The Limits of Growth* (published in 1972, for an update see Meadows et al, 2004), the prognostications of our ancestors regarding population growth were associated to the reality of the twentieth-century sustainability contentions (Kopnina & Washington, 2016).

The Population Bomb administered a model admonition that technology may not be satisfactory to abbreviate the calamitous ramifications of increasing populations. Although they were branded as "extremists" and alarmists at the time, contemporaneously, we can witness how their – and others such as the Club of Rome - forecastings for environmental damage due to an unbounded population growth, technological and industrial "innovations" to be right on the mark of global apprehensions (Kopnina & Washington, 2016; Schiermeier, 2018).

Before leaving the 20th century and focusing on our current population predicament, there is still a need to examine the works of two very different intellectuals, which shaped the way we understand our environmental dilemmas, and that will be of a preeminent relevance to the position of action we as humans take while confronting the multiplicative effects of human overpopulation.

These two people were William Vogt and Norman Borlaug.

Vogt, born in 1902, outlined the basic ideas for the modern environmental movement. Specifically, he founded what the Hampshire College population researcher Betsy Hartmann has called "apocalyptic environmentalism" - the concept that unless humankind drastically curtails consumption and limits population, it will overwhelm global ecosystem integrity and maintenance and biological continuity (Mann, 2018).

As Charles C. Mann recounts in his best-selling book *The Wizard the Prophet: Two Groundbreaking Scientists and their conflicting visions of the future of our planet* (2018):

> "In best-selling books and powerful speeches, Vogt argued that affluence is not our greatest achievement but our biggest problem. If we continue taking more than the Earth can give, he said, the unavoidable result will be devastation on a global scale. *Cut back! Cut back!* was his mantra."

On the other hand was Borlaug, born 12 years after Vogt, he assumed the form and emblem of the "techno-optimism" - the view that science and technology, when properly applied, will concede processes and approaches out of our ecological predicament. Furthermore, he was the best-known figure in the research that in the 1960s originated the Green Revolution, the combination of high-yielding crop strains and agronomic techniques that augmented grain harvests all over the world, helping to bypass countless tens of millions of deaths from hunger. Contrastingly, to Borlaug, affluence was not the problem but the solution. Only by getting richer and more knowledgeable can humankind formulate the scientific 'know-how' to resolve our environmental and ecological quandary. *Innovate! Innovate!* was his cry (Mann, 2018).

Uniquely, both men were thinking of themselves as operating under the aegis of scientific knowledge to face a planetary crisis. But that was where their resemblance ended. For Borlaug, human ingenuity was the unravelment to the ecological meltdown being engendered by mankind. One illustration: By using the advanced methods of the Green Revolution to expand on per-acre yields, he argued, farmers would not have to plant as many acres, sparing nature the transmogrification, an idea researchers now address as the "Borlaug hypothesis." In contrast, Vogt's considerations were the opposite: The solution, he said, should stem from the ecological knowledge to get smaller. Instead of growing more grain to produce more meat, humankind should, as his advocates state, "eat lower on the food chain," to attenuate the strain on Earth's ecosystems (Mann, 2018).

This is where Vogt ran counter to his predecessor, Robert Malthus, who argued that humanity would run out of food because of too high fertility rates. Vogt, shifting the argument, asserted that there was a possibility of growing all that food, but it would be at the cost of tearing down and corrupting every shred of the natural world (Mann, 2018).

Both men are long gone, but the dispute between their propositions has only become more impassioned and inflamed. Charles C. Mann describes it best in his *The Atlantic* piece *Can Planet Earth Feed 10 Billion People?* (2018):

> "[The adherents of Borlaug view the advocates of Vogt'] emphasis on cutting back as intellectually dishonest, indifferent to the poor, even racist (because most of the world's hungry are non-Caucasian). Following Vogt, they say, is a path toward regression, narrowness, poverty, and hunger - toward a world where billions live in misery despite scientific knowledge that could free them. [On the other hand, advocates of Vogt] sneer that Borlaug's faith in human resourcefulness is unthinking, ignorant, even driven by greed (because refusing to push beyond ecological limits will cut into corporate profits). High-intensity, Borlaug-style industrial farming, they say, may pay off in the short run, but in the long run will make the day of ecological reckoning hit harder. The ruination of soil and water by heedless overuse will lead to environmental collapse, which will, in turn, create worldwide social convulsion."

Vogt entered history in 1948, when he published *Road to Survival* (1948), a book that encompassed the foundational argument of the contemporaneous environmental movement: carrying capacity. Often addressed as "ecological limits," or "planetary boundaries," carrying capacity postulates that every ecosystem has a limit to what it can produce. Exceeding that limit for too long will prompt ecosystem ruination (the reader can recall or reinspect the concept of carrying capacity in the previous chapter) (Mann, 2018).

Road to Survival argued that, as human numbers swell our demands for food will outstrip the Earth's carrying capacity, and the resulting scenario will be calamitous: erosion, desertification, soil exhaustion, species extinction, and water contamination that will, sooner or later, incite massive famines (all these themes will be properly addressed in the coming chapters of Where the Wild Things Were and Hunger Games). Correspondingly, writers like Rachel Carson [(author of *Silent Spring* (original 1962; updated version 2002) and Vogt's friend)] and Paul Ehrlich (author of *The Population Bomb* (1968)), embraced Vogt's assertions and ideas about exceeding limits, which became the fountainhead of today's globe-spanning environmental movement - the only enduring ideology to emerge from the past century (Mann, 2018).

At root, their contrasting discrepancies were ideological, not scientific. Borlaug endorsed the mainstream values of his time and place - the American dream of material acquisition and improvement. Vogt didn't, he was a critic and an expositor. He requested that people reappraise and audit their own place in the world: to think ecologically about everything from what we consume to how we perceive history. He interrogated himself if the free market and corporate capitalism could be environmentally sustainable. Equally important, he was an advocate for population control, which went against many people's religious and humanistic ideals and principles at the time (Rome, 2018).

Fortunately, the two centuries ensuing Malthus reasoning did not see a human population crash, as food production kept pace with the escalating numbers of people (figure 2.1); indeed, in the twentieth century, the rate of food production even outpaced the rate of population growth.

Correspondingly, the Malthusian premise was thrown into disgrace, and the axiom of human exemptionalism from natural limits derived a triumphant boost (Crist, 2015) and fueled the flames of Borlaug's ideology that anything was possible for human ingenuity.

So, does this mean that Malthus, his predecessors and Vogt were disproved? Is carrying capacity a chimaera? No. As Vogt had anticipated, the colossal jump in productivity prompted a tremendous adulteration of the natural world: depleted aquifers, fertilizer runoff, aquatic dead zones, and degraded and waterlogged soils. Worse still in a human sense, the expeditious boost in productivity made rural land more valuable. Unexpectedly, it was worth plundering - and rural elites in many places acted on it, throwing poor farmers off their land (Mann, 2018).

Vogt's advocates argued that the Green Revolution would merely adjourn the hunger crisis, rather than permanently fixing it. With an expanding population and affluence what will have to materialize is a second Green Revolution. The problem is, to keep up with production, for a swelling human populace with a voracious appetite, the natural world won't stand a chance (Mann, 2018).

Charles C. Mann again:

> "Even though the global population in 2050 will be *just* 25 percent higher than it is now, typical projections claim that farmers will have to boost food output by 50 to 100 percent. The main reason is that increased affluence has always multiplied the demand for animal products such as cheese, dairy, fish, and especially meat - and growing feed for animals requires much more land, water, and energy than producing food simply by growing and eating plants. Exactly how much more meat tomorrow's billions will want to consume is unpredictable, but if they are anywhere near as carnivorous as today's Westerners, the task will be huge. And, Vogt's advocates warn, so will the planetary disasters that will come of trying to satisfy the world's desire for burgers and bacon: ravaged landscapes, struggles over water, and land grabs that leave millions of farmers in poor countries with no means of survival."

During the 1972 United Nations Conference on the Human Environment (the Earth Summit), international agendas encompassing population and sustainability were advanced. These international agendas disputed the underlying fallacy vitiating industrial capitalism, that indefinite growth both of population and the economy is possible on a planet of finite resources (Kopnina & Washington, 2016). As Bateson (1972) has noticed, the very first precondition for ecological stability is an equilibrium between the rates of birth and death. For better or worse, humanity has meddled with the death rate, specifically by regulating the major epidemic diseases and the death of infants. Presently, there is an augmented proportional discrepancy between the number of people on earth (7.6 billion in 2018) and the number of nonhumans, particularly apex predators left in the wild. While the former is custumarily checked by environmental restritions, that is not the case for *Homo sapiens* (Kopnina & Washington, 2016).

It seems that, like Bateson (1972) described:

> "The bigger the population, the faster it grows; the more technology we have, the faster the rate of new invention; and the more we believe in our 'power' over an enemy environment, the more 'power' we seem to have and the more spiteful the environment seems to be."

With such a prognosis, it is hardly startling that views of stabilizing and reducing the human population had sporadically spawned throughout human history and provoked antagonism. Anti-natalist notions about trimming the proliferation of the human species confronted deep-seated traditional convictions. By exposing the notion of excessive numbers, the population question cut across vitalist and religious taboos regarding the sanctity of life and privileging of human life. It objected to the Enlightenment perception about humans' mastery of nature and political economists' views on the engine of prosperity. It stirred on some of humanity's most fundamental interpretations about the sacred, life and death, as well as on some of its most enduring identities and rites regarding the family, marriage and sexuality (Coole, 2012).

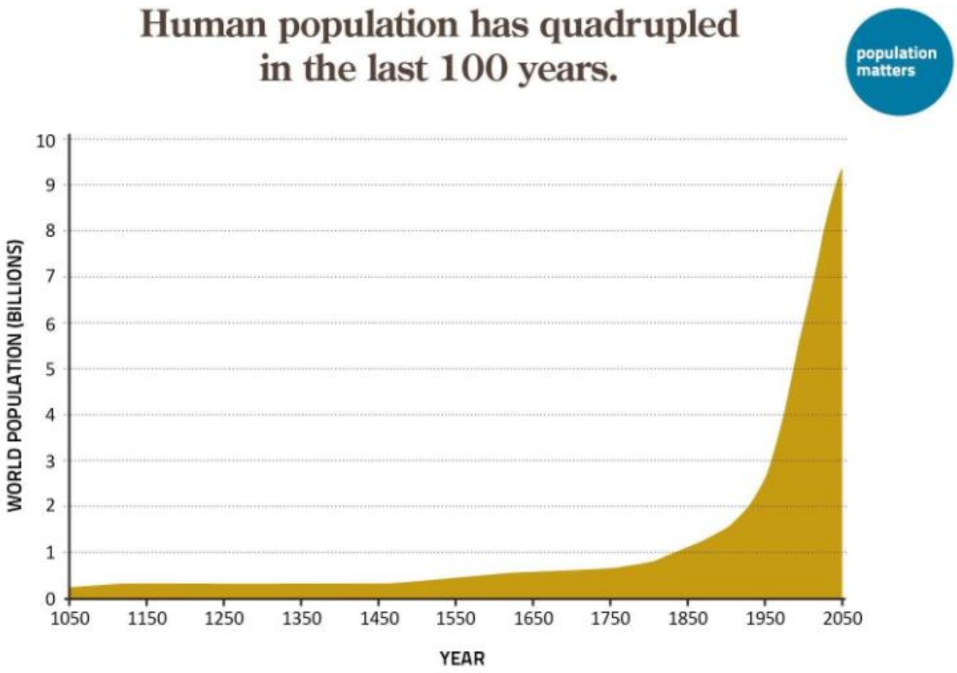


Figure 2.1: Human population in the last millennia. Projections until 2050 are based on the estimates from the United Nations World Population Prospects 2017 Revision. Image retrieved from populationmatters.org.

Nevertheless, during the 1960s, Malthusianism seized a brand-new reverberation in advanced industrial countries where there was a refreshed anxiety about a population explosion (Ehrlich, 1968; Meadows et al, 1972; Goldsmith, 1972). Even though the post-war baby boom was taking place, the population growth in the West was relatively limited, whereas the accrual affluence by larger numbers suggested an impending calamity. With the emergence of new reproductive technologies and feminist challenges to conventional gender roles, it was conveyed that population stabilisation was becoming more viable, albeit the task of revitalizing the equilibrium between population and environment was hinting to be no less strenuous given the propensity for sustained economic growth (Coole, 2012). A contraction of population nevertheless became the dominant narrative to an environmental responsiveness that marshalled new social movements and found common ground with new left examinations of consumer capitalism (Marcuse, 1964; 1969).

Limits-to-growth arguments correspondingly furnished the groundwork for a profound discourse in which economic and population growth were identified as jointly imperilling the aptitude of a finite planet to bolster a looming strain. Reestablishing harmony recommended an intrinsic social transformation in which fewer people would value a more frugal lifestyle, less wasteful consumption or excessive reproduction and above all, enriched by a more harmonious connection with nature (Coole, 2012).

By 1969, President Richard Nixon was warning Congress that the domestic burden of 200 million Americans was a menace to democracy and education, privacy and living space, natural resources and the condition of the environment (Population and Development Review, 2006). Nixon warned:

> "One of the most serious challenges to human destiny in the last third of this century will be the growth of the population. Whether man's response to that challenge will be a cause for pride or for despair in the year 2000 will depend much on what we do today" (Kolankiewicz & Beck, 2001).

Official reports to both the American (1972) and British (1973) governments counselled stabilising population numbers in the national interest. Yet this anti-growth orientation would shortly fall into dormancy, with the very language of limits or restriction being forsaken (Coole, 2012).

In like manner, historian Samuel Hays, in his landmark book *Beauty, Health, and Permanence* wrote that in 1970, "It was rather widely agreed that population should be limited" (Hays, 1987). Indeed, former president Eisenhower in 1968 said:

> "Once, as president, I thought and said that birth control was not the business of our Federal Government. The facts changed my mind… I have come to believe that the population explosion is the world's most critical problem."

Let us keep in mind that Ike said this as Vietnam was blowing up and when the Cold War was about as hot as it got. Three years earlier, President Lyndon Johnson had told the United Nations that "five dollars invested in population control is worth one hundred dollars invested in economic growth" (Ehrlich & Ehrlich, 1970, pp. 259, 295). As Dave Foreman puts it: "That wisdom should be chiselled into marble above the main door of the World Bank" (Foreman, 2012).

Given all these points, Adam Rome (2018) writes in the Books and Arts section of the journal *Nature* that:

> "Our species has had an amazingly successful run. Billions of people now live in environments radically transformed to suit human needs and wants. But humanity's future is far from guaranteed. How will we meet the looming challenges of the twenty-first century? We can work even harder to master the planet with technological ingenuity. Or we might need to accept that our desires can't be unlimited, and see ourselves as citizens of a larger-than-human community, rather than as world conquerors. We can't do both."

Human Population Growth vs Absolute Numbers

"The Humanity of men and women is inversely proportional to their Numbers."

- Aldous Huxley

Human numbers were relatively constant throughout humanity's antiquity, nonetheless, tens of thousands of years ago the population of our Homo sapiens forefathers managed to reach a meagre 20,000 individuals, exposing our species to the fate of extinction that has befallen many other countless lifeforms on this planet. The reasons behind this bottleneck are still not fully comprehended, but as anthropologist Stanley Ambrose of the University of Illinois has proposed, the Toba crater eruption in northern Sumatra around 72,000 ago forged a ten-year-long volcanic eruption that provoked a thousand-year long winter upon the world – and thus killed off all but a few thousand members of *Homo sapiens* thousands of miles away from Africa (Ambrose, 1998). On the other hand, more contemporaneous research (Yost, Jackson, Stone & Cohen, 2018; Smith et al, 2018; Williams, 2012; Vogel, 2018) seems to cast some doubt on the theory that the eruption – as well as the dust and other debris expelled - had such an intense and severe aftereffect on the human populations alive at the time, and that some population even thrived (Dvorsky, 2018; Daley, 2018). It just goes to show that even when the dust *really* has settled, if there is no agreed conclusion, the answer can only be more science.

Still, humanity not only survived through its prehistory but proliferated, leaving us to ponder on this human demographic exceptionalism, and Robert Engelman remarkably portrays it as such in his book *More: Population, Nature and What Women Want* (2008):

> "Why did we grow unlike any other species before us? This appears to lie in a series of evolutionary changes already evident In *Homo erectus*: more protein – and calorie-rich food, less time spent breastfeeding, and probably a longer period of fecundity over an individual's lifetime. These changes led to more births in less time per female than in any other hominid."

Albeit dire adversity, humanity slowly increased until reaching the first billion around 1804. After this, growth hastened, then ruptured. As figure 2.2 demonstrates, by 1927, when beloved naturalist Sir David Attenborough was a baby, humanity had already produced the second billion. By the time Attenborough narrated the first *Life on Earth* series at the end of the 1970s, our numbers had more than doubled again. We are now on course to reach our third doubling by 2023 when there will be 8 billion of us (Kuhlemann, 2018).

As David Attenborough (2018) recognizes in an article in the *New Scientist*:

> "It's an extraordinary thing. I started making television programmes in the 1950s. There are now three times as many people living in the world as there were then. Three times as many! They all need places to live and roads for their cars and hospitals and schools and places to grow food. Where is that going to come from? In the most part, it is going to come from the natural world, so the natural world is steadily being impoverished. The situation is becoming more and more dreadful and still our population continues to increase. It's about time that the human population of the world came to its senses and saw what we are doing - and did something about it."

Equally important is that population growth is slowing down, or better yet, the percentage of annual growth, but there is no end in sight: we are due to reach 11 billion towards the end of this century and to continue widening our numbers well into the next (UNDESA, 2015). The number of people added to this planet every year (approximately 83 million) has not changed much since the late 1970s, nonetheless, it translates into an ever-smaller *rate* of growth because our absolute numbers are getting larger (Kuhlemann, 2018).

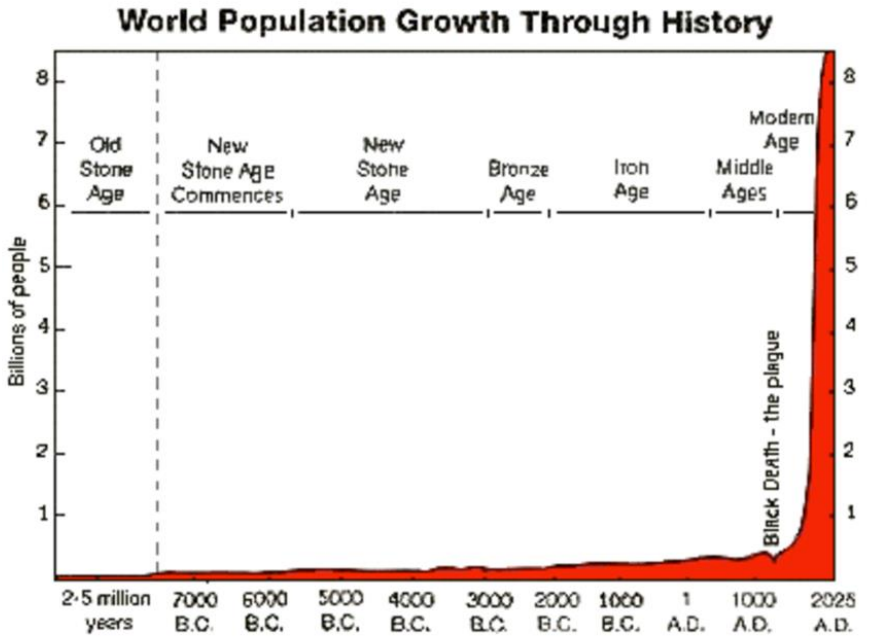


Figure 2.2: World Population Growth Through History. Retrieved from Wilcox & Jessop, 2009

By all means, it is true and important that fertility rates are receding, and that the worldwide annual population growth rate has declined along with them (UNDESA, 2011) (figure 1.7 and 1.8), as a result, curtailing fertility in developing countries is likely both an effect and a cause of enhancing the lives of the world's poor (especially women), hence, benefiting other duties of distributive and social justice (Hickey, Rieder & Earl, 2016). But in absolute terms, current world population growth is immense (figure 2.2), partly because these lower growth rates are occurring on top of an ever-larger base population. Ultimately, this notion of a slower annual population growth has created the notion that there is no population problem to deal with (Kuhlemann, 2018).

Meanwhile, the latest UN projections are for several *billion* more people to be added over the coming decades. Given the existent ample ecological flags warning that current human numbers are excessive, any considerable population increase should be recognized as detrimental, and possibly lethal, to the success of sustainability efforts (Crist & Cafaro, 2012).

All in all, from an environmental sustainability viewpoint, what matters is the current *and* cumulative effect of *absolute population size,* not the *rate* at which our numbers grow. As Karin Kuhlemann enunciates in her work *'Any Population Size Will Do?' The fallacy of aiming for stabilization of human numbers* (2018)*:*

> "It makes a great deal of difference to the prospects of human security and well-being, and for wildlife survival, if our population is 2 billion, 7 billion, 11 billion or, indeed, 16 billion."

The late Albert Bartlett was the genius behind the mathematics of population growth. His greatest legacy was the concise and scholarly fashion in which he bestows those calculations upon others so they could be able to interpret and reproduce it for themselves.

The example materialized here derives from Bartlett's original work in his hometown and requires very simple mathematical understanding. It goes as follow (Bartlett, 2012):

If the population is P (0) at time t (0) and is P (1), then it is possible to find the average growth rate from the following formula:

Growth rate(R) = [100/ (t (1) – t (0))] x ln [P (1) / P (0)]

In 1950 the population of Boulder, Colorado was 19,999; twenty years later, in 1970, it was 66,870. The average growth of Boulder's population growth for this twenty-year period was

R = [100/20] x ln [66,870/19,999]

= 5 x ln [3.344]

= 5 x 1.207

= 6.035 percent per year

Having the percent growth per year, the doubling time T (2) can also be calculated:

T (2) in years = 70 / (the percent growth per year)

According to the previous example:

T (2) = 70 / 6.035

= 11.48

What this means is that the population of Boulder Colorado doubled every 11.48 years.

These formulas can be applied to any scenario imaginable, and any reader can replicate it within his/her hometown or country, given the possession of the population data.

Under the circumstances of the example of Boulder, the growth rate described could not linger for an extended period of time, thus, in just ten doubling times, or 115 years, the population would be about a *thousand times* as massive as it was in 1970. Thereupon, by 2085, it would rise to over sixty-six *million* people. There is not enough space in the Boulder Valley for such a substantial population, nor are there resources to provide for them.

The crucial question that people in Boulder, and all around the world, need to ask is whether it will be possible to stop the growth in a timely and sensible manner. This question accosts many towns, cities and nations (Bartlett, 2012). In 2018 the growth rate of the world is still over 1 percent per year, driven primarily by high birth rates in the developing world (UNFPA, 2018).

Max Lu, which was introduced in the previous chapter, appeals in *Overpopulation Stresses Resources, Which In Turn Stresses People* (2016):

> *"It is one thing to keep 7 billion or more people alive: it is quite another to ensure that every member of the human race enjoys a healthy and fulfilling life. Achieving the latter is far more challenging than the former under any circumstances. Having so many of us on Earth just makes it so much harder and the potential for conflict that much greater. Unless we change the way we do things, the chances of eliminating poverty, malnutrition, and premature deaths are not good."*

In the light of this, Lu calls attention to the *Cassandras* of Human Overpopulation:

> "We have been lucky that the doomsday scenarios predicted by population pessimists have not played out so far, but there is no guarantee that they will not happen in the future."

Therefore, taking into account all the voices that raised concerns over the ages regarding population, our priorities for the future should follow what Massimo Livi Bacci underlined in *Our Shrinking Planet* (2017):

> "The international community's guiding star must be the dismantling of the Malthusian trap that still ensnares one billion people: poverty, malnutrition, precarious survival, high fertility, high population growth rates, and access to fresh water. This trap was tough to crack in Malthus's time, but today, with the availability of new knowledge and greater resources, we can neutralise and dismantle it."

CHAPTER III

JUDAS AND THE ELEPHANT IN THE ROOM

“The raging monster upon the land is population growth. In its presence, sustainability is but a fragile theoretical concept.”

– Edward O. Wilson

“The ultimate intelligence of our species will be determined by whether we face our population issue and get it under control, or continue to sweep it under the rug because it’s an uncomfortable conversation. The future of life on Earth depends on us doing the former.”

- Leilani Munter

In this chapter, I will attempt to convey the different kinds of difficulties in discussing population growth, immigration, overconsumption and all the taboos created around them. It’s a chapter that prepares the reader for the adequate state of mind necessary in understanding the hurdles imposed on the population movement and why it hasn’t been more successful, since its foundation is one of science, reason and humanity, above all.

Over the progress of history, many scientists and activists have cautioned societies about population numbers that have been, unceasingly, growing (Gao, 2015). As described in the previous chapter, the 1970s were a period in which the subject of the need for political and activist action on the link between population and sustainability was spawning into existence, additionally, regulation was less controversial, partly due to the baby boom years that had shaped concerns about scarcity of resources (Navarro, 2011). However, recently, it appears that this link has become controversial (Kopnina & Washington, 2016). Patrícia Dérer writes for *The Overpopulation Project* (Dérer, 2018a) how:

> “Many of us still remember how researchers, environmentalists and the media were concerned about population growth between the 1950s and the 1980s. Many of us could also notice, that this concern and attention declined during more recent decades, despite continued population growth. Nowadays there is almost a complete silence about overpopulation, both in the media and academia.”

To understand our contemporaneous relapse we need to travel back to the time when Paul Ehrlich’s bestseller “The Population Bomb” (1968) was making its rounds, prognosticating that the world’s population would double in less than 35 years - a daunting speed. The book had an extensive impact but sparked a retaliation that made almost any further discussion of population completely toxic and radioactive, triggering a fallout for everyone who dared to bring the topic into discussion (Kissling, Musinguzi & Singer, 2018).

At present we can assess how not every prediction by Ehrlich, fortunately, hit its mark (ensuing chapters will deal with some of the scenarios that are even worse than Ehrlich foreseen). In *The Science Show* podcast (2018a), former president of the Royal Society of London and present Astronomer Royal, Martin Rees had the following to say in this respect:

> "Well, it's certainly true that some of the doom laden statements made by the Club of Rome and Paul Ehrlich have not been fulfilled, partly of great advances in food production, but nonetheless I think it is clear that if pressure on populations continues and if each person aspires to a standard of living which is more extravagant in terms of use of resources et cetera, we will cross planetary tipping points, which could lead to problems. So even though we've been okay, Paul Ehrlich may be right in saying that the problem has just been delayed because we have 7+ billion people on the planet, we expect 9 billion by mid-century, and maybe even more by the end of the century, and I think people already say that the planet couldn't sustain even 1 or 2 billion if they all lived like present-day Americans. So if we want to have a better life and a more equal life for the 9 billion people who are on the planet by mid-century, clearly it's got to be a different lifestyle from what prosperous people enjoy today. So we are going to be up against these boundaries which will need new technology to solve."

In any event, in the interest of this chapter, I shall address the discussion of the population taboo. In the first place, it might be remotely connected to the contentious solutions that Ehrlich assumed would become common-place in an overcrowded world. To this effect, Ehrlich asserted that if voluntary family planning didn't contract population rapidly enough to impede an ecological meltdown, famine and other natural disasters (now firmly connected with to anthropogenic climate change), there would come a time to resort to a sort of "break the glass" emergency in which coercion and the withdrawal of food aid to countries that did not manage their internal populations would be necessary and justifiable (Kissling et al, 2018).

As Frances Kissling, Jotham Musinguzi and Peter Singer argue in the *Washington Post's* (2018), *Talking about overpopulation is still taboo. That has to change*:

> "He had plenty of supporters, but feminists and progressives rejected such draconian solutions."

When China established its one-child policy and reports of forced abortions surfaced, feminists were in the vanguard of efforts to put an end to it. In the same fashion, foreign aid policies that set contraceptive targets in return for aid were castigated and disparaged to the point that they just withdraw almost completely. Moreover, feminists also were instrumental in the emergence of this taboo by urging a shifting away from policies focused on population control to policies supportive of reproductive health and rights (Kissling et al, 2018). At present, both feminists and population stabilization advocates now recognize that providing reproductive health services to women is of paramount relevance (UNFPA, 2006), as well as standing as the most ethical way to avert population growth (Kissling et al, 2018), but nevertheless it is imperative to recognize the historical appositeness of these movements and decisions and how they have shaped the discourse and population dynamics themselves in the coming segments.

In due time China's coercive one-child policy produced a rise in social conservatism in the United States - which were leading in the awareness of the population question - linked with the country's animosity to anything perceived as hampering individual freedoms, be it the right to bear arms or children (Navarro, 2011). Likewise, discussing population has always been a volatile, easily misinterpreted subject matter, seeing that it involves sex, reproduction, cultures, religion, and severe inequities around the world. Indeed the shift of focus from population matters has created overwhelming complications for the future of humans on this planet (Campbell, 2007).

On the whole, the degradation of nature culminates from the economic, technological, and demographic dynamics distinctly being shaped by human activity, and yet, regrettably, the scientific community customarily hovers with hesitation in debating and examining global population size and expansion with the same rigour and strictness that comprises the scientific method (Crist et al, 2017). Figure 3.1 sums up our current predicament and the ineptitude of our reaction.

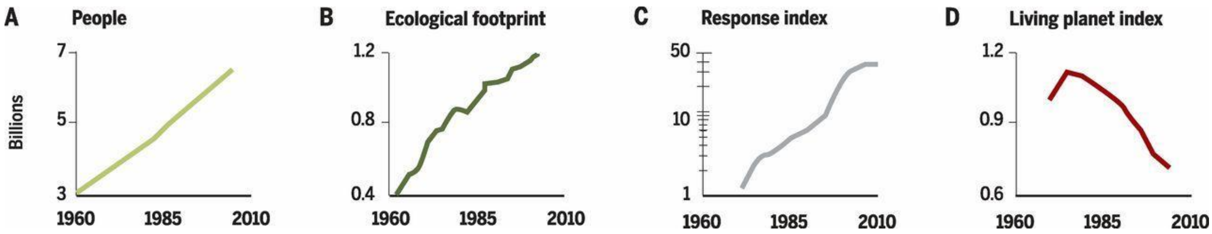


Fig. 3.1 Linkage between the number of people and impact on nature. (A to D) Recent global trends in human population (A); its ecological footprint (B); response index, a metric reflecting the extent of implementation of conservation actions (C); and the status of biodiversity (D). Although considerable variability may exist at smaller scales, these globally available statistics suggest that no conservation action so far has able to significantly avert the impact on biodiversity triggered by the footprint of humanity's increasing numbers and consumption. GRAPHIC: ADAPTED BY H. BISHOP/SCIENCE. Retrieved from (Crist et al, 2017).

To put it differently, the propagation of the fallacy that *population is not the problem* stems from the fact that insufficient attention is given to the contrasting differences between the environmental impacts of rich and poor. While the United States, for example, generates overwhelming amounts of carbon dioxide that disperse on a global scale, Madagascar's population has elicited massive deforestation and calamitous species extinction (Cafaro & Crist, 2012). Moreover, although the overdeveloped countries have had a legacy of causing substantial ecological devastation, such as climate change, the poor countries are expeditiously "catching up" as it is observed and attested by "developing" nations such as China, India, and Brazil. Along these lines, Cafaro and Crist (2012) encapsulate it as such:

> "To scrutinize the global North and see only the variable of consumption is to remain blind to that mass that qualifies it. A major factor underlying destructive consumerism is population size: the sheer numbers of consumers around the globe. To propagate the myth that population growth is not itself a problem and to lament, instead, the harmful effects of unsustainable production and consumption bypasses one leading reason that production and consumption are unsustainable."

In essence, the ravenous reach of the affluent is global, and that of the destitute tends to be more parochial, encompassing deforestation for subsistence, agriculture and fuel, or the acceleration of the bushmeat trade, leading to the ominous "empty forest syndrome" (Ainsworth, Vasquez & Cooney, 2011; Kopnina & Washington, 2016) (this theme is properly analysed in No Sanctuary).

By and large the expostulation that *population growth is not a problem* is overly simplified, and cleaving people into the dreadful rich Westerner consumers and the immaculate underprivileged non-Westerner bottom class, is preposterous and incites the examination on population to become radioactive and morally charged, leading *Academia,* the media, policymakers and the general public to refrain from discussing it (Kopnina & Washington, 2016).

The restraint in action may emanate from prevalent viewpoints of a history of exceeding and even misconduct in population policies, and from routine principles that human numbers cannot be influenced other than through coercive "population control" (Halfon, 2007). Such strategies to manage population have often *incorrectly* been branded "coercive," alluding to draconian measures such as sterilization and quotas for childbearing. Altogether, such oversimplification turns into *reductio ad absurdum*, where environmental effects are dissociated from the number of people involved. Ultimately, as Dietz and O'Neill (2013) denote:

> "We need smaller footprints, but we also need fewer feet."

Likewise, overly condensed divisions tend to underestimate the growth of middle classes in developing countries and the environmental impact that the expanding population in poor countries entails (MEA, 2005). Correspondingly, polarization between the virtuous, poverty-stricken individual and the felonious well-off serves to make any exchange in favour of discussion of population growth conceivably politically volatile and dangerous (Kopnina & Washington, 2016).

As a result, the 1990s and 2000s saw an abrogation and repudiation of involvement regarding population in scientific, policy, and public arenas (Mora, 2014; Meffe, 1994; Potts, 2009). In addition, a number of determinants assembled to deemphasize ecological and socioeconomic issues related to population growth. Moreover, the global decline in fertility rate - described in the previous chapters - bolstered a pervasive perception that the population intricacy was on the way to settling itself out (Pearce, 2008). Similarly, the alliance of an ageing population and low fertility rates in some developed nations has brought about apprehension that a waning workforce might unfavourably affect public finances and our living archetype (Lee et al, 2014). Ultimately, another factor assisting the neglect on the population motion was the materialization of climate change as a major confrontation, which shifted attention toward the problem of overconsumption in developed nations (Crist et al, 2017). Obviously, the patterns of heightened affluence in the over-developed world are a vital concern, provided that these don't obfuscate the discussion while casting a shadow on the population affair.

The dearth of an assertive and commanding scientific narrative on the question of a sustainable human population has also been partly responsible for the silence encompassing population matters (Sayre, 2007; Sinding, 2000). For one thing, the paucity of concession regarding the scale (or even the existence) of peril that population growth raises can be tracked to the history of the affair since at least the early 1970s. Forthwith, elements from the environmental sciences envisioned gargantuan famines in the time to come due to "the population explosion" outstripping food production (Ehrlich, 1968; Meadows et al, 1972). These prognoses did not come to fruition, on account of the Green Revolution crop varieties, technologies, and inputs that accomplished increments in the food supply—at a rate even faster than population grew in the same stretch of time. In essence, the triumph of the Green Revolution cast ambiguity on the idea of human "carrying capacity" (i.e., the maximal population of a species that an environment can support without being degraded) (Daily & Ehrlich, 1992). It animated the conviction that human numbers are not constricted by environmental forces but can elude limits through technological and agronomic modernization (Ellis, 2013). These factors, along with others, gathered to demean consideration about human population size and growth (Crist et al, 2017).

Perhaps more tragic even, is the imperilment of the needs of the poor themselves, when society turns a blind eye to the discussion of population. When the critics sever sustainability from population, they are neglecting that conservation is the cornerstone of many fragile environments and their ecosystem services, upon which populations in developing nations are intrinsically dependent on (MEA, 2005) – both materially, but also in a spiritual and cultural manner. Moreover, this separation underplays the economic differences within countries, for example, urban poverty in "developed" nations and the expansion of middle classes in “developing” ones (Kopnina & Washington, 2016). On top of that, it also overlooks ecological limits and ecological reality (Washington, 2013) since the developing world is now swiftly broadening its use of energy and resources. Indeed, China (which, relinquished its one-child policy in 2015) is presently the world’s largest greenhouse gas emitter (Assadourian, 2010).

Equivalently, 60 percent of the world’s ecosystem services are in a state of corruption or used unsustainably, according to the *Millennium Ecosystem Assessment* (2005). The *Living Planet Index* points to a contraction of 60 percent since 1970 (WWF, 2018a) and *without change* two-thirds of life on Earth may face extinction by 2100 (Raven, Chase & Pires, 2011). Evidently, this situation was not created just by the top rich 5 percent, it is due to the total population and its persistent growth, both in numbers and in the use of resources. With this in mind, the old mantra that the problem is just “in the North” or the overdeveloped world disregards on purpose the fact that numbers matter, and that the developing world is rapidly widening its consumption patterns (Washington, 2015). Yet population continues to be an impermissible topic in international policy circles. None of the 17 Goals or 169 targets of the U.N. Sustainable Development Agenda endeavours in recommending a slow in the expansion of human population, nor does this topic receive much focus in World Bank documents. In *Discussing why population growth is still ignored or denied,* Helen Kopnina and Haydn Washington (2016) proclaim that:

> “Policy documents issued by the United Nation’s Sustainable Development Goals (SDGs) *do not seriously address population issues.* At the UN Conference on Sustainable Development (also called Rio+20) in June 2012, among the problems discussed was a concern with agricultural productivity and efficiency, and the necessity to provide food for a growing population. There was *practically no discussion* about stabilizing and then reducing population, as if concerns with habitat destruction and biodiversity loss were somehow “unconnected” to it, when in fact they are a key driver.”

The United Nations Environment Program (UNDESA, 2014) takes a considerably paradoxical and incompatible position regarding population and the environment. Even though their report asserts:

> “A major driver of the overall increase in raw material extraction and use is population numbers. The world’s, and each country’s, material use is tightly coupled to the number of inhabitants.”

At the same time, their report continues:

> “From another perspective, metabolic rates can be seen as the ‘material footprint’[…] These metabolic rates are more than one order of magnitude different for different countries […] While global resource use has increased eightfold during the course of the 20th century […] average resource use per capita merely doubled.”

Coupled with this, the report goes on to propose that resource use and population may, in fact, be actually negatively correlated, stating:

> “It appears that densely populated areas and regions, for the same standard of living and material comfort, need fewer resources per capita [than less densely populated areas]” (UNDESA, 2014).

However, I feel I have to come to the rescue of UNEP’s previous statement and err on the side of caution. Taking into account Geoffrey West’s body of work, which condenses around the fact that cities operate like biological systems, as demonstrated in his seminal book *Scale: The Universal Laws of Growth, Innovation, Sustainability, and the Pace of Life in Organisms, Cities, Economies and Companies* (2017), it could be possible that UNEP was trying to make the point that a densely populated city appears to become more sustainable as it scales up when compared with a population living in a dispersed rural area, if they both had the same per capita consumption patterns. I can't know specifically what they intended to transmit with that statement, but I can't rule out this possibility as well, because it seems to fit with the data. Nevertheless, let us proceed with the chapter.

Given these points, Kenneth Smail (2003; 2016) cogitates that despite the impracticability of decoupling population from sustainable concerns, the issue of population has acquired a certain "political charge." Population growth is disdained and snubbed in the politically correct academic circles, with critics claiming that there is no global overpopulation issue, but instead, a global problem of overpopulation of just the highly favoured and unscrupulous minority, and that population growth is employed as a scapegoat by rich over-consuming elites (Kopnina & Washington, 2016).

In this exposition, those who associate population to sustainability are branded neo-Malthusian, racist, or misanthropic. While *most* the Northern populations are contracting (and consumption still surging), the Southern countries, specifically in sub-Saharan Africa, are still expanding in population. The ethical examination posed is that the global "North" or "West" should not advise, express or instruct people in the "South" that they should have fewer children, which regularly ends up opening a Pandora's Box of potential recriminations (Kopnina & Washington, 2016). As a matter of fact, researchers admit they are deterred and hindered from writing about the associations between population and climate change or the survival of marine environments for example (Kissling et al, 2018).

As Frances Kissling, Jotham Musinguzi and Peter Singer assert in the *Washington Post's* piece (2018) previously mentioned:

> "We should not shy away from discussing what actions are ethically permissible to facilitate a stable level of population growth, nor should we leave this discussion in the hands of the affluent. The conversation about ethics, population and reproduction needs to shift from the perspective of white donor countries to the place and people most affected by poverty, climate change and environmental degradation."

Under these circumstances, why is population prevailing as the "elephant in the room" we cannot see? As Hulme (2009) has remarked, if there is a "safe" level of greenhouse gases to avoid runaway climate change, then "is there not also a desirable world population?" Although engaging in the issue of overpopulation will succumb to major impediments varying from scientific motivation to public scientific illiteracy to religion to media attention, the bottom line is that failing to throw ourselves into dealing with overpopulation will multiply and reinforce not only the extent of anthropogenic stressors but also the exertion linked with strategies to overturn biodiversity loss (Mora & Sale, 2011) and to enhance and revamp human welfare (APPGPDRH, 2018; Campbell, Cleland, Ezeh & Prata, 2007; Mora, 2014).

With this in mind, let us move the discussion and disclose what have been the main elements contributing to the current reticence, stillness and loss of momentum in the population debate. A detailed analysis of each of the seven main factors will be revealing and illuminating.

Falling Birth Rates

"To everything there is a season … a time to be born … a time to embrace, and a time to refrain from embracing."

-Ecclesiastes 3:1-2, 5

The **first element** in the list of reasons that led to laconism in the population debate is birth rates, which have been falling around in the world as a whole. Comparatively, it has been in the less developed countries that the effect has been more evident and sharp, owing to the family planning programs since the 1950s, which brought down the world's fertility from 5 and a half to 3 children per woman. In particular, average family size has contracted to very low levels in Europe and Japan, and much media attention has focused on the challenge of an ageing population (Campbell, 2012).

An interesting date to start this analysis would be 1946 - the first year of the baby boom - when soldiers were coming home, there was an international impetus to father more children, and so the total fertility rate (TFR - the average number of children per woman) - for American women in 1950 was 3.5 (Foreman, 2012). Thenceforth, something astonishing took place as William Ryerson describes: "[T]he birth rate in the United States dropped dramatically… By 1973, the fertility rate had fallen to replacement level." In 1975, the TFR was only 1.7. Under these circumstances the media proclaimed the drop with piercing headlines "Population Problem Solved" and "U.S. Arrives at Zero Population Growth" (Ryerson, 1999). However, it was a radical misjudgment that getting to replacement-level fertility meant that zero population growth had been gained. "Population momentum" retains the population soaring for "up to 70 years after the replacement-level fertility is reached," wrote Kolankiewicz and Beck (2001). Moreover, it was only wealthy countries that had attained replacement-level fertility. For this reason, the West and other wealthy nations presumed the population threat had blown over. Many environmentalists and conservationists presumed and assumed the same, and as a result neglected the population issue (Foreman, 2012).

Regarding this first reason, attention to the substantial fall in birth rates around the world has not been followed in the press by the news that fertility in the world's poorest countries, such as Niger, Uganda, and Nigeria, persist in being adamantly excessive. Moreover, the staggering amount of literature on poverty since 1994, has had little mention of the population growth factor (Campbell, 2012). This started to change in the UK as a result of the 2007 report of the UK Parliamentary hearings on population growth in low-income countries with connection with the Millennium Development Goals (APPG, 2007). It comprised expert testimony that no country (with the exception of a small number of anomalous oil-rich states) has extricated itself out of poverty while preserving high fertility rates (Campbell, 2012).

Notwithstanding, there is still a need to remind ourselves of what Ray Wheeler (2013) affirms:

> "The extremely sanguine projections that human population will stabilize around 9 billion are predicated upon steeply leveraged assumptions about reduced birth rates in impoverished third world countries. These reductions are simply taken for granted by population projection demographers. But they would require immediate and massive population control measures around the world, without which the projections are complete fantasy."

Evidently, these projections in the reduction of fertility and population accommodate a crucial assumption, which goes hand-in-hand to what is briefly demonstrated in the first chapter - the conservative and undervaluement of population growth due to presumptions in reductions of birth rates (Collins, 2018).

There are reasons to infer that such an assumption is prone to error. In a 2013 working paper (Collins & Richards, 2013), the authors asserted that as fertility was heritable, this would incline descendants of individuals with preferances for larger families to gravitate to such behaviours themselves. Such an attribute would come to monopolize the population – in an evolutionary sense – prompting markedly higher populations than those predicted (Collins, 2018). As a result of this research, a 2018 paper titled *The heritability of fertility makes world population stabilization unlikely in the foreseeable future* (Collins & Page, 2018) delivers the following abstract:

> "The forecasting of the future growth of world population is of critical importance to anticipate and address a wide range of global challenges. The United Nations produces forecasts of fertility and world population every two years. As part of these forecasts, they model fertility levels in post-demographic transition countries as tending toward a long-term mean, leading to forecasts of flat or declining population in these countries. We substitute this assumption of constant long-term fertility with a dynamic model, theoretically founded in evolutionary biology, with heritable fertility. Rather than stabilizing around a long-term level for post-demographic transition countries, fertility tends to increase as children from larger families represent a larger share of the population and partly share their parents' trait of having more offspring. Our results suggest that world population will grow larger in the future than currently anticipated."

Altogether, the main take from this first element is that prognostications hinting at contractions in birth rates have invited – and continue to pose a risk of - torpidness and indolence in assertive action regarding stemming population growth, by leaving us in a state of miscalculated confidence.

Patterns of Consumption

"The first law of sustainability: population growth and/or growth in the rate of consumption of resources cannot be sustained."

- Albert Bartlett

The **second factor** that motivated such taciturnity in rational discourse was how the deliberation has been shifted towards consumption while casting a shadow on population affairs. These patterns of consumption are a tremendously conspicuous factor affecting the environment and natural resources, including the production of greenhouse gases, cutting of forests and losses in biodiversity. There is a profuse inclination to argue that consumption in the developed world is the only factor responsible for the environmental decline, as if high-affluence developed nations such as the US, Europe, South Korea, Japan and many others weren't already overpopulated. As a matter of fact, population is a crucial factor as well, being regarded as a paramount driver of resource loss and environmental stress (Campbell, 2012). Condemning only consumerism, or postulating that a high standard of living for everyone may lead to sustainability is what Tom Chance characterizes as "burying our head in the sand." Chance adds: "If one works in this area for any amount of time, one quickly realises that reducing our environmental impacts to a truly sustainable level is really hard" (Chance, 2013).

In the same fashion, the press is filled with descriptions regarding dire straits, most of which have a root cause at least in part by the entwined but unspeakable twin elephants of population growth and overconsumption. Then again, spiking food and energy prices, expanding water shortages, intensification of severe weather, melting ice caps, dying coral reefs, vanishing species, collapsing infrastructures, terrorism, and novel epidemics are almost never associated to the elephants. Granted there are limits to sustainable human numbers and to humanity's aggregate consumption, those limits are almost never voiced and specified, let alone discussed (Ehrlich & Ehrlich, 2012). The ecological crisis is the aftereffect of the consumption patterns of a behemothic human population. Even so, a leftist nucleus of the environmental movement has alleged that overconsumption in the global North is unduly liable for the biosphere's degradation, leaving the global South, where population is growing most rapidly, largely immune and exempt of criticism. Owing to this broadly recited interpretation, in the last two decades population growth fell from grace or was extinguished from the debate, due to its conversion into a taboo in several areas of discourse, while Western consumerism, corporate malfeasance, and neocolonial policies have been lambasted as the main drivers of inequity and ecological carnage. As a result, there has been a tendency to obscure the detrimental effects of population (Crist & Cafaro, 2012).

The Nile is an excellent case in point that defies the prevalent fable of benign consumption in the global South. The demand for water is increasing in all ten countries of the Nile Basin, as these countries all have agricultural economies and rapidly growing population, as it can be easily seen in table 3.1.

Country	2016	2025	2050
Burundi	**11.1** 8.5(2010)	**17.2** (14)	**30.4** (25.8)
Democratic Republic of Congo	**79.8** 67.8 (2010)	**124.2** (101.4)	**213.8 (166.3)**
Egypt	**93.5** 80.4 (2010)	**121.6** (103.6)	**168.8** (137.7)
Eritrea	**5.4** 5.2 (2010)	**7.3** (7.4)	**10.4** (10.8)
Ethiopia	**101.7** 85 (2010)	**132.9** (119.8)	**168.6** (173.8)
Kenya	**45.4** 40.1 (2010)	**63.7** (51.3)	**88.2** (65.2)
Rwanda	**11.9** 10.4 (2010)	**16.4** (15.8)	**23.6** (28.3)
Sudan	**42.1** 43.2 (2010)	**61.7** (56.7)	**105.0** (75.9)
Tanzania	**54.2** 45 (2010)	**81.5** (67.4)	**134.8** (109.5)
Uganda	**36.6** 33.8 (2010)	**58.1** (53.4)	**101.5** (91.3)
Total	**481.7** 419.4 (2010)	**684.6** (588.4)	**1.045.1** (875.6)

Table 3.1: Actual and projected population sizes (in millions) of countries of the Nile Basin. Adapted from the revised version of Campbell (2007) in Life on the Brink (2012). The values inside () represent the actual and projected values in Campbell's work. The new values were added in order to compare how the populations in the 10 countries changed in 6 years and how the projections altered as well. Values are original from Population Reference Bureau 2016.

The Blue Nile from Ethiopia and the White Nile from Uganda merge as Khartoum, Sudan, and by the time this almighty river makes landing in the Mediterranean it is sharply depleted. The populations of Ethiopia, Sudan, and the remaining countries in the Nile Basin together are forecasted to more than double by 2050, and the amount of Nile water for Egypt is likely to recede (Campbell, 2012). The scientific literature has cultivated a wide spectrum of possibilities from an 80 percent decline by the year 2060 to an actual gain of 22 percent if global warming results in more rainfall in the region (APPG, 2007). The predicament is that the population of all these countries is expanding rapidly, which will mean further depletion of water resources.

Population growth, and now overpopulation is inflaming this circumstance, as protracted families fell trees to free up more space to replenish construction materials. Behemothian floods have become routine, due to erosion caused by deforestation, which ends up washing over a billion tons of Ethiopian sediment into the Nile each year, clogging dams and bereaving farmers of much-needed soil nutrients. As crops atrophy and shrivel, food prices escalate and many rural communities, who have historically depended on steady rains to irrigate their land, have been pitched even deeper into poverty. Some villagers have given up on agriculture as a whole (Schwartzstein, 2017).

But the amount of water is not the only concern, its quality suffers continued degradation from the moment it surges in Ethiopia until it hits the Mediterranean in Egypt.

As governments attempt to account for their new citizens' needs, the Nile is absorbing the deficiency in the overseeing. For the most part Khartoum – the city in Sudan where the White and Blue Niles meet – reflects the problems of other sizable Nile cities (Schwartzstein, 2017). As an illustration, the municipal wastewater network has barely grown even as the Sudanese capital's frontiers have ponderously expanded over the past few decades, with Khartoum now hosting a population ranging from 6 to 7 million (World Population Review, 2018). With incapable and lacking rubbish disposal facilities to deal with the required requisite *BBC's* Peter Schwartzstein discloses that: "Factories and businesses have taken matters into their own hands, dumping everything from toxic runoff from nearby munitions plants to unwanted exotic animal parts from the downtown ivory market, into the muddy, chemical-tainted shallows" (Schwartzstein, 2017).

Moreover, Egypt being the last country to utilize the Nile, they are regarded to be in a more vulnerable position. Using the formula presented at the end of the last chapter, to calculate the growth rate the city of Boulder, Colorado, the same principle can be applied to Egypt. Likewise, and using the data from Table 3.1, its growth will be:

Growth rate(R) = [100/ (34)] x ln [P (168.8) / P (93.5)]

= 2.94 x 0.59

= 1.74 percent

This means that Egypt's population will be growing 1.74 per cent per year, from 2016 till 2050, but the water in the Basin is decreasing in amount and quality, due to all the uses upstream. According to Schwartzstein on his *BBC's* article *Death of the Nile,* with Ethiopia's dam nearly completed, conflict over water resources reaching Egypt and its population may escalate quite quickly (Schwartzstein, 2017).

This second reason, is consonantly prompted by the absence of public information that population growth is a major component in the competition among Egypt, Ethiopia, and Sudan for the waters of the Nile; among Turkey, Syria, and Iraq for the Euphrates, and at least 6 other large anticipated trouble spots around the world over the critical resource of water (further reading in the segments **Watermark** and **Malthusian Trap**). This crisis could be recognized if there was a noticeable effort by the media to identify the role that population growth plays in these affairs and educating its audience (Campbell, 2012), but as researcher Euan Ritchie, co-author of a paper in the *Journal Nature Ecology and Evolution* (2018) that connects population growth as a key driver of biodiversity loss, says in an interview to *ABC News* (2018):

> "It's often a taboo to talk about human population size and family planning and how much we consume as individuals."

Religious Fundamentalism, Anti-abortion Activists, Liberal Left, Feminists and Environmentalists

"It's not just the religious right that hampers access to family planning… so does the feminist and social justice left… They derailed any direct targeting of population growth by linking it to indifference to women's rights, racism and eugenics."

- Madeline Weld

The **third element** reinforcing the saturninity on population is related to anti-abortion activists, religious leaders, conservative think tanks (Campbell, 2007) a few branches of the liberal left as well as feminists (Kates, 2004) that have been prominent in reducing attention to population growth. These groups are likely to gravitate to the idea perpetuated in the media – namely, that the population explosion is "over" (Lutz, Sanderson & Scherbov, 2001). Correspondingly, it is worth remembering that the most arrant and pronounced advocates against abortion are not supportive of family planning (Campbell, 2007).

As with other political ideologies, some on the Left are paradoxically antagonistic to conservation. Population is one conspicuous example. In the Earth Day era, socialist environmentalists considered that "Earth Day had been hijacked" with population pessimism and thereby weakened the environmental movement. Consequently, and as an example, in the 1998 Sierra Club (founded by the conservationist John Muir in 1892, it stands as possibly the largest and most influential grassroots environmental organization) election on immigration policy, the Far Left under the aegis of the so-called Political Ecology Group (PEG) delegated and ordained an end of the immigration-lowering initiative (Foreman, 2007; Kolankiewicz & Beck, 2001).

After feminists and human-rights advocates seized a position of power on the committee of Sierra, they committed themselves to convert the empowerment of women as the main goal (the consequences of this endeavour are explored in the upcoming segment Cairo, 1994). Dave Foreman, author of *Man Swarm* (2015) and life-long environmentalist was on the committee and disputed this since the goal was population stabilization and then reduction. The empowerment of women is a noble and virtuous endeavour but it should stand as the most compassionate key path to that goal, not the goal itself (Energyskeptic, 2017).

Moreover, internationally speaking, leftist environmentalists relinquished overpopulation on an early stage; for example, the 1972 United Nations Conference on the Human Environment in Stockholm, Sweden, withdrew from overpopulation altogether. For one thing, social justice leftists felt that discussion about overpopulation condemned the world's poor for the "environmental" plight; instead, they denounced the high living patterns in wealthier countries, henceforth censuring any rational analysis on population (Foreman, 2012). China's one-child policy and India's widespread sterilization were also regarded as assaults on freedom, fueling the insurgency. All things considered, China was able to preserve its one-child policy in effect, downsizing its population growth markedly. India, on the other hand, stopped its program after the assassination of Indira Gandhi. The upshot was, China now has "sharply reduced child malnutrition" and only "7 percent of its children under 5 are underweight." Unfortunately, India, has an "epidemic" of childhood malnutrition, with 42.5 percent of its children under five underweight (Sengupta, 2009).

In the essay *Population, Migration, and Globalization*, Herman Daly (2004) comments on the reality of China and India:

> *"Serious efforts to reduce birth rates in these countries are sometimes condemned, because, with the advent of ultrasound technology that can determine the gender of the fetus, the cultural preference for males has led to selective abortion of females. The problem here is neither birth control nor ultrasound but the immoral preference for males and indifference to the social costs of a gender imbalance a generation hence."*

Some feminists have devoted their diligence to religious conservatives by attacking population programs, alleging that all population policies, together with subsidies for children and access to contraception and family planning, hinder women's reproductive rights and ignore the "true causes" of poverty and environmental degradation: militarism and consumerism (Schiele, 1999; quoted in Kates, 2004), class-based eugenics, and, at best, pursuing an agenda which ignores their concern with empowering women (Petchesky, 1990; Dixon-Mueller, 1993; Kates, 2004).

The "population movement" has been depreciated for focusing on lessening population growth, rather than ensuring the right of women to control their bodies and lives, and Lynn P. Freedman (1995) construes it as such:

> "… the 'freedom' of the individual to decide was, in the view of the population movement, readily limited by the 'responsibility' to make the fertility-limiting decision imposed by government population policies purportedly in furtherance of the public good [i.e. to control world population growth]".

A point often unnoticed is that overpopulation impairs women, stifles the promise of welfare and prosperity and confines them to a perpetual state of poverty while robbing their children of an auspicious future. Granted that all this holds true, it should become obvious that attaining the carrying capacity of places with a sustainable demand is deeply humane. A deficient response to do so means that women, already second-class citizens in so many countries will be more victimized and mistreated and forced to carry water and wood from longer distances, as resources run dry (Shragg, 2015).

It is particularly surprising how extensive the liberal opposition to population programs is, given the sheer substance of evidence of an impending environmental catastrophe. At the same time, a liberal rationalization for reproductive liberty would treat it as an exercise of individual prerogative which would, in principle, be conditioned to some confinement if it came into conflict with other rights or, from a utilitarian prospect, if it caused significant social harm (Kates, 2004). However, many liberals have merely depreciated and tossed aside environmental problems (as issues of economic development) as "cynical" and "weak" (Boland, Rao & Zeidenstein, 1994). Some liberals have even argued that if "reproductive rights" are universal moral conventions, they should not be "qualified" by the language of "responsibility to the community" with respect to population objectives (Abrams, 1996). Hence, liberal opposition to population affairs raises an elemental question about the rational foundation for professing a fundamental and indefeasible right of reproductive liberty (Kates, 2004) – this topic will be further developed in the chapters Population Engineering and Morality of Procreation, in the upcoming Volumes.

At the same time, the feminist outlook that coercive antinatalism poses the same menace to women's autonomy as coercive pronatalism is spelt out by campaigns for women in patriarchal countries with forceful pronatalist culture that allude to poverty and a lack of legal protection, pensions, and economic opportunities as a reason women must bear children, especially sons, in the hope that at least one will provide economic relief and sustenance in old age. Feminists then point out that anti-natalist population programs would undermine and wreak havoc in these women's lives (Dixon-Mueller, 1993).

Important to realize is what Madeline Weld, president of Population Institute Canada stated in, *Deconstructing the dangerous dogma of denial: the feminist-environmental justice movement and its flight from overpopulation* (2012), that:

> "The Marxist/feminist/social justice ideology that denies the population factor and vilifies those who address it… An ideology that claims to promote social justice, but does not recognize that the Earth is finite, is more than unethical…"

Comparatively, in her book *Collision Course – Endless Growth on Finite Planet* (2014), Kerryn Higgs recounts how forces on the right exerted influence:

> "The Vatican, which had always opposed contraception, exerting substantial influence not only in the United States but also at the UN population conferences that took place in Mexico City (1984) and Cairo (1994). Evangelical Christians, influential in the Reagan and George H. W. Bush administrations, joined forces with Catholics to push US policy at home and abroad in the same natalist direction, a trend that intensified under George W. Bush. The Saudi Arabians also supported this approach. In Mexico, the United States withdrew its funding for the UN population program, declared that the advance of free market economies was "the natural mechanism for slowing population growth (Kraft, 1994).

And how, on the other corner of the political spectrum, Marxism dealt with growth (2014):

> "Most Marxists embraced the promise of scientific and technological advance fully and saw no constraints on industrialization throughout the world – at least under socialism. Concerns about population growth, environmental damage, and resource depletion were sometimes seen as symptoms of a reactionary collusion with the ruling class and as distractions from the real issues of poverty and imperialism. The "ecology movement" was though to embody the misguided foolishness of "Malthusian pessimists (Fuchs, 1970). Although some Marxists were less dismissive, acknowledging that modern capitalism "threatens all the natural bases of human life," most insisted that a radical redistribution of wealth and resources under socialism was the crucial requirement (Enzenberger, 1974). Marxists have been especially dismissive of the case for population policy, an attitude that continues in much ecosocialist thinking today (Angus & Butler, 2011; Pearce, 2010; Monbiot, 2009)."

Under these circumstances, the revived attention to demographic affairs has agitated reactions from many of the feminist and social justice activists. At one end of the spectrum are the "population naysayers," who conjecture that demographic argumentation represents a fallacious, delusive solution to our environmental problems. From their perspective, our efforts should stem an abatement of consumption in developed countries and countering environmental degradation under the aegis of corporations. Those who uphold this view essentially revoke or renounce the connection between population and environmental degradation and therefore reject the need for family planning for ecological reasons (Weeden & Palomba, 2012).

One of the most notorious champions of this view, Betsy Hartmann (2010), wrote:

> "In many ways, this focus on population control threw the American environmental movement off track. By shifting the blame elsewhere, to the proverbial dark-skinned Other, it prevented many Americans from taking a deeper look at their own role, and the role of the U.S. government and corporations, in causing environmental degradation at home and abroad"

The myopic spotlight of Hartmann and others on the high rates of consumption in the West as the malefactor in climate change and other environmental concerns essentially insinuates that those in countries with low per capita consumption are virtuous and praiseworthy as long as they remain poor (Weeden & Palomba, 2012).

In essence, why such taciturnity on something so firmly established in the foundations of the environmental, economic, and social challenges the world faces? Some resistance originates from the "impersonal reduction of humans to quantity," in the words of English historical demographer Peter Biller (2000). Accordingly, Kolankiewicz and Beck (2001) write:

> "Now centered in a feminist rather than environmental mission, many population, family planning, and women's groups would support no talk of stopping growth or reducing average family size because that implied restrictions on what they considered a universal right of women to choose their number of children entirely free of the merest hint of official or informal pressure."

As has been noted, anti-abortion activists, religious leaders, and conservative think tanks, which portray reason three for the silence on population, strike one as uncompromising in their doctrines and related values about population. But the rest of the world is not as enthusiastic as these groups in the United States, and some important changes are occurring in Ethiopia, Colombia, Portugal, and Mexico City, which have all recently liberalized their abortion laws (Campbell, 2012).

All things considered, feminists; the social justice left and those on the conservative and religious right must assimilate an overpopulation narrative into their dauntless efforts. The unison of women's empowerment, access to birth control/legal and safe abortion and culturally changing expected family size would be a much more cogent road to follow (Shragg, 2015).

Feminists must dutifully persevere in their struggle to protect women in a world that continues to torment them. Population activists, however, are the friends of feminists, not the enemies. They should be attentive to scientists and overpopulation experts, who are prescribing an ominous admonition of food and water shortages, biodiversity loss and prolonged conflict. Women will be the first to take advantage of a world with a sustainable population (Shragg, 2015).

Immigration and Population Growth

"Even if you agreed that longevity is a curse for a society, there are many things you might do before deciding to import the next generation from another continent"

- Douglas Murray, *in The Strange Death of Europe*: *Immigration, identity, Islam* (2017)

The **fourth** reason and most likely one of the most contentious subjects that is most intimately associated with population growth, the rise in affluence and human footprints is immigration.

Recalling that by mid-1970s, the TFR in the United States, as in Japan and many European countries, had descended below 2.1 children per woman, which portended the population was set to even out (Foreman, 2012). With this in mind, in 1989 the Sierra Club's stance on immigration was that "it should be no greater than that which will permit achievement of population stabilization in the U.S." Whereas, in 1990 that stance was remodelled and reorganized, with the conservationists fearing alienating leftist and racial rights groups, henceforth dropping immigration from their platforms (Energyskeptic, 2017).

Kolankiewicz and Beck (2001) portray the situation:

> "When most Americans began to focus on U.S. growth in the 1960s, immigration was an almost insignificant fraction of growth… At the very time that American fertility fell to a level that would have allowed population stabilization within a matter of decades, immigrants and their offspring were contributing nearly 70 percent of U.S. population growth."

They go further and write:

> "If immigration and immigrant fertility had been at replacement level rates since 1972 - as has native-born fertility - the United States would never have grown above 250 million. Instead, U.S. population passed 273 million before the turn of the century".

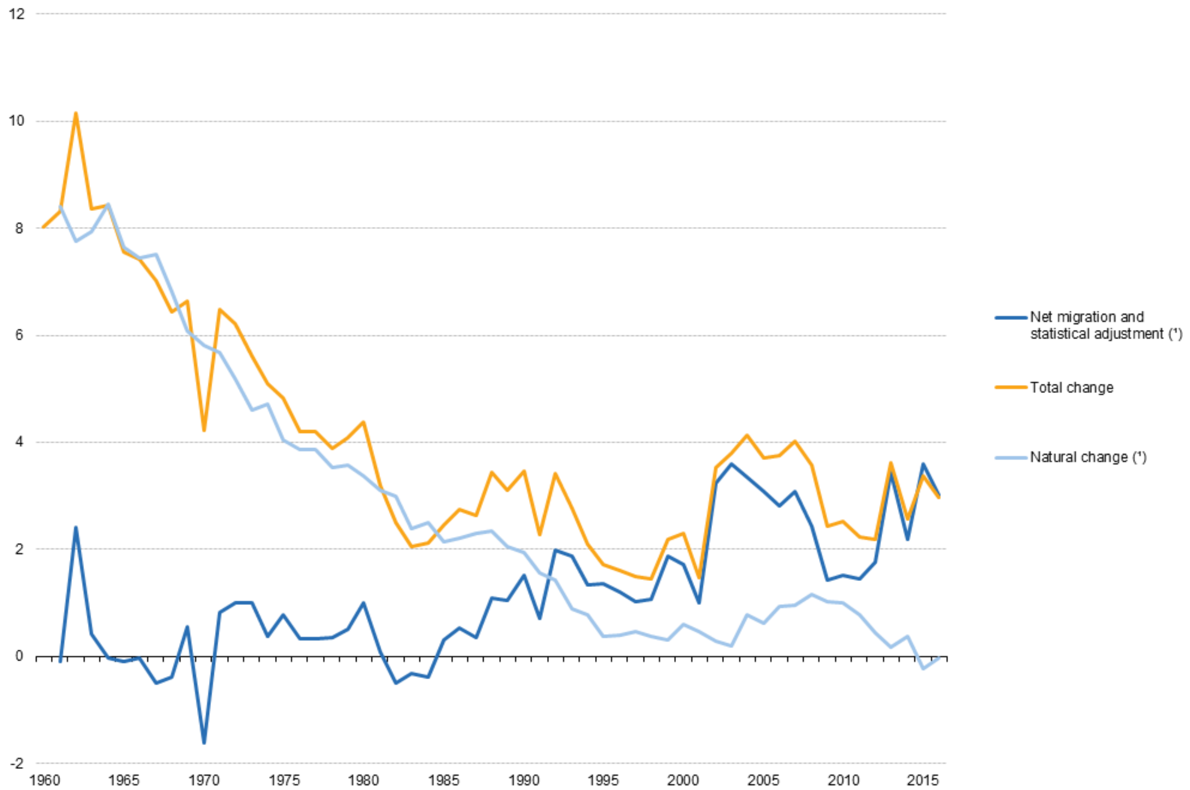
According to the estimates of the Population Reference Bureau (2017), the US has 325 million people and is expected to reach 397 million in 2050. I welcome anyone to ponder and meditate on those numbers and deliberate if overpopulation is indeed the only problem of the Global South because surely, the numbers are uttering a different story.

In the forty years after 1925, immigration into the United States was fairly low - with two hundred thousand people a year. After immigration law "reforms" in 1965, yearly immigration ascended to one million - or five times what it had been earlier. Since 1990, the immigration flood has enlarged to one and a half million every year, or more than seven times what it was (Cafaro & Staples, 2009). In 2016, 1.49 million foreign-born individuals settled in the United States, a 7 percent increase from the 1.38 million coming in 2015. Despite its long history of immigration, the United States has fluctuated between perceiving immigration as an inestimable resource and as a major trial. The 2016 election and the serious conduct on immigration taken by the Trump administration have further elevated the issue in political and public debates (Zong, Batalova & Hallock, 2018).

Indeed, now that immigration drives growth, it has become difficult to deliberate on the issue, because it is interwoven with race and ethnicity (Palmer, 2012). As a matter of fact, most of the current growth in the United States comes from India, China/Hong-Kong, Mexico, Cuba and the

Philippines. India surpassed Mexico in 2013 as the leading country for most arrivals in the United States (Zong, Batalova & Hallock, 2018).

Equally important is the current demographic situation in the EU-28, which is marked by continued population growth - in 1960 it had surpassed 400 million and in 2017 the value had transitioned to approximately 510 million (Eurostat, 2017). Since deaths demurely outnumbered live births in the EU-28 (for the second time since the time series began in 1961), what ensued was a slight natural decrease in the population (figure 3.2 below). The population change (positive, with 1.5 million more inhabitants) was, thence, due to net migration and statistical adjustment (Eurostat, 2018).



Note: Excluding French overseas departments up to and including 1997. Breaks in series: 1991, 2000-01, 2008, 2010-12 and 2014-16.
(¹) 1960: not available.
Source: Eurostat (online data code: demo_gind)

Figure 3.2: Population change by component (annual crude rates), EU-28, 1960-2016 (per 1000 persons). Retrieved from Eurostat, 2018.

On the grounds that immigration is now the *raison d'etre* of population growth in the United States, as well as in Europe, the flock mindset of political correctness stops any contemplative and introspective scrutiny about population. The sheer acknowledgement that immigration is fueling population growth gets one accusations of racism (Foreman, 2012). Kolankiewicz and Beck (2001) reveal how immigration congested conservationists from working to freeze population in the United States. The same repression held true for Europe and as an illustration, Robyn Maynard, President of Population Matters - a non-profit NGO based in the UK - talks with Dave Garner in the Overpopulation Podcast to paint a picture of the regression in the conservation movement when it collided with the population reality (World Population Balance 2018, ep.11).

Pragmatically, Douglas Murray offers some valuable insight in his book *The Strange Death of Europe*: *Immigration, identity, Islam* (2017), where he claims:

> "Nevertheless, the idea that Europeans have simply stopped having enough children and must, as a result, ensure that the next generation is comprised of immigrants is a disastrous fallacy for several reasons. The first is because of the mistaken assumption that a country's population should always remain the same or indeed continue rising. The nation states of Europe include some of the most densely populated countries on the planet. It is not at all obvious that the quality of life in these countries will improve if the population continues growing. What is more, when migrants arrive in these countries they move to the big cities, not to the remaining sparsely populated areas. So although among European states Britain, along with Belgium and the Netherlands, is one of the most densely populated countries; England has taken on its own would be the second most densely populated country in Europe. Migrants tend not to head to the Highlands of Scotland or the wilds of Dartmoor. And so a constantly increasing population causes population problems in areas that are already suffering housing supply problems and where infrastructure like public transport struggles to keep up with swiftly expanding populations."

Heretofore, parties of the far left and in particular "Green" parties in the West used to crusade for a fix in the population eruption. They maintained that in order to secure an "optimum population," every couple should restrict themselves to having one child, or no more than two. Developed countries were foreseen to lead the way. Unremarkably, as third-world migration to Europe swelled, it culminated in the Green organizations desisting from arguing for population limits or to campaign for restrictions on reproduction (Murray, 2017). Murray characterizes it as such in his critical aforementioned book (2017):

> "While happy to tell white Europeans to stop breeding, they became somewhat more reticent about making the same request of darker-skinned migrants. Nevertheless, the idea that Europeans have stopped having enough children and must ensure that the next generation is comprised of immigrants is a disastrous fallacy."

For one thing, the way environmental and conservation clubs consider to act through the agency of progressivism, makes them fear exasperating Leftist benefactors and dignitaries of racial-advocacy troupes by acknowledging what more immigration will lead to. Moreover, when the funding community that supports these clubs was overpowered by social activists, foundations one after the other ended funding to groups that shone a light on immigration and later on overpopulation as well (Foreman, 2012).

From this segment, I intended for the reader to perceive and distinguish some of the main intimidations and outright tactics of intellectual coercion, which have stifled and shaped the current population effort. It is said that *sunlight is the best disinfectant,* therefore, it is by shining a light on the vitriolicism and virulence of such stratagems that one can recognize that, independently of distinctive personal backgrounds and motivations, the end-goal of reducing human suffering and misery is shared by every concerned party so it would be best to come together and partake on some constructive dialect.

I will resume the discussion on immigration in the segment that examines the link between anthropogenic climate change and the forced displacement of individuals, and again, in the chapter Exodus, which takes the examination started here a step further while contemplating the associations between the movement of individuals, demographics and ecology.

AIDS Epidemic

"We live in a completely interdependent world, which simply means we cannot escape each other. How we respond to AIDS depends, in part, on whether we understand this interdependence. It is not someone else's problem. This is everybody's problem."

- Former U.S. President Bill Clinton

The **fifth reason** that supplemented the quiescense in the population dialectic has been the sheer scale of the AIDS epidemic that captured the world's attention. People often despondently ask, isn't AIDS "taking care of" the population growth problem? The answer is no (Campbell, 2007). In Uganda (population 5 million in 1950) fertility is 5.4 per woman, and in spite of the AIDS epidemic, the population is expected to surpass 95.6 million by 2050 (PRB, 2017). East and Southern Africa are the regions most ruthlessly hit by HIV. These harbour 6.2 percent of the world's population but have 19.4 million people infected with HIV, over 50 percent of the total number of people living with HIV in the world. In 2016, there were 790,000 new HIV infections, 43 percent of the global total as figure 3.3 illustrates below (UNAIDS, 2017a).

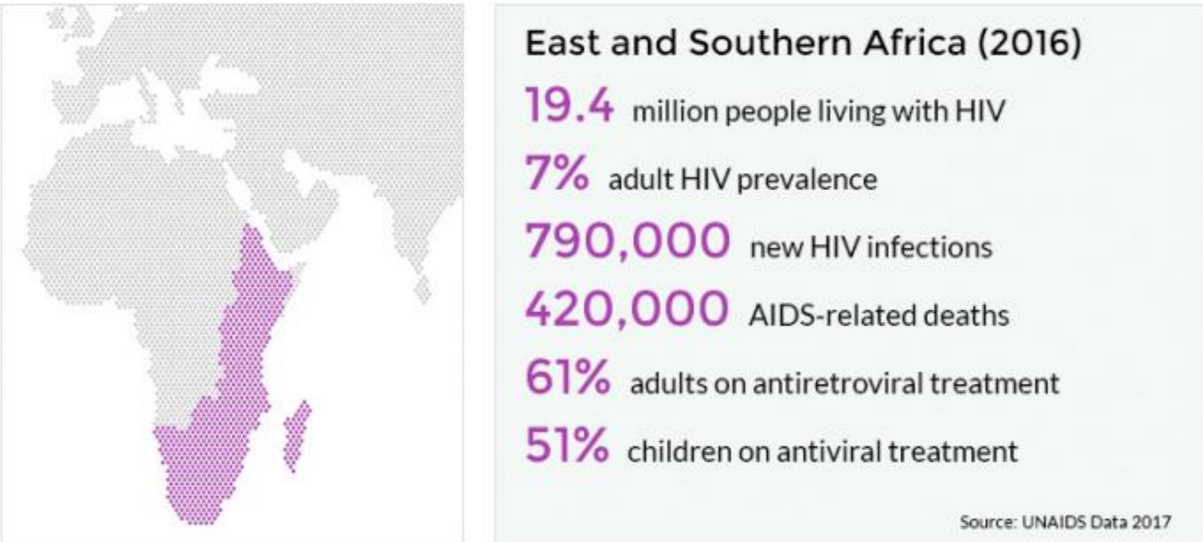


Figure 3.3: HIV and AIDS in East and Southern Africa Regional Overview. Retrieved from (avert.org 2017)

South Africa tallied the one third (270,000) of the region's new infections in 2016, with another 50 percent transpiring in eight countries: Mozambique, Kenya, Zambia, Tanzania, Uganda, Zimbabwe, Malawi, and Ethiopia (UNAIDS, 2017b). Not to mention, under half a million people (420,000) died of AIDS-related illnesses in East and Southern Africa in 2016, although the number of deaths has fallen considerably from 760,000 in 2010. Equally important is the fact that women are indecorously affected by HIV in the region, accounting for 56 percent of adults living with HIV (UNAIDS, 2017a). In 2015, there were around 4,500 new HIV infections among young women every week, double the number seen in young men (UNAIDS, 2016).

It must be remembered that, in six of Africa's countries (Botswana, South Africa, Namibia, Swaziland, Zimbabwe, and Lesotho), fertility has been decreasing from an average of <3.0 in 2004 (PRB, 2004) to an average of 2.5 in 2017 (PRB, 2017), thus population growth is now modest but still on the rise. In the remaining two (Zambia and Mozambique) fertility is still high

(Zambia in 2017 was 5.2 and 5.6 in 2004; Mozambique in 2017 was 5.3 and 5.5 in 2004) (PRB, 2017; PRB, 2004) and population growth is close to 3 percent per annum in both countries (Worldometers, 2018a; 2018b).

Important to realize is that even if the demographic impact of HIV/AIDS was more preeminent, "solving one problem one dying parent at a time, one dying child at a time, is not any kind of solution that should be welcomed," Martha Campbell (2007) declares and adds:

> "Indeed, strong advocacy for family planning is driven by the desire to avert catastrophic events like famine, disease, and conflict that are exacerbated, or made more probable, by population growth."

In all of the fast-growing countries, there is a registered need for family planning, which is recurrently strenuous and onerous for many women to obtain. In fact, roughly 885 million women of reproductive age (15-49) in developing regions want to ward off a pregnancy and about two hundred and fifteen million women around the world do not yearn and desire another child either ever or in the next two years, but are not using modern contraception (Guttmacher Institute, 2017; Sedgh, Ashford & Hussain, 2016). This subject is developed more thoroughly in the chapter Access in the upcoming Volume II.

Explicitly, it has been perceived that attention to the AIDS problem grew when advocates for therapeutic drugs for HIV-infected people advanced an effective program: they recognized that parliaments and foreign aid agencies were more unconcerned about health than about poverty, and along those lines centered their publicity on the effect of the disease on poverty. John Cleland and Steven Sinding pointed out in *The Lancet* that population growth might have an even more preponderant detrimental impact on poverty in Africa than AIDS (Cleland & Sinding, 2005). It is not known at this point where this debate will lead, but it seems plausible that as the connection between high fertility and poverty becomes more appreciated, attention to the population factor will follow (Campbell, 2012).

Demographic Transition Theory

"There is a well-documented correlation between poverty and high birth rates [...] This is why helping other countries become self-sufficient is not only elementary human decency, but is also in the interest of those richer nations. One of the central issues in the world population crisis is poverty. [...] Our job is to bring about a worldwide demographic transition and flatten out the exponential curve [in population growth] - by eliminating grinding poverty, making safe and effective birth control methods widely available, and extending real political power to women. If we fail, some other process, less under our control, will do it for us."

-

- Carl Sagan, *in Billions & Billions: Thoughts on Life and Death at the Brink of the Millennium* (1998)

The sixth factor deflecting attention from population concerns has been the classic demographic transition theory (DTT) (endeavouring to interpret the shift from high mortality and fertility, to lower mortality while fertility remained high, superseded by the consequent decline in fertility) (Potts & Campbell, 2005). Facetiously, the primary paradigm in comprehending human fertility decline has bolstered population growth off the public agenda and out of public discourse. The paradigm essentially has cultivated the idea that couples around the world have always desired large families, and the only way that can change is when some sort of profound variation materializes in their society. Again Martha Campbell (2007) delivers some wise words in this regard:

> "The assumption is that when people become wealthier or more educated then change occurs, and somehow couples will shift their predilection for many children in favor of a smaller family size. The belief that it is "natural" for couples to want many children leads to the inference that they have to be induced to want a smaller family. This in turn fuels the apprehension of entering the realm of inappropriate persuasion or even outright coercion".

DTT consists of one of the heroic narratives of modernisation (Kirk, 1996). As Lee and Reher (2011) write:

> [This] "Historical process ranks as one of the most important changes affecting human society in the past half millennium, on a par with the spread of democratic government, the industrial revolution, the increase in urbanization, and the progressive increases in educational levels of human populations."

Moreover, DTT pinpoints four demographic stages that are indispensable to modernisation, as displayed in figure 3.4. The states are composed of the following: relatively stable populations with high fertility and mortality (DT 1) are agitated by biopolitical regimes that slash mortality rates. This, in turn, generates rapid population growth due to a typical lag before fertility dwindles correspondingly (DT 2). Thereafter, low mortality is paired by low fertility: the transition. Growth nevertheless endures by virtue of the momentum of large, youthful populations (DT 3). Ultimately, in a final stage is the transition completed as the population ages and growth stops, thereby restoring equilibrium albeit at a higher level (DT 4) (Coole, 2012).

At the center of the classic theory was the presumption that the insistence for narrowing family size was an adjustment brought about by some societal deviation extrinsic to the personal experience of the parents making reproductive decisions. This conjecture portrayed a demographic transition to lower fertility in the last stage, transpiring when factors of modernization, such as urbanization, led to a reduction in parent's natural desire for many children (Notestein, 1953). The rationalization for this paradigm was catered through innumerable comparisons of fertility descent and large datasets recounting socio-economic growth and analogous modernization components, displaying significant correlation, which was understood as causality. However, as family planning expanded in East Asia and Latin America in the 1970s and 1980s, exceptions to the demographic transition theory started to pile up (Campbell, 2007).

Equally important is how DTT is deficient in explaining why inquiries reveal that women's desired family size on average dwindles ahead of the decline of actual family size. It also fails in accounting for family planning being made easy to obtain, as in Thailand, where women with lower or no education, use birth control as much as educated women; albeit in the Philippines, where the government makes family planning hard to get – chiefly because of the pressure from the Catholic Church – uneducated women have a very low use of contraception. DTT also does not coincide well with the biology of human reproduction, due to the omnipresence of frequent sexual intercourse of couples in virtually all societies, easy access to fertility regimentation methods is purely a requirement to reduce the average family size (Potts, 1997).

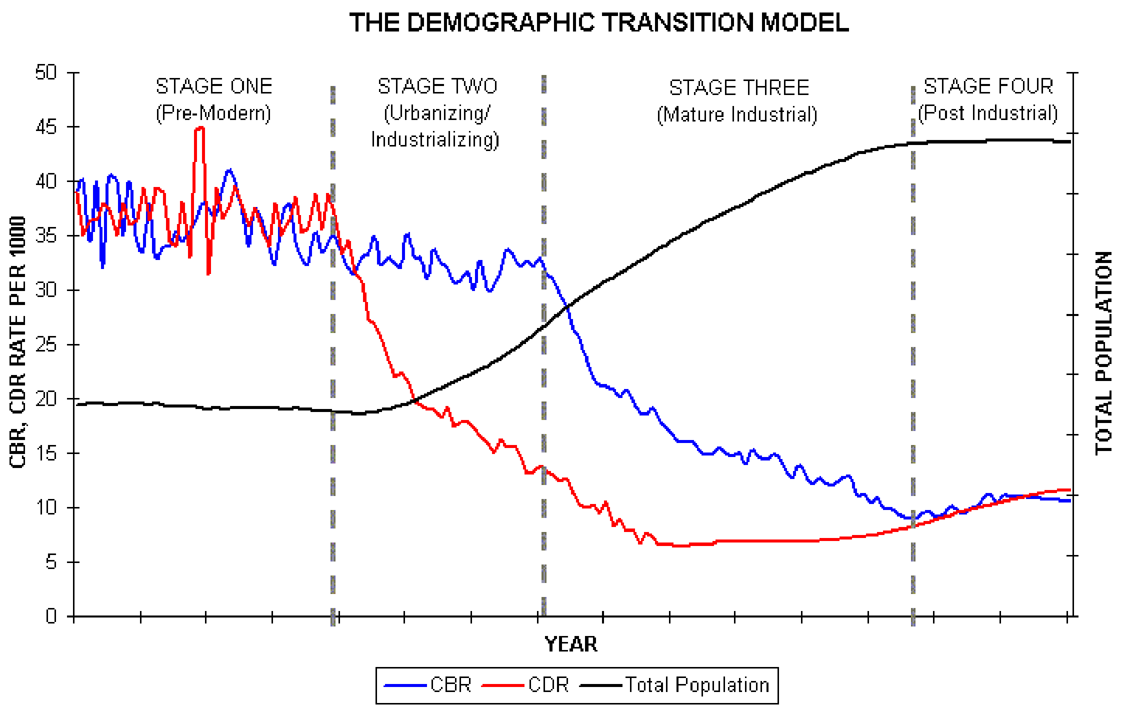


Figure 3.4: The Demographic Transition Model and its four stages. Retrieved from Montgomery (2000)

Identically, demographers taught that "Once fertility declines are underway they tend to continue" (Bongaarts, 2003). When the spotlight was divested off fertility programs after Cairo (as described in the next segment) the TFR rose from 5.0 in 1995 to 5.21 in 2005 (Potts, 2018). When scholarly analyses "demonstrated that there is no tight link between development indicators and fertility" (Bongaarts & Watkins, 1996), the authors still persisted on professing, "the role of socioeconomic development in accounting for fertility declines remains inherently plausible" (Potts, 2018).

In light of these events, the 'theory' has been taught to manifold generations of demography and economics students with regrettable sequela. The hallucination and misconception that population growth will be wary of itself is prevalent and nefarious (Potts, 2018). One such example was a 2013 OECD analysis and policy document on food security in West Africa that garlanded the laxness associated to population growth, with the authors stating that "The demographic transition in West Africa is advancing" (OECD, 2013).

The report (OECD, 2013) states that West Africa is construed as:

> "One of the last regions in the world to complete its demographic transition. Its high growth rates in the last few decades correspond to the start of the phase characterized by a reduction in mortality and continued high birth rates."

Consequently, such rhetoric insinuates that later 'phases' of the demographic transition will take place. Malcolm Potts (2018) realistically and candidly declares:

> "They may not. In Burkina Faso the infant mortality fell but the average family size hardly changed. In neighboring Niger, the TFR rose. Over the past 30 years agricultural production in Niger increased by 2.6 percent per year and population growth by 2.7 percent per year."

The blind faith in the progress of DDT has prompted many people to be apathetic and innattentive to the growth of population, since they assume that as soon as the level of welfare rises, birth rates will drop, which has proven to be true, not just in Japan and Europe, but in many other developed nations. In consonance with DDT, one is inclined to predicate that population starts with stable, equal, and rather high fertility and death rates. Thereupon, as medical technologies become broadly accessible (particularly vital is the availability of antibiotics and vaccinations), as well as improved diets, that results in a lowering of mortality (Kopnina & Washington, 2016). As a consequence, this raises both the population and per capita affluence. The crucial factor is that it spearheads higher rates of education and women's empowerment (Weeden & Palomba, 2012; Weisman, 2013).

In the final stages of the transition, as birth-control technology is implemented and propagated throughout the population, with higher educational levels and increased material wealth, the theory assumes a reduction in fertility. At some stage, the rates of mortality and fertility find a point of equilibrium (Kopnina & Washington, 2016). The hypothesis is that these factors will equalize population size without policy intervention: "Development is the best contraceptive," hence we can be contented and confident that population *growth* will cease (Alcott, 2015). Reflecting on the assertion that left to its own devices, population will stabilize at 9-10 billion in the twenty-first century, Smail (2016) expostulates that:

> "Much of this guarded optimism is based on the assumption – but not the assurance – that certain inferences based on the demographic transition model are empirically justified, particularly the claim that there is a strong positive correlation between increased economic, social, and sexual well-being and steadily decreasing fertility levels. But it is entirely possible that these assumptions and correlations are also "projections rather than predictions."

Massimo Livi Bacci, Emeritus Professor of Demography at the University of Florence, evinces in his book *Our Shrinking Planet* (Bacci, 2017):

> "Some argue that the world is heading toward the 'end of demography' – that is, a stationary balance that will gradually include the various regions of the world and their populations. It is thought that the completion of the demographic transition and a global levelling out of the inequalities between countries will inevitably lead to a homogenisation of demographic behaviours."

Livi Bacci contends:

> "This hypothesis seems rather unrealistic, and for many various and obvious reasons. The first is that thus far globalisation has brought an increase and not a decrease in the inequalities between countries. Moreover, the demographic inequalities between countries are today at historical highs: there are populations that produce an average of six children per woman and others that produce barely one, populations with a life expectancy close to 90 and others at not even a half of that, countries with demographic exoduses of biblical proportions and countries that absorb these same exoduses. It would be difficult indeed for the demographic transition to wipe out these differences, just as it is unthinkable that there could be a worldwide economic and social "levelling out."

Quite possibly the greatest champion of the Demographic Transition Theory was the late statistician Hans Rosling. Through excellent communication and a genuine dedication to improving the lives of others, Rosling was a crucial player in the conviction that the way to resolve challenges is through facts and data. But he was also wrong in respect to population. Rosling's popular but fracturable conviction that population isn't a predicament worth worrying about and that future population growth will definitely resolve itself out, was only possible due to a profound unenlightenment and nescience regarding environmental problems, the extent of the current and future ecological emergency, an over-simplification of population data and above all a *faith* in the demographic theory that hasn't been proved and technological solutions that that haven't been implemented or even invented (Population Matters, 2018a).

In one point Rosling was absolutely correct, women's empowerment, education, lifting people out of poverty, access to contraception, legal and safe abortion services, family planning are all essential (Population Matters, 2018b) to the objective of reducing the size of the human populace – but from this list what actually does the most work is the access and provision of high quality, effective family planning services. In effect, nations that have popularized active family planning protocols which administer services, sexual and education regarding contraception, besides the most crucial point of actively encouraging the cultural adoption of smaller family sizes, result in greater decreases in fertility than the average for developing countries (figure 3.5) (Population Matters, 2018a).

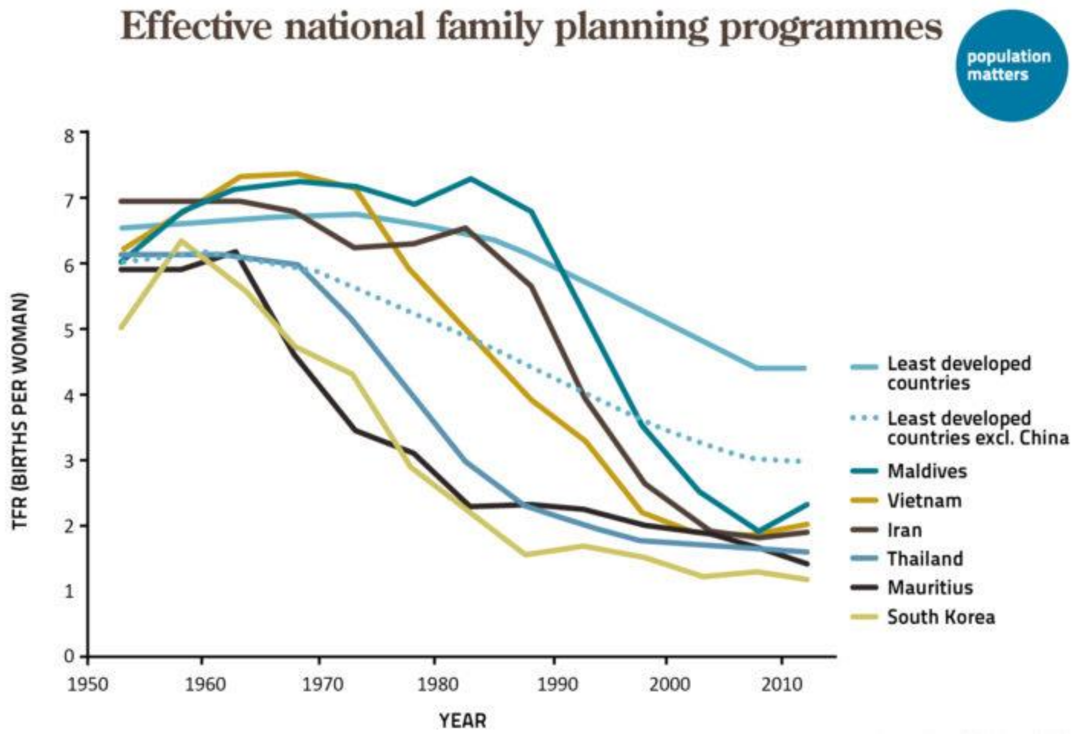


Figure 3.5: Reductions in Total Fertility Rates Correlated with Effective National family planning programmes. Source: O'Sullivan, 2016, p.45. Retrieved from Population Matters, 2018a

However, a growing body of evidence (Harper, 2015) also indicates that the credence that Rosling placed on the DTT – in a word, countries moving out of poverty must experience a decline in fertility rates – is placed unwisely. For one thing, the pattern was vigorous and energetic in the history of many currently developed nations as they were elevated out of poverty, fertility rates are, at present, falling so slowly and languidly in a number of Least Developed Countries that demographic transition is scantily occurring at all (Population Matters, 2018a).

In reality, the human population continues to expand by roughly 83 million individuals per annum, and each of these new passengers is going to need to be fed, a place to live, clothing, energy, transportation as well as exerting a significant effect on the natural world, through the acquisition of resources, transmogrification of landscapes, the discharge of residues, waste and altered components and the transmutation of natural biogeochemical cycles that impose on the ecological integrity. As described in the chapter Prometheus, we know that in 1798, an English clergyman had something to say about the juncture of geometrical population growth and arithmetic growth in the food supply (Potts, 2018). Under these circumstances, demographic transition theorists more often than not posit that contemporary trends are moving fast enough to avert grave ecological catastrophes – most probably a false presumption, given the speed of global ecological decadence and climate change that we are beholding (Crist & Cafaro, 2012).

Cairo, 1994

"Demographics is destiny"
- Arthur Kemp

The **seventh** factor relates to certain policy developments. The 1994 United Nations International Conference on Population and Development (ICPD, or "Cairo" for short) was the critical juncture in discarding the population proposal from policy treatise. Specifically, the crucial difference between Cairo and the previous UN population conferences was its accentuation on the needs of women around the world, especially low-income women scarce-resource areas. For this reason, antecedent to the two-week conference in Cairo, a politically incorrect atmosphere started to develop around deliberations on population (Campbell, 2007).

Once more Martha Campbell (2007) formulates the situation as such:

> "Drawing attention to any connection between population growth and environmental destruction became taboo – again, because such a connection was viewed, or promoted, as disadvantageous to women. It became inappropriate to say that slowing population growth would make it more possible to preserve the environment for future generations and reduce poverty. "Malthusian" and even "demographic" became derogatory terms describing anyone still concerned about population growth."

To demonstrate this, the 1994 Cairo conference proclaimed a human rights foundation for "reproductive rights," recognizing:

> "The basic right of all couples and individuals to decide freely and responsibly the number, spacing and timing of their children and to have the information and means to do so, and the right to attain the highest standard of sexual and reproductive health. It also includes the right of all to make decisions concerning reproduction free of discrimination, coercion and violence as expressed in human rights documents. In the exercise of this right, they should take into account the needs of their living and future children and their responsibilities towards the community. The promotion of the responsible exercise of these rights for all people should be the fundamental basis for government – and community – supported policies and programmes in the area of reproductive health, including family planning" (UNFPA, 2014).

With this in mind, the ICPD acknowledged that in many societies sizable numbers of women are marginalized, regularly lacking equal treatment under the law, divorced and detached from educational and economic convenience, doing substantial portions of the agricultural work while being impaired of the freedom to own or manage property, and repeatedly being casualties of domestic violence. As part of the Cairo endeavour to succour women, heedfulness was also drawn to instalments of coercion in family planning for which there were priors in India in the 1970s and in China's one-child policy later. Ridiculously, the domestic and cultural coercion women encounter when they have no say over how many children to have, or whether to have children and when has been far more excluded than government-driven coercion in family planning programs (Campbell, 2012).

Thereupon, the approach embraced at Cairo to engage in issues about pregnancy and childbearing was to incorporate family planning with all aspects of health that are particular to women, calling it "reproductive health." The hegemony of that movement, intentionally or unwittingly, advocated the idea that all family planning efforts before 1994 were "coercive," classifying them "population control," a term henceforth viewed as essentially derogatory.

While voicing a hearing of the UK Parliament on Population and the Millennium Development Goals, the President of the International Planned Parenthood Federation admonished the Cairo conference: “The taboo about population… was the result of a mythology… that equated population policies with coercion” (APPG, 2007).

The proposition to stimulate silence on population and family planning was directed at the betterment of women’s health and well-being. However, the grand design was counterproductive to both sets of intent, as access to family planning options did not inflate and magnify with the growth in the number of women who required them. Under those circumstances, women’s reproductive rights and choices have thus not been scaled up globally. As a result, after Cairo, in a number of countries, the discrepancy in fertility rates between the richest and poorest economic quintiles increased (Fotso, 2006).

Henceforth, the shift of language from family planning to reproductive health, in particular, endowed the massive reduction of monetary patronage for family planning allocation in foreign aid agencies. As an illustration, the designation “reproductive health” was perceived in the women’s health movement, and in agencies operating in these international arenas, but it was arduous to identify in the U.S. Congress, European parliaments, and even with the broad public (Campbell, 2007).

Consequently, and according to Sinding (2006):

> “A fatal blow was struck at the International Conference on Population and Development (ICPD) at Cairo in 1994. There, societal goals such as reducing population growth for poverty alleviation and environmental sustainability were supplanted almost entirely by individual goals defined in terms of sexual and reproductive health and rights (SRHR).”

Two main factors were accountable for the exclusion of population concerns at Cairo. First, a steadfast and resolved alliance of feminists and social justice activists had triumphed in creating a disproportionate and, indeed, a defective image of international family planning programs as coercive and violating women’s rights. Second, and as it has been mentioned before, there was an expanding but fraudulent impression that the “population problem” was largely resolved (Sinding, 2006). On the other hand, and from an insider’s perspective, what transpired was a politically crafty and adroit feminist/social justice lobby that successfully thwarted the old-guard populationists through a rendition of “population control” as politically incorrect (Weeden & Palomba, 2012).

As two analysts (McIntosh & Finkle, 1995) wrote of the Cairo Conference:

> “In the search for consensus, [such] conferences are… likely to be excessively sensitive to the ‘political correctness’ of the day. This tendency exemplifies what has been called the ‘mobilization of bias,’ meaning that some issues are organized into politics while others are organized out.”

Population reduction in itself was not part of the agenda due to it being considered antithetical to women’s rights. A cynosure on economic advancement alone was expected to bring about a reduction in population growth (Weld, 2012), as detailed in the previous segment.

The Cairo conference forged a unanimity that population policies, “which treated women instrumentally, as tools through which to implement population programs,” were obliged to be replaced by a health and rights concept which sees women as “intrinsically valuable” (Shalev, 2000). Cairo represented the archetypal deflection in development efforts, far afield from a focus on population control, towards a paradigm of “empowering women” and support for a full range of reproductive health services (Kates, 2004).

Given these points, by the early 1990s, the ascendancy of the family planning “revolution” – which produced replacement fertility in much of the developed world and nearly halved fertility in developing countries – led to the widespread speculation that world population was no longer pullulating, and surely, a befuddled media acquiesced with this conjecture (Wattenberg, 1997). However, demographic data eroded this contentment. Global population persists on surging by more than 83 million per year, as it has for the last four decades (Weeden & Palomba, 2012).

What ensued was an echo of the few non-governmental population organizations advocating the demographic philosophy for population activism. Up to that time, purported mainstream population groups such as the Population Council and Pathfinder International had relinquished population stabilization and environmental concerns, as the veterans were dislodged by those with a women’s health and rights panorama. In the past, those organizations had aligned efforts with national environmental organizations in the wishing that concerns about global environmental issues would redouble and refresh succour for population stabilization and family planning services (Weeden & Palomba, 2012).

All together, and according to Frances Kissling a long-time reproductive health activist quoted in *A Pivotal Moment: Population, Justice, and the Environmental Challenge,* from Laurie Ann Mazur (2009):

> “For environmentalists, the shift was a mind-bender. They had entered the field of population out of concern for the effect of population size and growth on the environment. If addressing the relationship was now considered unethical, was there any reason for them to stay in the field? Within a few years after Cairo, most environmental groups bowed out of population work.”

Kissling snowballs with:

> “The Cairo conference was imbued with the same taboo that has thwarted serious public discussion about population growth over the last few decades – that is, that international population stabilization policies are coercive and ultimately violate women’s rights. Thus, representatives from the feminist and social justice movement became strange bedfellows of the Vatican and other conservative religious advocates.”

While Cairo may have been of some avail, expansion of access to family planning did not enter the equation. This has resulted in an earnest breakdown, but as Meetika Srivastava emphasises (2009):

> “[The] ability of women to control their own fertility is absolutely fundamental to women’s empowerment and equality.”

In light of this, family planning experts, writing in the British medical journal *The Lancet* (Cleland et al, 2006), state:

> “The recommendations of the Cairo Conference replaced the hitherto dominant demographic-economic rationale for family-planning programmes with a broader agenda of women’s empowerment and reproductive health and rights.”

As a result, financial backing for international family planning was discontinued in a relentless fashion. By 2000, the drafters of the UN’s Millennium Development Goals pretty much abolished and rescinded any presentiment regarding overpopulation and omitting family planning’s urgent need (Cleland et al, 2006). In the UN Population Division's 2002 expert group meetings, there was salient and perceptible downsized support for population programs since Cairo (Kates, 2004). The framework shift from macro-social entanglements to individual welfare might have been a "problematic" result of Cairo, according to Jason Finkle (2002). In fact, at recent international meetings on climate change in Copenhagen, Cancun, and Durban, population concerns were not up for debate (Levitt, 2009).

To summarize, in the decade and a half following Cairo, the ubiquitous speechlessness on the population issue extended to other key players, which were made up of development institutions, donors, country health programs, and universities. The word *population* developed into an anachronism, taboo, and essentially beyond words (Weld, 2012).

Madeline Weld (2012) tells us that, among the politically correct left:

> "Anything remotely resembling demographic [concerns and objectives] was racist, anti-woman, anti-poor, and flirting with eugenics."

On balance, today, the few environmental groups that do bring on board population issues promote the Cairo Agenda almost entirely. An interview with the staff of the National Wildlife Federation (NWF) convinced one observer that female empowerment – as opposed to reduced birth rates and population stabilization – was their population program's main objective (Kolankiewicz & Beck, 2001).

This becomes even more relevant when accounting for the Post-2015 Development Agenda that brought together the international community under the umbrella of the United Nations, with the animus of propelling the planet's political, cultural and financial powers to uphold the agenda's goals (UNDESA, 2015). What resulted from this assemblage became known as the Sustainable Development Goals (SDGs). Even though the agenda's goals ventilate the themes of poverty (goal 1), nutrition (goal 2) and health and survival (goal 3), the document does not incorporate any covenant or concordat regarding the pace of demographic change, family and associative forms, the manners of human settlement (expect large-scale urbanization), domestic mobility, or, most crucially, international migration. It validates what has been made evident throughout this chapter, that in general, the official international community perceives demography as extraneous and not pertaining to sustainable development, despite all evidence to the contrary (Bacci, 2017).

Discourses of Dismissal and Disavowal

"The major problems in the world are the result of the difference between how nature works and the way people think."

- Gregory Bateson

"To find out what is destroying your society, discover which ideas are considered beyond criticism."

- Brett Stevens

In the latest decades, population growth has shaped up to become a decisive issue in sustainability discourse, with disputations ranging from dubiousness and incertitude to animosity and malice toward those who "blame" overpopulation. The polarization into the censurable and reprehensible high-consumption Westerners and destitute victims in developing countries (who cannot help having a multitude of children and who have a much smaller carbon footprint due to their hardship) for a fact, play into the hands of those who call for population management, as "racist" or socially unfair (e.g. White, 1994; Hartmann, 2004; Robbins, 2012; Fletcher, Breitling & Puleo, 2014). Representing this anti-population-control disposition, White (1994) denounces "green politics" in reviling population growth (Kopnina & Washington, 2016). In an analogous fashion, Hartmann (2004) has argued:

> "The greening of hate – blaming environmental degradation on poor populations of color – is once again on the rise, both in the U.S. and overseas. In the U.S., its illogic runs like this: immigrants are the main cause of overpopulation, and overpopulation in turn causes urban sprawl, the destruction of wilderness, pollution, and so forth. Internationally, it draws on narratives that blame expanding populations of peasants and herders for encroaching on pristine nature. In the first instance, the main policy "solution" is immigration restriction; in the second it is coercive conservation, the violent exclusion of local communities from nature preserves. Both varieties of the greening of hate are about policing borders… One does not have to scratch very far beneath the surface to find the links between the green wing of the anti-immigration movement and nativism and white supremacy.

By the same token, proponents of stern measures for protecting biodiversity have been labeled negatively as elitist and misanthropic (Marvier, 2014; Fletcher, 2014). It is challenging and quite prohibitive to raise a voice in defence of an extinguishing natural world when academic circles persist on condoning such biased branding. To demonstrate, an emblematic video tellingly titled the "War on humans" is published by the Discovery Institute (Discovery Institute, 2014), which upholds that any arguments against population growth are militantly *antihuman:*

> "Should pigs and peas have constitutional rights? The War on Humans is a 31-minute documentary that critiques growing efforts to disparage the value of humans in the name of saving the planet. The documentary investigates the views of anti-human activists who want to grant legal rights to animals, plants and "Mother Earth," and who want to reduce the human population by up to 90%."(Quoted in Kopnina & Washington, 2016)

Together with this, another reasonable rationale for not wanting to address overpopulation has been the expostulation that in focusing too much responsibility and condemnation on population growth, the commitment for basic human development (and poverty abatement) is overlooked. With the convergence of the 1992 Earth Summit in Rio, a vocal coalition of developing countries "insisted on broadening the list of actors that contributed to ecological deterioration beyond the obligatory reference to population growth" (Cohen, 2005). This affair combined with the differences between the "wealthy" North and the "populous" South prevails one of the most contentious argued issues of our time (Sachs, 2002; Kopnina & Washington, 2016).

One of the unremitting claims is that resource use by peripheral communities, those of the "victimized South" is either "relatively benign" or "environmentally innocuous" (Robbins, 2012). Those oblivious to population deduce that the global population growth is detached from overconsumption in the West. Moreover, factors such as the growing middle classes in developing countries, and migration from high to low population and high consumption areas are infrequently taken into account (Kopnina & Washington, 2016).

In her seminal work "*Too many bodies? The return and disavowal of the population question"*, Diana Coole (2012a) discusses the types of discourse that dominate the population effort. The following segment is, in essence, a chirurgical operation of excerpts taken from her valuable and fundamental work, displayed in an arrangement that permits the reader to follow the required narrative. I will refrain from paraphrasing and instead cite Coole whenever it's her words, and direct the reader to any author presented in her original article. I invite anyone to consult the full document since what I present here does not make justice to the complete work of Coole.

The analysis that follows identifies five categories of silencing discourse: *population-shaming; population-scepticism; population-declinism; population-decomposing and population-fatalism*. These are analytic distinctions and Diana Coole (2012a) delivers a brief explanation to prepare us for the right approach of inquiry required for this segment:

> "In practice the discourses overlap or work in conjunction, the most obvious factor they share being antipathy to the Malthusian equation between population growth and resource shortages. But these are not merely analytic categories; they are also profoundly political. Each has a distinctive genealogy in terms of its ideological and professional investments, the political interests it serves and the narratives in which it is embedded. The more that key demographic variables become amenable to policymaking, the greater the impact of the discourses that frame them."

Population-Shaming

Among the five silencing discourses, population-shaming is the most prolific. Its protagonists reject claims that there is an objective demographic growth problem. Rather than charging neo-Malthusians with misplaced anxiety, however, they suggest that ostensible concerns about overpopulation are a subterfuge for pursuing heinous ulterior motives (Furedi, 1997). The *humus* of population-shaming is a pervasive suspicion that limiting population actually means limiting certain categories of people who are deemed redundant or undesirable. Those who persist in advancing such arguments risk public humiliation for playing a numbers game that is interpreted as a blame game: one in which the world's problems are refracted through population growth and blamed on the inhabitants of the global South (Coole, 2012a). Sometimes advocates of population stabilisation are presented as misanthropic people -haters, as when Murray Bookchin (1991) asserts that deep ecology 'blames "Humanity" as such for the ecological crisis - especially ordinary "consumers" and "breeders of children."' Sometimes they are charged with misogyny, inasmuch as women's fertility is blamed for under-development or family planning programmes are credited with promulgating unsafe contraceptive procedures

(Hartmann, 1987; Rao, 2004). But the most serious charge concerns racism, linked here to colonialism, eugenics and genocide. As an article in the *New Statesman* (Nicholson-Lord, 2004) states: 'We dare not discuss population growth lest we be called racist'.

In order to trace the genealogy of this association, analysis of a brief discussion in Hardt and Negri's book *Multitude* is instructive (2004). The relevant discussion occurs in 'Global Apartheid' where they write:

> "We should add… the final ingredient that completes the global topography of power and exploitation. Most discussions of demographic explosions and population crises… are not really oriented toward either bettering the lives of the poor or maintaining a sustainable total global population in line with the capacities of the planet."

Multitude's provocative claims regarding their 'real' concerns rely on strategic signifiers that *précis* a particular political past. Reconstructing this past, can therefore, help in assessing the contingency of the three linkages the authors make between population concern and racism (Coole, 2012a).

First, despicable motives are attributed to population agencies, which are condemned for disguising their real aims through humanitarian rhetoric. This allegedly hides their true agenda (racism) and practices (coercive), which are claimed 'in fact' to represent the dictates of international institutions and national governments. International agencies are charged not only with sponsoring compulsory sterilisation but also with 'withholding from some populations aid for food or sanitation infrastructure' with the specific aim of culling the world's poor. Multinationals 'thirst for profit' is presented as complementary to a broader racist project in which 'poverty and disease become indirect tools of population control'. In short, both sorts of Malthusian checks are identified here: the preventive type being imposed coercively and the positive kind cynically being left to run its course. In the context of developing countries, they acquire distinctly racist significance (Coole, 2012a).

Such charges are not unfounded, with India especially commending itself as the referent for Hardt and Negri's invective (Coole, 2012a). Mass famines there had sometimes been presented by colonial administrators as salutary checks on over-population. Neo-Malthusian views would subsequently persuade the new republic to initiate the world's first family planning programme (1952) but it soon found itself dependent on foreign aid and mired in geopolitical interests. While at home Americans were fretting about the domestic effects of a population explosion on the environment, abroad their Cold War anxiety linked population growth to social instability and hence vulnerability to communism. Following disastrous harvests in the mid-1960s, food aid to India was used by the Johnson administration as leverage to insist on a robust family planning programme whose respect for human rights was noticeably deficient (Caldwell, 1998, Rao, 2004, Connelly, 2006). These equations formed the basis for considerable hostility to the population establishment and its Western supporters, with the opposition being eloquently rehearsed by third world delegates to Bucharest in 1974 (Finkle & Crane, 1975). They interpreted population policies advocated by the US government as neo-colonial and racially-motivated while accusing the West of blaming population growth for poverty rather than recognising the international capitalist system as the principal cause of under-development (Coole, 2012a).

By situating the population issue in the context of the mid-1970s, Hardt and Negri invoke genuine dangers of state interference in demographics. But they also draw on a particularly febrile period when population was a cipher for broader ideological struggles. Because they are unspecific about these circumstances they imply that all family planning programmes with wider demographic goals are coercive and racially-motivated (Coole, 2012a). Despite *Multitude's* focus on the poor, its authors ignore the bleak effects of rapid population growth on the everyday lives of those who inhabit slums or the misery of unwanted pregnancies for those whose need for contraception remains unmet (Davis, 2006; Stephenson, Newman & Mayhew, 2010). Nor can they consider the global consequences of increasingly affluent populations, since ecological concerns have been ruled out as mere hypocrisy (Coole, 2012a).

The **second** association between population policy and racism is made via allusions to eugenics. Hardt and Negri condemn those who are 'concerned primarily with which social groups reproduce and which do not'. For much of the twentieth century the project of improving the species' genetic stock had influential adherents but by the 1920s, negative eugenics entailed sterilising the degenerate: the insane, the criminal, certain races. This policy gained its most notorious expression under Nazism as population policy became genocidal (Coole, 2012a). The link in *Multitude* is undoubtedly reinforced by its authors' indebtedness to Foucault, who explains that treating population as a matrix of different races permits the state to kill others as a condition of making life healthier (Foucault, 2003). In an age of colonial ambitions race accordingly justified genocide, while for eugenics programmes killing the enemy was a way to purify one's own race. Historically, such references remain very powerful. Yet again, the link to population policy is specific and contingent. It is surely not a good enough reason to avoid population talk in the current century although it does provide a good explanation for our proclivity to do so (Coole, 2012a).

In a **third** linkage, Hardt and Negri refer to 'racial panic': a phenomenon elsewhere referred to as 'race suicide'. In light of the decline of white European populations, they argue, perceptions of a demographic crisis primarily concern racial composition: the increasingly 'darker colour' of European and world populations. 'It is difficult', they argue, 'to separate most contemporary projects of population control from a kind of racial panic' (Coole, 2012a). The term race suicide emerged early in the twentieth century when President Theodore Roosevelt condemned families who chose to produce merely two progeny: a nation that willfully reduced its population in this way would deservedly commit race suicide, he maintained, adding that the differential fertility rates among Anglo-Saxons and immigrants might deliver an especially regrettable form of race suicide (Roosevelt, 1903). It is indeed the case that population policies have sometimes been motivated by nationalist or ethnic desires to increase people's powers by multiplying more strenuously than its competitors. But this is not limited to white European populations; it is more typically associated with selective pronatalist population concerns which are not reducible to eugenic ambitions, especially when it is the affluent who are most unsustainable (Coole, 2012a).

Hardt and Negri are helpful for illustrating how vulnerable demographic policies - especially those designed to achieve differential birth rates - are to racism and xenophobia and how susceptible to entanglement in broader geopolitical struggles, they can become (Coole, 2012a). The warning remains salient inasmuch as such connections have acquired renewed resonance in light of unprecedented migration flows since the mid-1990s. In developed countries, immigration has replaced fertility as the principal demographic variable provoking public anxiety about population growth (United Nations, 2000; Coleman, 2010), with concerns about overcrowding and the environment again being interpreted as cloaks for racism. The connection certainly reinforces the sense in which population numbers are an inherently controversial issue. But does it not also show why anxieties provoked by demographic change must be subjected to public deliberation rather than being rejected as too shameful to acknowledge (Coole, 2012a)?

Population-Skepticism

This section picks off from the brief discussion on the demographic transition theory (DTT) initiated in the previous segment, which is currently the dominant narrative and is responsible for population-scepticism among experts (the reader can find the necessary introductory elements in here).

Scepticism here means the doubt that there is no longer a population problem since fertility is declining almost everywhere. It claims universal applicability but European experience provides its template and ideal. The fact that the theory relies on dubious teleological assumptions to inflate its predictive claims greatly enhances its sceptical potency (Coole, 2012a). For example, DTT presupposes that secular, Western attitudes to contraception and family size will prevail, yet it is by no means certain that this can be relied upon in a multicultural world in which religious, patriarchal cultures are gaining a relative demographic advantage (Norris & Inglehart, 2004; Kaufmann, 2010). It assumes there is no Malthusian trap whereby high fertility forecloses opportunities for development, for example by suppressing capital accumulation (Coole, 2012a).

While current projections are broadly congruent with DTT expectations, this is unsurprising inasmuch as projections must extrapolate from current trends, a practice that relies on assumptions themselves furnished by DTT optimism (Coole, 2012a). So while the UN's oft-cited medium variant for 2100 is 10.1 billion, this increases to 27 billion were 2005–10 fertility rates to remain constant (United Nations, 2010). In short, there are no guarantees that fertility will decline universally or irreversibly. Ironically, since worldwide completion of transition relies on contingent factors such as the willingness of international donors to fund family planning programmes, population-scepticism helps to disincentivise the very policies fertility decline depends on and to challenge projections' accuracy (Coole, 2012a).

By the same token, population-scepticism is espoused by experts who doubt that population growth is problematic. Scepticism is reinforced by revisionist claims that population growth is advantageous: a view that is congruent with the neoliberal desires for sustained economic growth and anathema to limits-to-growth arguments (Coole, 2012a). Julian Simon (1977), one of demographic revisionism’s principal proponents, maintains that population growth is, in the long run, beneficial for economic growth and the environment because more people are a spur to and resource for hard work, ingenuity and technological innovation. This approach continues to furnish the standard riposte to limits-to-growth arguments: bigger populations are held to be sustainable because the inventiveness of more people will endow ecosystems with the resilience needed to accommodate them (Australia Government, 2011).

Population-declinism

Population-declinism is a corollary of population-scepticism in that it is an expression of the final stage of demographic transition. A symptom of completing transition is that the population ages. This phenomenon engenders a sense of melancholia and loss connected to fears of relative decline. Population-declinism is currently powerful in precluding enthusiasm for population stabilisation because it promulgates images of enervation and decay in which the faltering powers and risk-averse outlooks ascribed to older people are attributed to whole regions (like ‘old Europe’) (Coole, 2012a). For declinists, low-fertility societies are destined to fail relative to more youthful, energetic competitors, with feebleness in the global economy accompanying weakness in the military theatre (Jackson & Howe, 2008). The remedy is to encourage renewed growth (Coole, 2012a).

In like manner, population-declinists promote pronatalist views, alongside immigration, in order to rejuvenate developed world populations (Commission of the European Communities, 2005; Dixon & Margolis, 2006). In 2009 almost half the governments in these countries regarded their population growth as too low (United Nations, 2009). The populations of the United States, United Kingdom and Australia, *inter alia*, are all projected to increase substantially by 2050, through a mix of natural growth and net migration (Coole, 2012a). Yet the power of declinism is such that this is rarely complemented by consideration of whether upward trends enhance the quality of life or the environmental systems on which it depends (Coleman & Rowthorn, 2011).

On the one hand, longer life expectancy inevitably entails more elderly people: a situation likely to persist worldwide as mortality declines. It need not be perceived in declinist terms but not doing so would require a radical change in current perceptions of older people and evaluations of the good life (Coole, 2012b). Notwithstanding, the rhythm of transition and its effects on the age profile also produce an acute, if shorter-lived, hiatus, especially where fertility declines rapidly. In this latter case, several decades of exceptionally but temporarily high dependency ratios ensue as the last high-fertility cohort ages (currently the case with post-war baby-boomers) (Coole, 2012a).

Then again, the initial period of ageing does pose genuine, if short-term, challenges for policymakers, and this is what provokes declinists to advocate population growth. In particular, as the age bulge moves through the population a ‘demographic dividend’ of a large working-age group becomes a demographic deficit. As this spur to increased productivity passes, the dominant economic-growth framework implies policies to replenish the labour force. In practice, however, pro-natalism is largely irrelevant because the situation will be eased by the time new citizens become productive (Coole, 2012a). Immigration achieves faster economic impact but it is ‘a fallacy that higher immigration counteracts population ageing' (Australian Government Productivity Commission; United Nations, 2000; House of Lords, 2008). In the longer term, both these demographic solutions reproduce the difficulties they are intended to resolve. Because of new bodies and migrants also aging, ceaseless additions would be needed to service and replace larger elderly cohorts. Yet tackling challenges of more elderly people will only be exacerbated if populations expand and ecological services correspondingly deteriorate. The principal danger of declinism is that it operates within a short time frame that focuses on temporary fiscal and productivity challenges, yet its demographic remedies are likely to aggravate unsustainability later on (Coole, 2012a).

Population-decomposing

Talking about population as a totality that can be planned and managed has come to be regarded as not only politically dangerous but also methodologically crude. This is a more elusive discursive effect than the first three categories but it has been effective in disenfranchising the population question in two ways: normative and methodological (Coole, 2012a).

Normatively, population-decomposing has been effective in rejecting ‘the numbers game’. Iconic texts like Paul Ehrlich's The Population Bomb were explicit about population being a numbers game. In light of an imminent environmental crisis, Ehrlich (1970) defined population control as ‘the conscious regulation of the numbers of human beings to meet the needs not just of individual families, but of society as a whole'. As a consequence, the focus on population size and growth rates, especially when linked to targets and sanctions, fell into disrepute (Coole, 2012a). This antipathy is encapsulated in UNFPA's (United Nations Population Fund) observation that since the mid-1990s, there has been 'a shift in population policy and programmes away from a focus on human numbers' to a focus on 'human lives'. Policies based on perceptions of a 'race between numbers and resources' are eschewed as synonymous with a 'numbers game' presented as antithetical to human rights (UNFPA, 2008). In sum, even to focus on overall demographic quantities becomes anathema to personal choice and liberty. Reproduction is recast as a self-regarding act (Coole, 2012a) (This topic will have its own chapter in Morality of Procreation, in the upcoming volumes).

Likewise, one outcome has been to devolve population issues into matters of reproductive health and individual welfare entitlements. Of course, these measures are eminently worthy. But the change of emphasis they entail has helped to exclude discussions about overall numbers while supporting the view that population is best approached as an individual or familial level (Coole, 2012a). This point was already addressed in the segment dedicated to Cairo, 1994.

In the same fashion, demography as a discipline has itself become more closely modelled on economics and concerned with economic data, thus sharing with economics its own movement away from macro-level approaches towards micro-level, statistical studies where individuals feature as rational agents making choices on the basis of cost–benefit analysis (Coole, 2012a). Le Bras maintains that every branch of demographic analysis has been renewed in this direction over the past two decades. 'In fertility studies, the dominant position is now occupied by microeconomic models of the family' based on work by Gary Becker and George Schulz (Le Bras, 2008). Ehrlich also argues that as a discipline, demography 'has largely diverged from environmental concerns and the broad analyses of social structures' it formerly undertook. It now 'focuses on measuring and modelling the dynamics of various populations': a process judged valuable but peripheral to 'the really big demographic issue' of the environmental cost of population growth and its rectification (Ehrlich, 2008). In sum, the normative and methodological dimensions of population-decomposing together help to demolish the framework in which population numbers matter and in which society has an interest in and responsibility for sustainable levels. This makes it difficult to identify, problematise or debate population growth as a social issue amenable to democratic debate or collective action (Coole, 2012a).

Population-fatalism

In a final discursive category, the term population-fatalism captures the renewed concern about expanding numbers, in a suggestive return of the population question. Population-fatalists are confident that the challenges of 9-10 billion can be met. But they are fatalist in treating population growth as a given; as an aggravating or critical factor, they are powerless to change and reluctant to address. Instead, they identify challenges and calculate abatement costs. This distinguishes their arguments from: population-scepticism, which does not see population growth as a problem; population-declinism, which encourages population growth to foreclose shrinkage; population-decomposing, which disavows the very framework of numbers. But it shares their antipathy to anti-natalist policy and is probably apprehensive about population-shaming (Coole, 2012a).

In the same view, *The Stern Review: The Economics of Climate Change* is a good example of population-fatalism. Although population growth is included as a significant contributor to global warming there is no suggestion that a demographic element might be incorporated into climate change policy (Stern, 2006). This formula of neglectful concern has been the hallmark of other recent studies, which prefer technological solutions to controversial political interventions (Coole, 2012a). The UK government's Foresight Programme has produced two recent reports in this genre. *Land Futures - Making the Most of Land in the 21st century* (Foresight, 2010) links population growth in the United Kingdom to pressures on the land, biodiversity, carbon sinks, urban green spaces and water that may badly erode wellbeing. *The Future of Food and Farming: Challenges and Choices for Global Sustainability* cites population growth as an urgent challenge in light of the need 'to ensure that a global population rising to nine billion or more can be fed sustainably and equitably (Foresight, 2011). But in neither case is there any suggestion that further population growth might be tackled. *The Economist's* (2011) '*The 9 billion-people question*' and the Institution of Mechanical Engineer's 'Population: One Planet, Too Many People?' (2011) follow a similar logic, with (bio)technological solutions being proffered for a demographic *fait accompli* (Coole, 2012a).

Accordingly, The Royal Commission on Environmental Pollution's (RCEP) *Demographic Change and the Environment (*2011) goes further by explicitly excluding population growth as an appropriate policy domain (Coole, 2012c). Despite acknowledging that 'total population is likely to continue to grow, at a historically relative high rate' in the United Kingdom and that some regions suffer 'obvious pressure on infrastructure, services and environment (RCEP, 2011), the report constructs an either/or choice between seeking to influence demographic change and trying to mitigate its environmental impact. It unequivocally opts for the latter, declaring the former not 'a good basis for policy' because unspecified 'objections on social and ethical grounds would outweigh the environmental gains' (RCEP, 2011).

In this regard, the Royal Society's *People and the Planet* (2012) is unusually non-fatalistic. It advertises the efficacy of public policy and foreign aid in pursuing the UN's projected low-growth variant, especially regarding unmet contraceptive need: 'global population growth needs to be slowed and stabilised' and actual numbers will 'depend heavily on the population policies for the next few years'. It heeds the interactions between consumption, demographic change and environmental impact, recommending that the 'most developed and the emerging economies must stabilise and then reduce material consumption'. It accordingly challenges the economic drivers of population growth by calling for the development of socio-economic systems and institutions that 'are not dependent on continued material consumption growth', while reintroducing a discourse of finitude, scarcity and limits that acknowledges a declining population can lessen pressure on natural resources. *People and the Planet* perhaps signals a paradigm shift (Coole, 2012a).

The identified five discourses that together explain why there is currently no politically acceptable framework within which population numbers can be problematized, or remedial action commended, were presented above.

Two of these discourses seem especially powerful: population-shaming, because it renders the population question so morally treacherous, and population-scepticism, because of its complacency and its congeniality for hegemonic pro-growth ideologies (Coole, 2012a).

Friend or Foe?

"There can be no permanent progress in the battle against hunger until the agencies that fight for increased food production and those that fight for population control unite in a common effort."

- Norman Borlaug

The previous segment was meant to analyze how the population effort is being distorted in its narrative, so as to decrease and taint its reputation, goals and ambitions. By creating an atmosphere of shame, doubt and discord, a taboo arises, impeding an honest discussion that needs to occur. The main principle of the last segment was that the ones creating this pressure are external to the population effort. In this segment, I present a compilation of anecdotal situations from agents, authors and entities that were meant to side with the population movement to achieve their objectives, but are neglecting or declining its importance, hence, hampering and lessening the efforts required. This segment is meant to bring all of those people under the same roof and presenting human overpopulation as a commonality that unites us all, and for this reason, consolidating everyone's resolution would aid in the realization of this greater good.

Two of the most crucial apprehensions affecting our age are how to enhance human welfare (UNFPA, 2011) and to avert and put a stop to the ongoing calamity affecting the natural world (Secretariat of the Convention on Biological Diversity, 2010; WWF, 2008). Unfortunately, reversing these tendencies continues to invite competition despite international initiatives such as the Millennium Development Goals and multitudinous international venues such as the World Conference on Human Rights, The Convention on Biological Diversity, Agenda 21, and the United Nations Framework Convention on Climate Change, among others (Mora, 2014).

One of the failures that can be noted stems from the dearth of international institutions to address these problems cooperatively and simultaneously. The rationale is that there are substantial feedback loops between biodiversity loss and human welfare and various other concerns such as climate change, overexploitation of resources, habitat loss, violence, and so forth, plus we lack institutions that can piece together all issues synchronously, particularly at transnational scales (Walker et al, 2009).

On top of all this Camilo Mora argues in *Revisiting the Environmental and Socioeconomic Effects of Population Growth: a Fundamental but Fading Issue in Modern Scientific, Public, and Political Circles* (2014) that:

> "Another, and perhaps even more critical, reason for failure is the reluctance of many of these initiatives and institutions to call for specific action on the issue of population growth [...] the issue of overpopulation is being critically underplayed and fails to influence decisions in which millions of people and species could be negatively affected by a situation that might have been otherwise avoided."

In detail, and as further evidence of this inconsideration on population, Philip Cafaro (2012) directs his attention to a deliberation of the most voluminous discussion of population growth in the International Panel on Climate Change's (IPCC) *4th Assessment Report,* given below in its absoluteness is informative:

> 'The challenge - an absolute reduction of global GHG emissions - is daunting. It *presupposes a reduction of energy and carbon intensities at a faster rate than income and population growth taken together.* Admittedly, there are many possible combinations of the Kaya identity components (in Category: Chaos), but with the scope and legitimacy of population control subject to ongoing debate, the remaining two technology-oriented factors, energy and carbon intensities, have to bear the main burden' (IPCC 2007, p. 109; emphasis added).

The IPCC's stance suggests that population restraint is too contentious to ventilate (Cafaro, 2012). This absence of argument creates a colossal vacuum in their analysis (Grant, 2006). Within the *4th Assessment Report*, one encounters a cornucopia of meticulous excursus of surrogate agricultural practices, building techniques, airplane, train and automobile technologies - and no colloquy of how to limit the number of people whose need for food, shelter and transportation is predominantly driving global climate change (Schneider, Rosencranz, Mastrandrea & Kuntz-Duriseti, 2010).

Taking the issue of food security, [the IPCC 4th assessment report] makes narrow to no references to the issue of population growth or family planning, or any complementary matter. Likewise, one could argue that food security will not just be contingent on our capacity to produce food, but on how much food our population will continue to request; nonetheless, some of the most seminal recent reports on food security were deficient in any reference to the role of or need to concentrate on population growth in ensuring current and future food security (Mora, 2014; Clay, 2011; Foley et al, 2011). Similarly, in the chapters on adaptation, there are intricate examinations of how societies can strengthen their defences against climatic changes - but no mention that limiting the number of people demanding and disputing the likely diminished resources might help countries adapt to a warming world (Cafaro, 2012).

The difficulty of a metamorphosis in values and social norms is enfeebled whenever and wherever those most befitting to apprehend and rationalize the risks that are driven or aggravated by population growth, thus throwing light upon it while edifying the public, decide to stay silent on it. Particularly agonizing is the scenario where the only voices speaking on population are pronatalist ideologues representing capitalist, patriarchal or religious interests (Kuhlemann, 2018). An immoderate taboo has matured whereby scientists, activists and policymakers 'talk around' population growth and trifle with or withhold reference to the need for smaller family sizes when discussing climate change, food or livelihood insecurity, loss of biodiversity and environmental degradation (Campbell & Bedford, 2009; Coole, 2012a; Mora, 2014). In doing so, these actors are duplicitous in creating an environmentally destitute world in which many millions, possibly billions, of people may starve, uprooted or have no hope of securing decent livelihoods. This needs to change (Kuhlemann, 2018).

This hampered and restricted commitment of scientists, universities, environmental NGOs, human rights activists that then percolates into the public format has been related to narrow and minimal rewards as well as disicentivation on the part of institutions, limited avenues for communication, potential lack of support or endorsement from colleagues, credible possibility of belligerence from interest groups and the inherent loss of one's job (Chan, Higgins & Porder, 2005; Batts, Anthis & Smith, 2008; Pace et al, 2010). It is important to realize that expanding the public's knowledge and awareness about the issue of overpopulation is vital to its resolution.

For one thing, public consciousness can compel and predispose people's choices in favour of having smaller families (Lee, 2011), as well as arousing and energising political will and representation (Nisbet & Mooney, 2007) on top of driving public and private funding (Schindlmayr, 2001).

Expressing this message of the relevance of population growth to the general public is further encumbered by skepticism from historical-flip-flops about the gravity of overpopulation (Lee, 2009), environmental generational amnesia or the proceeding through which receding baselines over generations depreciate levels of concern (usually referred as 'Shifting Baseline Syndrome') (Miller, 2005; Knowlton & Jackson, 2008), languishing engagement with environmental and ecological issues in the face of other imminent concerns such as jobs and wealth (Revkin, 2009), the inundation of information and its evasion when perceived as irrelevant (Nisbet & Mooney, 2007), psychological biases toward short-term versus long-term benefits (Laibson, 1997), and a common attention cycle compelled by the sound-bite nature of news media and the short-term focus of many politicians (Downs, 1972).

It is conjecturable that population growth being mostly absent from the scientific program accounts in part for the dwindling public knowledge and interest in this subject. Meffe (1994) acquainted us with the concept of "missing awareness" to elucidate the current paucity of recognition of the magnitude of our population even among segments of our society with higher education. In the United States, public opinion on population growth as an exigent issue declined from 68 percent in 1992 to 8 percent in 2000 (Schindlmayr, 2001) and it is not even an option in more contemporaneous opinion polls (Polling Report, 2018; Mora, 2014).

An antecedent behind such an outcome can be directed to prodigious rates of scientific illiteracy of the public in general. To demonstrate, in countries like the United States, Canada, Japan, and others in Europe, the proportion of scientifically literate adults is below 17 percent (Gross, 2006) and one can conceive even lower proportions in developing nations (Mora, 2014). By all means, scientific literacy is fundamental for a better cognizance and responsiveness to the association between individual actions and environmental conditions (Blumstein & Saylan, 2007); how human activities amass to impinge on the integrity of the biosphere (Perry, 1993); and in the case of overpopulation, real apperception and discernment of what the plethora of ramifications and reverberations our numbers encompass (Meffe, 1994).

An instance of this was realized by Meffe (1994), in which he conducted a survey of university students and these were asked to give their estimates of population growth and overall human population. The answers were disquieting and ghastly, due to the fact that they were completely unreal overestimations, such as populations of one to three trillion and annual increases of hundreds of billions (Mora, 2014). If anything this boils down to a culture of scientific illiteracy, as well as a failure on the part of educational institutions, that seem to be shielding students from our ecological reality, instead focusing their efforts into creating individuals to enter the workforce, completely bypassing the intrinsic and indispensable role of these institutions to bring into being full-fledged citizens that are conscious and acquainted with quandaries that plague our world.

One perfect example of how population is being "trivialized or ignored" by the scientific community, which then seeps in to public opinion (Meffe, 1994) took form in a *Time*'s magazine issue (Park et al, 2007), in which it devised the "51 things we can do to save the environment;" needless to say, not one was remotely connected to population. Even as we become increasingly conscious to the scientific reality that human-induced climate change is real and happening now, many of us still delude themselves while shivering and shaking at the thought that this has any paramount connection to how many of us there are (Engelman, 2008).

In the next few segments I will focus attention on each and every particular group that ought to be conscious and aware of the population issue, but rather, out of neglect and disregard or disdain and aversion, impede this much-needed dialogue and conversation to be had.

Human Rights Activists

Activists in all walks of life routinely focus on alleviating torment and affliction, not on their genesis. While activists scrimmage between the desecrations of malnutrition, lack of potable water, disease and poverty, the barricade of overpopulation is repressing them. The manifestations they and many others rival with are the unavoidable results of local populations exceeding the capacity of their water, soil and energy resources. To triumphantly lessen suffering, groups like Water.org must also work on stabilizing and reducing populations while trying to bring clean water to them (Shragg, 2015). The websites of activist groups like 350.org or Al Gore's Alliance for Climate Protection are unsuccessful in referencing population growth, when expounding the causes or possible solutions to global climate change. So do the websites and magazines of more deep-rooted environmental organizations, such as the National Audubon Society (USA) and Greenpeace International (Cafaro, 2012). To achieve long-term success, activists must incorporate the theme of the humane reduction of human numbers (Shragg, 2015).

Other NGOs like the Clinton Foundation, the Jolie-Pitt Foundation, Matt Damon's Water.org or the commitment of active and dedicated activists like actor Sean Penn have a lot of significance in the world and are forces for good on alleviating transitory poverty and upgrading the human condition (Shragg, 2015).

The following statement comes from Water.org (2018a):

> "Everyone in the world should have sustainable and affordable access to safe water and sanitation. To get there, we must fundamentally change the system. And this change must be driven by the intrinsic power of the poor as customers and citizens [...] Globally, 844 million people still lack basic water service—a drinking water source that is accessible within a 30-minute round trip from their home. Even more people, 2.3 billion, still do not have access to basic sanitation—a toilet or latrine that is not shared with other households […] The World Bank estimates that achieving these targets will cost approximately US$114 billion a year between now and 2030, and those are only the costs for constructing new infrastructure, not the costs of operating and maintaining infrastructure over time.

Water.org (2018b) adds:

> "The scale of the water crisis demands many different approaches. Providing water and building wells is one approach. We have a different and entirely unique approach."

Reacting to Water.org statements, Karen Shragg writes in her book *Move Upstream* – A Call to Solve Overpopulation (2015):

> "It is interesting to note that their projects are all in the seriously overpopulated countries of India, Haiti, Ethiopia, Bangladesh, Kenya and Uganda. I try imagining my home state of Minnesota with the population density of one of these countries. As of this writing we have 5.3 million people. We would have 79 million people if Minnesota's population density equalled that of Haiti. I would be calling Matt Damon to help us get water too, but only after calling on an overpopulation group to help stabilize and humanely decrease our numbers."

In like manner, the dedicated activist, actor Sean Penn devotes a substantial share of his time and efforts in Haiti cooperating with the rehabilitation efforts after the devastating earthquakes. The Oscar-winning actor was quoted stating that, "My job is to help people get the future they want to have." Then again, Haiti is already overpopulated and continues to expand, and without intervention, the nation is foreseen to almost quadruple its population density per square mile, according to the projections from the United Nations Population Funds, UNFPA (2010). By and large, if these famous activists remain silent in engaging in Haiti's severe and weighty overpopulation problem, the harm from enlarging human density will offset their good intentions (Shragg, 2015).

All these foundations and famous activists conduct their necessary work in overpopulated areas and countries, but they remain uncommunicative on the theme. Organizations like Pathways to Peace uphold that peace is through the environment but only in a spiritual way. They conceive that human lives need only to be linked spiritually to nature. They endorse non-violent lives and pursuing compassion but do not fundamentally understand the force of overpopulation (Shragg, 2015).

Identically, the example from COTAP (Carbon Offsets to Alleviate Poverty) funded by the Clinton Foundation perfectly exemplifies the repercussions of not concentrating on the root cause of the issue. Their purpose in Malawi in sub-Saharan South Africa is to plant trees to enlist impoverished people to work while offsetting corporate carbon emissions. It is notably ingenious to combine solutions to several problems in a single project, although according to COTAP's website they are apprehensive about the project's long-term goals and keeping it sustainable (Shragg, 2015). Nowhere on COTAP's website is the following data as Karen Shragg (2015) outlines it (updated numbers):

> "Malawi is a densely populated, landlocked country with only 36,367 square miles of land (as of 2012), struggling to feed, clothe and educate well over 18.6 million inhabitants (PRB, 2017). Malawi has a growth rate which has more than doubled its population since 2000, with a total fertility rate of 4.4 (PRB, 2017), making it the most densely populated country in Africa. These facts would make it clear that with more people living unsustainably in this country, the viability of planting trees for this project is limited. To make matters worse, is that most Malawians heat with wood and charcoal. The immediate need for sources of firewood will put mounting pressure on this project. If no one at COTAP steps up to the overpopulation plate, Malawi will have 25.6 million people by mid-2030s (PRB, 2017). They will struggle to exist in a landscape where the Clinton Foundation employed farmers to plant trees but neglected to also work on helping Malawians to humanely reach a sustainable population. People do not lack compassion over human suffering. They do lack a deep understanding of the source of these problems."

As another illustration, Ethiopia experienced a famine in the mid-1980s, while at the same time seeing its population soar from 42 million in 1980 to 105 million in 2017 (PRB, 2017). An international humanitarian response was set in motion to bestow external help, but no funds were dispensed to assist the Ethiopians from continuing to expand their population. Now the country is once again on the verge of another overpopulation-inspired ruination, with an almost tripling of the population. On top of ever more individuals requiring resources from the land, Ethiopia is prone to drought and has deficient sanitation services which means their natural resource base of soil and water cannot support the people attempting to live there. Dispatching financial aid to contrive better sanitation facilities will not work without curbing and reducing population (Shragg, 2015).

Karen Shragg dedicates an entire chapter in her book *Move Upstream* (2015) into discussing how our humanitarian efforts will fall flat on its face if we don't attend to the elephant in the room:

> "When there are humanitarian interventions that provide food for the starving and undernourished, more life will happen in places unable to sustain such populations. It is critical that activists around the world provide humanitarian aid accompanied with birth control. Otherwise larger famines will keep occurring."

The Feed My Starving Children website asserts that nutrition will resolve the world's problems, in detail, they postulate that nutrition alone will permit health, education and jobs. This is erroneous inasmuch as, without measures to deflate the birth rate, nutrition will prompt more population growth in places unable to support any more people (Shragg, 2015).

Feed My Starving Children does not appraise the number of people a landscape can support (carrying capacity) and helps perpetuate unsustainable numbers until the next disaster strikes. Bread for the World is an NGO that defends that it can end hunger in our lifetime if everyone enshrined their aims on poverty and injustice. They don't see the infeasibility of that well-intended idea, because 10,000 are added to their bread lines every hour, net gain (Shragg, 2015).

If groups like Feed My Starving Children and Bread for the World want to revamp the status of the poor, they would associate with population groups and outline companion birth control and family planning programs (Shragg, 2015).

Dick Klade, author of *Conservancy: The Land Trust Movement in America* (2005) comments on this issue:

> **"We can feed starving children in Somalia forever, and if we cannot somehow prevent the overproduction of children in Somalia, we accomplish nothing"** (bold added).

Significantly, the United Nations Millennium Project pledged an audacious initiative to end poverty by 2015. It didn't materialize so the deadline is now 2030. It is desirable, but it is contrary to reason to phase out poverty through donations, redistribution of wealth or the most cutting-edge program the UN contemplates. It is less of a political landmine to work on poverty, but the evidence is incontrovertible, richer countries tend to have lower birthrates and poorer countries tend to have higher birth rates (Shragg, 2015).

To point out, the U.S. and Canada have spent billions on foreign aid in striving for families to make a better living without focusing on reducing the number of births. In 2007 Canada published a report that after 45 years of total development aid to sub-Saharan Africa amounting to 575 billion in US dollars, many people are worse off than they once were (Canada Senate Committee report Feb. 2007). While a portion of the failure may be traceable to corruption, it still testifies to the insufficient proposition off trying to lift people out of poverty with donations of money without boxing in population growth (Shragg, 2015).

Markedly, the human rights movement has not taken human numbers into its arms because it appears antithetical to their credences (Shragg, 2015). In the same fashion, activists who eschew and disavow population, devote themselves to the problems without concentrating on the cause. Major environmental groups have eluded the subject of population numbers manipulation for decades, watchful to not getting caught up in the bruising politics of reproductive health (Navarro, 2011). Some groups also fear to flog an anti-immigrant sentiment, since immigration explains about one-third of the growth rate in the United States alone. "We see reluctance and fear to deal with this issue," said Jose Miguel Guzman of the United Nations Population Fund. According to Mireya Navarro (2011) in her piece *Breaking a Long Silence on Population Control* for *The New York Times*, groups contacted for the article generally declined to discuss the issue or did not return calls. Some of these social justice activists have even vehemently opposed overpopulation as a notion and dismissed its activists as being racists (Shragg, 2015).

By all means, human rights organizations like the Southern Poverty Law Center and the Center for New Community revoke the claim that there are too many people on the planet and are aggressive in maligning those concerned with overpopulation (*population-shaming* discussed in the previous segment). They feel trepidation it will be used as leverage against people who are disadvantaged when the exact opposite is true. Overpopulation precipitates and gives rise to injustice because it creates a scarcity of resources that leads to inequality (Shragg, 2015).

Notably, The Bill and Melinda Gates Foundation has diagnosed the serviceableness of infusing efforts into voluntary family planning. They do outstanding work trying to dissolve and distil the cultural, monetary and physical barriers that forestall access to birth control to an estimated 220 million women in developing countries. The Gates Foundation states they want to revamp women's lives but their lives cannot improve for long in overpopulated areas. They need to go further and name overpopulation as the inception of the problem, or else their goals will never be attained. Overpopulation needs to be named and understood so that far-reaching and all-inclusive policies and programs can be set in motion (Shragg, 2015).

By all means, well intentioned and dedicated people that pledge their lives for others by fixing things in countries that are in suffering state should be extolled and lauded for their efforts. They build schools, dig deeper wells, vaccinate and usher in much needed food and clothing. At the same time, their noble aspirations are undermined without an all-embracing family planning education and birth control program that will culminate in the people that are being helped today growing up and reproducing in unsustainable numbers tomorrow (Shragg, 2015). Humanitarian groups described in this segment have a great foundation but they need to concentrate on overpopulation because people become anonymous in masses of humanity and massive suffering results. This suffering won't be mitigated no matter how much money we send to peace, justice and humanitarian relief organizations unless there is a strong collective voice that attaches these principles to addressing overpopulation (Shragg, 2015).

Climate Change Activists, Scientists, Environmentalists and Population Groups

In the previous segment I intended to put on display how the humanitarian effort that circles around peace, social and environmental justice as well as humanitarian relief organizations, would take their missions a step further in efficiency by welcoming and incorporating a population perspective and action into their vocations. In this segment I turn closer to 'home,' by which I refer to specialists and experts in climatic and Earth scientists, environmentalists and population groups; that should and ought to be mindful and cognizant of our population predicament, but instead elide and are derelict of its criticality and seriousness. I already alluded to the societal problem embedded in high rates of scientific illiteracy of the general public and some of the reasons that lead *Academia* to turn away from discussing and incorporating population in their works. In here I will delve into some of those difficulties.

It is astounding that many environmentalists have been circumspect to address human overpopulation as a paramount matter, as it is at the core of understanding what is happening to biodiversity. Any meaningful conservation game plan must include a program to curb population growth, in order to avoid failure (McKee, 2012).

William Ryerson, president of the Population Media Center, described in *Wild Earth* how political correctness precipitated an international withdraw on overpopulation (Ryerson, 1999). Kolankiewicz and Beck (2001) delineate five drivers behind the "American environmental movement's retreat from population advocacy": (1) dropping fertility ; (2) anti-abortion politics; (3) emanation of women's issues as an antecedence concern of population groups; (4) a schism between conservationists and New Left roots; and (5) immigration becoming the chief growth factor.

As an illustration, when Mireya Navarro (2011) attempted to reach the president of the National Audubon Society (one of the oldest conservation NGOs, based in New York) they dismissed an interview without explanation. The chairwomen of the Green Group, a loose association of several dozen environmental organizations, did not return calls or emails. Kevin Knobloch, president of the Union of Concerned Scientists, declared the research on reducing emissions by abridging birth rates was not yet "robust" enough to make a convincing case for its execution.

Carl Pope, the chairman of the Sierra Club, said the organization now had an entire personnel of one individual connected to population affairs, who was working on international reproductive health services. Pope asserts in an interview (Navarro, 2011):

> "In this country [United States] there are reasons for keeping a low profile on the issue. Look at Planned Parenthood (retrospecting on the group's pulverizing strife with Republican lawmakers over federal financing in 2010), there's a huge atmosphere of intimidation. The moment you say 'family planning', immediately somebody pulls out abortion."

On the *Peak Prosperity's* podcast, episode *Dealing with the Elephant in The Room: Overpopulation* (2018), Bill Ryerson, president of Population Institute enters the fray and states:

> "I would venture that the leaders of virtually every environmental group, if spoken to privately, would clearly recognize that population growth is a major threat to the environmental goals of their organization. And yet, publicly, they've made a decision not to touch that issue for fear that they'll get themselves in trouble. And part of the reason for that I think has to do with their approach to environmental issues."

Ryerson adds:

> "Many environmentalists think in terms of regulation as the solution to everything: if we have a climate problem, let's have a carbon tax; if we have a pollution problem, let's have pollution laws and regulations. But if we have a population problem -- oops, what does that mean? Does that mean we have to tell people how many children to have? Therefore they conclude they better stay away from population because telling people how many children to have would obviously get them into trouble."

By the same token, Dr. John Bongaarts described the lassitude and indolence by environmental groups as a missed opportunity. "The global warming community is staying away from anything having to do with population," he said, "and that's frustrating" (Navarro, 2011).

Overpopulation is so misconceived that being *bona fide* about it often assures donations will evaporate. It is much more remunerative to home in on fundraising on downstream issues like education, research and the creation of caring communities than on trying to restrict human populations into breeding themselves to oblivion, which, still and all, remains as the most efficient answer for long-term success (Shragg, 2015).

Unfortunately, conservation factions are customarily not aware of the parlance, politics or intricacies of the overpopulation issue. They do not rummage on the human numbers, the median numbers of children per family or the math regarding overshoot of resources, even if these are interlaced with their guardianship and stewardship missions. At the same time, a multitude of young people on university campuses have been coached over the past three decades that the junction between population growth and the environment is not a copacetic subject for discussion. Indeed, in many circles it is politically incorrect to evince that slowing population growth will help to make it possible to preserve the environment for future generations (Campbell, 2007).

In his book, *Ethics for a Full World, or Can Animal-Lovers Save the Planet?* Tormod V. Burkey (2017) writes about the current situation that describes many of the NGO's:

> "Somewhere along the line many big NGOs (BINGOs) shifted towards working in collaboration with the corporate sector, and allowing this to colour their approach on a number of issues. Corporate relations became a big part of the job. In other cases, the NGO sector funding depends on the very government that their watchdog function mandates them to monitor. Around the world, good people run around like hamsters on a treadmill, checking the boxes required by the terms of their pay checks, their job description, and their deliverables for the year… Another hazard of organizational life can be that sometimes the organization's own long-term survival and fundraising ability is accorded too much weight in strategic and tactical decisions. [At the same time] You can't even get an honest answer about how we are doing, because they have to put a positive spin on their own ability to bring real solutions in order to maintain their funding."

Burkey concludes:

> "Given the choice between going through the motions, continuing play-acting at doing a job, or becoming unemployed, most will choose the former. Some people make good money going through the motions and keeping their mouth shut and heads down. Good people spend their lives fundraising while Rome burns."

Virtually alone, the Center for Biological Diversity is breaking the mould by directly binding population growth to environmental disputes through efforts like giving away condoms in colourful packages depicting endangered animals (figure 3.6). The conviction is to start a debate about how human overpopulation leaves no room for other species and hastens climate change (Navarro, 2011). Kierán Suckling, executive director of the center, a membership-based nonprofit organization in Tucson said he had a *Eureka*! moment a few years ago. "All the species that we save from extinction will eventually be gobbled up if the human population keeps growing," he said.

Aid for Africa, a charity alliance of US-based nonprofits, is attempting to safeguard land for lions. This is another well-intended goal, but will ultimately fail on a continent with the fastest growing population in the world (Shragg, 2015).

Figure 3.6: The condoms' packages were designed to start a discussion about how human population growth affects other species. Retrieved from Tony Cenicola/The New York Times in Navarro, 2011.

In her book, *A Pivotal Moment: Population, Justice, and the Environmental Challenge* (2009), Laurie Mazur acquiesces population as a factor in environmental problems. However, her book downplays the scope of its significance, henceforth counsels against a return to "population control" procedures, and reviles population and environment advocates who propound that the United States should stabilize its own population by reducing historically high immigration numbers (Weeden & Palomba, 2012).

Mazur (2009) concedes that:

> "There is a lot of fear – and outright hostility to – talking about population and environment in the same breath".

The book celebrates feminist and social justice concerns – particularly the Cairo Agenda – as triumphant and auspicious events, while with enmity and resentment, acknowledging population growth as a catalyst for environmental decadence as a background factor (Weeden & Palomba, 2012).

Mazur consummates her thesis with:

> "Human numbers are not a primary cause of environmental degradation, but they do magnify the harmful effects of unsustainable production and consumption."

Then again, Kolankiewicz and Beck (2001) intervene by stating:

> "Now centered in a feminist rather than an environmental mission, many population, family planning, and women's groups would support no talk of stopping growth or reducing average family size because that implied restrictions on what they considered a universal right of women to choose their number of children entirely free of the merest hint of official or informal pressure."

There are also others engaged in the population problem who argue that the solution to equalizing the population is by having *more babies*. “I see people as the ultimate resource,” says Steven Mosher, of the Population Research Institute in Virginia. According to Mosher, more people signifies more minds bestowing brain power to solutions, and more competition leading to more innovation - innovation that can tackle the problems created by too many bodies, which eventually will shape itself into a demographic transition on its own (Stockton, 2015).

Other experts are doubtful that the population can regulate itself. Corey Bradshaw, an ecologist at the University of Adelaide in Australia has to say (Stockton, 2015):

> “That idea is so wrong in so many ways... No question, the human population is the core of every single environmental issue that we have."

Bradshaw says unchecked reproduction overlooks an ecological principle called density feedback:

> “When you increase population in a finite space, per capita aggression increases, and an increased competition for resources arises.”

Bradshaw emphasizes it is essential that societies which undergo a demographic transition aren’t disallowed of the comforts of post-industrialization. But he retains that limitless population growth will make conditions much worse and that technology allowing the planet to support more people has always lagged behind the rate of population growth (Stockton, 2015).

“We can’t even feed the people on the planet now,” says Bradshaw, noting that there are nearly one billion hungry people on the planet (World Hunger, 2017).

In another unfortunate turn of events, the enormous, influential and popular organization World Wildlife Fund (WWF) released a report (WWF, 2018a) on the status of the world’s wildlife with one of the more preeminent messages being that 60 percent of population of vertebrate species have been eliminated from 1970 to 2014 by human activities (more on the next chapter). Heartbreaking and woeful as this announcement is, there is more to be said about it. WWF spells out the causes of biodiversity loss, with those being essentially habitat destruction and overexploitation, but regrettably, does not conjoin it the ravages of population growth (Population Matters, 2018g).

By failing to pinpoint the role that our growing numbers have as a component in the contemporaneous ecological genocide, WWF is doing more harm than good. And this comes as a surprise, since the report itself names the “exploding” human population and incorporates several graphics (pages 26 and 27) with socio-economic trends such as the rise in the human population, global water use, primary energy use, paper production, transportation, fertilizer consumption among others, while at the same time presenting graphs with earth system trends such as carbon dioxide in the atmosphere, nitrous oxide, marine fish capture, tropical forest loss, terrestrial biosphere degration together with others. But in a perplexing move, and in direct contradiction to the evidence presented, the authors shift the blame only to unsustainable consumption (a proxy to the developed world) as the originator and begetter of these dire trends, while completely sidestepping from expressing disapprobation for unrestrained population growth (mainly observed in the developing world) (Population Matters, 2018g). The report (WWF, 2018a) even distinctively states in a classic 'population avoidance' outline that:

> "It is economic development and the growth of the world's middle classes, not population rise per se, that is dramatically influencing the rate of change of Earth's life support system."

Nonetheless, WWF got it right when asserting that business-as-usual conservation efforts miss the boat in abating and impeding the expeditious erosion of biodiversity. The prominent NGO calls for an urgent Paris-style global agreement for "nature and people," however focusing exclusively on reducing consumption is both unproductive and fruitless. Responding to the omission of population in WWF's report, the Director of the non-profit Population Matters, Robin Maynard argued (Population Matters, 2018g):

> "For an otherwise courageous conservation organisation, campaigning and delivering practical action to staunch our world's haemorrhaging wildlife, the Panda is strangely silent on the subject of human population. Our population has more than doubled over the past 50 years, whilst populations of wild animals have more than halved. Consumption rates in rich countries show no sign of levelling off, whilst at the same time the number of high-level consumers across the world is set to double. People in poorer countries indeed deserve a fairer share of the Earth's resources. So, yes, we have to address human consumption, but in harness with addressing the inconvenient issue of human population – we will not succeed in saving nature or enabling everyone everywhere to live decent lives unless we do."

Identically, climate change activists and scientists have done an outstanding function by bringing their work from *Academia* to be a part of our everyday conversation, but have floundered inadequately in helping people conceive of the connection to overpopulation (Shragg, 2015). John Bongaarts and Brian O'Neill (2018) postulate in their article published in *Science, Global warming policy: Is population left out in the cold?* That population increase was well discussed between the 1950s and the 1980s, but ever since, it has evanesced from the agenda. This is unmistakable in on several levels. The Intergovernmental Panel on Climate Change (IPCC) declares population growth as a factor behind climate warming but is inarticulate about how to come to grips with the problem (Cafaro, 2011). Likewise, in the Paris Agreement on climate change, the population factor is not even part of the equation. Unfortunately, many are voiceless on population issues. For example, in the UN's development goals, the question is not even mentioned, says Frank Götmark, Professor of Ecology at the University of Gothenburg (The Overpopulation Project, 2018a; 2018b). This theme is further developed in the segment that explores lost opportunities to deal with climate change and population issues, in The Ship That Sailed By the Water Under The Bridge.

Coupled with this, the 'techno-fix' doctrine dominating the discourse is that the problem of a warming planet can be solved solely with green technology and conservation measures. The intellection given is that the much-needed remodelling of our current climatic and ecological predicament can be negotiated with biofuels, organic food, electric cars and solar panels when each day the repercussions of population growth undermine those downstream acts (Shragg, 2015).

Furthermore, climate change deniers and skeptics have unforgivably tainted this dialogue with anti-science based doubt. One case that comes to mind, that can have far-reaching repercussions stems from the high-profile scientist Prof. Jordan Peterson, a renown academic and quite possibly one of the most well-known intellectuals of our day and age. Despite Peterson's contributions to the political discussion, his stance on climate, environmental and ecological issues leaves much room for improvement, and due to the sheer magnitude of his influence (each of his almost daily appearances on Youtube amasses more than 1 million views) one could even say that his standpoint might be considered alarming. Next is an excerpt from an interview with journalist Helen Lewis for *British GQ* (2018) available on Youtube here:

> "- (Peterson): I think the climate is probably warming, but it has been warming since the last Ice Age...
> - (Lewis): But it has dramatically accelerated in the last couple of decades…
> - P: Ya, maybe, possibly, it's not so obvious… I went through the relevant literature… and it's not so obvious just like in any complex system. The problem I have, fundamentally … is to distinguish environmental claims from those that are a secondary anti-capitalist front. It is so politicized that is so difficult to parse out the data from the politicization."

Granted, there has certainly been and continues to occur some time of politicization of the environmental science narrative and not everyone agrees that this mix benefits science overall (Pielke, 2004), then again, it is also the industrial sector and the conservative right – which uphold that the industrial capitalist order should be mainly exempt from exposition and denunciation, by renouncing the significance of problems such as climate change and erecting barriers to the efforts of achieving some sort of sustainability (McCright & Dunlap, 2011; Demeritt, 2006; Jacques, 2006). Now back to the interview with Peterson, where the population issue is discussed:

> "(Lewis) – David Attenborough is something kind of close to a national religion in Britain, and there is a bit where you say in the book (12 Rules for Life: An Antidote to Chaos, 2018) that population control advocates, and you confront him with the question "why is it then virtuous to propose that the planet might be better with fewer people?"
> (Peterson) – It's the motivation that I question. What kind of statement is 'the planet would be better off with fewer people on it? First of all there is an easy solution. You could 'leave'.
> (L) – Unfortunately, in spite of the best efforts of Elon Musk that is not an option…
> (P) – That is not what I mean…
> (L) – Committing suicide?
> (P) – That's what I meant. If you are very concerned about your carbon footprint there is a very fast solution to that. Or the other people, the ones that haven't been born yet. This is also the problem I have with the environmentalist movement, the powerful stream of anti-human sentiment that motivates it, masquerading under the guise of virtue on a planetary scale.
> (L) – This is why I'm fascinated where you're coming from, cause in the book you talk so much about things being balanced and in harmony, what overpopulation has done is…
> (P) – Who says we have Overpopulation? […] It looks like we are going to top out at 9 billion, I think we can handle that. I think probably one of the problems that people will say in one hundred years, assuming there are even creatures like us around, is that there will be too few people like us around, not too many. There is every reason to assume we can cope with that, especially given the rapid decreases in poverty around the world, there is a bit of a bottleneck, there will probably be some more extinction, what we are doing to the oceans by overfishing doesn't seem very smart, but we have only been aware of our role as planetary stewards since the 1960's, and we are not doing too bad for people who just woke up to the fact that we are a planetary force, and I don't think we are overpopulated…

Ok, so where to start here? I suppose this conversation is as second to none of an example of how the discourse regarding population is brimming with dismissal and disavowal. In the first place, deriding environmental and ecological concerns (for example in the form of reduced footprints) with the the *nonpareil* approach of taking one's life is at the very least untactful, indecorous and iniquitous, to say nothing of the fact that Peterson is a clinical psychologist and also "acts as though God exists." A recommendation of voluntary suicide seems to be detached of both those matters.

Coupled with this, Peterson shows apprehension to another recurrent fabrication, the "anti-human sentiment" linked to those expressing concerns with the augmentation of human numbers. Here is the vision and mission of the non-profit organization World Population Balance (2018c):

> "We envision a world where no one suffers in dire poverty and misery for lack of enough food, water, and other basic needs. We see a world where all species thrive and where lower consumption and population are in balance with Earth's finite resources.
> [Our mission] we alert and educate that overpopulation is the root cause of resource depletion, species extinction, poverty, and climate change. Our mission is to chart a path for human civilization that – rather than causing greater misery – enables good lives on a healthy planet. We advocate and and support a smaller, truly sustainable human population – through dramatic and voluntary reduction in birth rates."

Next is the official position from the UK-based non-profit organization Population Matters (2018h), in which they describe the values that they are commited to:

1. In the value of healthy and diverse ecosystems, and of just and sustainable human societies.
2. That we all have duties to the community and to future generations to act in ways that do not undermine the protection, fulfilment and advancement of fundamental rights and freedoms; in a world of limited resources our reproductive and consumption choices are of critical importance to discharging these fundamental moral duties.
3. That everyone has a right to a standard of living adequate for health and well-being, and to an international order in which fundamental rights and freedoms, including gender, sexual and reproductive rights, can be fully realised.

Does any of this sound like an anti-human disposition? Most of the people involved in efforts to discuss and deliberate on population issues share the visions, missions and values of the organizations mentioned. The problem with Peterson and others who keep recycling such concoctions, is that such falsehoods keep being disseminated with little or no critical sense to evaluate their veracity. That is why this deceit lingers on our public discourse and hinders the efforts of well-intentioned people.

Furthermore, and as it is displayed in the first chapter and several times throughtout this work, human population is forecasted to reach 9.9 billion by 2050 (PRB, 2018), and at least 11 billion by the end of the century, according to the medium projection (UNDESA, 2017), which assumes that fertility rates will continue to decline throughout the century. However, these projections are shown every year to be innacurate and underestimates due to their overly conservative nature (figure 3.7), which means that we can be looking into a global human populations at the end of this century, several billions above (Kuhlemann, 2018) the one claimed by Peterson. Finally, there is the question of "There is every reason to assume we can cope with that," and this one is substantiated and documented throughout the rest of this work, so I will leave it at that at the the moment.

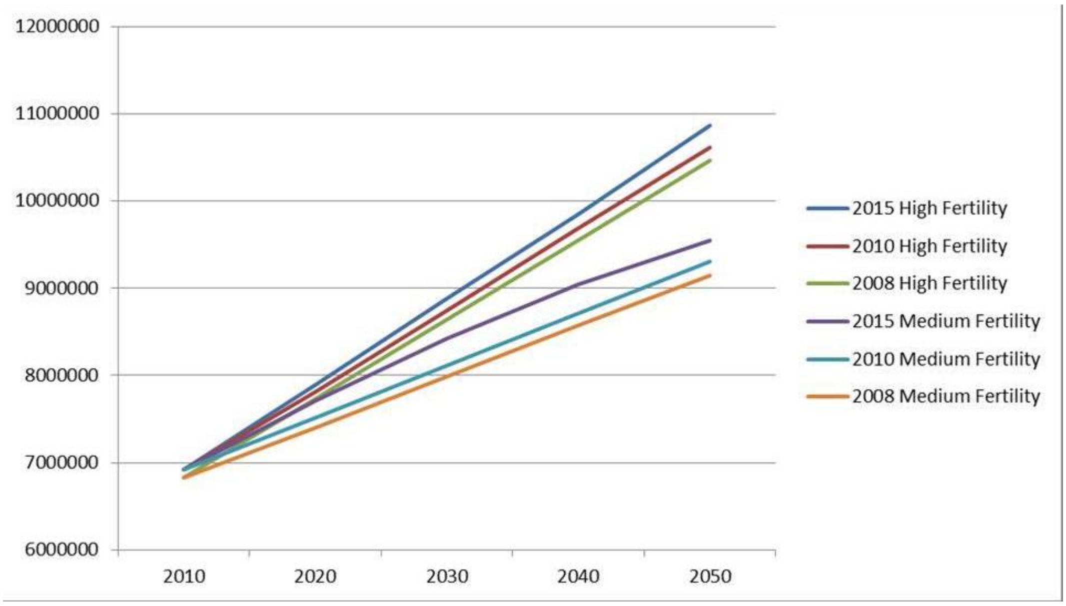


Figure 3.7: Changing world fertility forecasts from 2008-2015. Every year the trends are revised upwards due to overestimation of the decline in fertility rates, and the conservative nature of the forecasts. Retrieved from UNDESA, 2017.

All things considered, the individuals and organizations included in this segment, just as in the previous one, are dedicated, loyal and wholehearted to their respective vocations. On the other hand, they are also the ones with the highest moral imperative to act on the population front and not be dismissive or contemptuous, since they have the science at the tip of their fingers as well as having practical and real knowledge of the consequences instigated and abetted by an ever-expanding human population. Now we leave the conservation and science and will focus on the role of artists, politicians and journalists in propagating this narrative, as well as some of the interference posed by them.

Journalists, Comedians, Artists and Politicians

Progressive journalists do not seem to fathom that the poor are the first victims of overpopulation (Shragg, 2015).

Haiti is a devastating example of this. The deforestation of the small mountainous island country of 10,714 square miles is due to its overpopulation, which has led to such far-reaching soil erosion that a ring of mud surrounds the drained island. That mud was topsoil which could have grown food. The sheer numbers of individuals who populate the Haitian landscape erect slums where farms would otherwise be. By the same token, one of the main expositions for Haiti's ineptitude to ripen enough food for its own people is due to its overwhelming numbers. Foreign aid and church groups all share the same common goal of ending Haiti's desolation and despondency (Shragg, 2015). An after-effect of this massive deforestation propelled by mounting human numbers is what a team of scientists described in their research titled *Haiti's biodiversity threatened by nearly complete loss of primary forest*, published in the journal *Proceedings of the National Academy of Sciences* (Hedges, Cohen, Tiyan & Yang, 2018), in which the team described how **less than one percent of the primary forest** remains in Haiti, with all the endemic species, especially amphibians and reptiles were expunged along with the trees (Chung, 2018; Lundeberg, 2018). This is what human overpopulation looks like.

In general, journalists cover stories of unselfish good Samaritans who are bequeathing building materials for schools and sending a deluge of mattresses, food and pencils. They are not imparting the much-needed forces of public health and social workers to help them abridge their overpopulation. More journalists need to be acquainted and enlightened on the deeper sides of this issue, yet rarely do they ask questions that would create an informed dialogue around the way overpopulation drives these problems (Shragg, 2015).

It's bewildering that journalists covering the perpetual disasters in Bangladesh scarcely ever reveal the simple fact that Bangladesh has 164.7 (PRB, 2017) million inhabitants existing in a country that is 50 percent the size of Portugal, but has 1600 percent of its population (Portugal had 10.3 million in 2017) (PRB, 2017).

By all means, this frame of reference would expose a factualism rarely heard from the media, but as Karen Shragg (2015) states:

> "The ghosts of population control haunt this issue. The idea of governments telling people how many children to have often prevents progressive journalists from covering the topic. It is crucially important that journalists treat overpopulation as an issue that permeates nearly every issue they cover. Traffic, violence, rising oil prices, violent storms..."

Other candidates to the list: housing prices, species extinction, crowded services, anti-tourism marches, immigration, terrorism, lack of materials and minerals among many others would suddenly appear in a new light.

A story of success came from Thailand, where a restaurant owner endeavoured in persuading his fellow citizens to get comfortable with the apparatus that would withdraw them from a state of poverty: the condom. Mechai Viravaidya was tireless in his propaganda of the usefulness of condoms and small family planning, getting cab drivers and officers to hand condoms and even starting a program. Women in Thailand went from averaging 7 children to just under two. Nine million pregnancies were forestalled and the poverty that would have gone hand in hand with all of those mouths to feed (Shragg, 2015). This is a splendorous case study that should be highly propagated and disseminated throughout the media.

Artists who are in a standpoint of swaying the world include comedians, filmmakers, dancers, musicians and poets as well as visual artists. They have a set of marvellous tools which can evoke change in the world. "Now that you have seen it you must act on it," is the assumption of political art, says author and speaker Stephen Duncombe (Shragg, 2015).

Comedians have helped us to see the ridiculous side of our complexion. George Carlin always was valiant and undaunted in including overpopulation in his repertoire and Doug Stanhope takes a provocative look at our overpopulated work in his vignette, "Abortion is Green". Bill Maher has also committed himself by interviewing Alan Weisman, award-winning author of *Countdown, the Last Great Hope for Mankind on Earth.* If more comedians did the same, they would reach a more mainstream audience (Shragg, 2015).

In a final analysis, what constitutes potential solutions to overcome the many difficulties surrounding the discussion of population? Well, the first step is to acknowledge that we have a problem on our hands and that we need to relinquish denial, and deliberate solutions, on the double. To this effect, Robert Engelman (2012) provided us with *Nine Population Strategies to Stop Short of 9 Billion*, in which he argues that overpopulation *can* be tackled with non-coercive strategies to stabilize population at 8 billion:

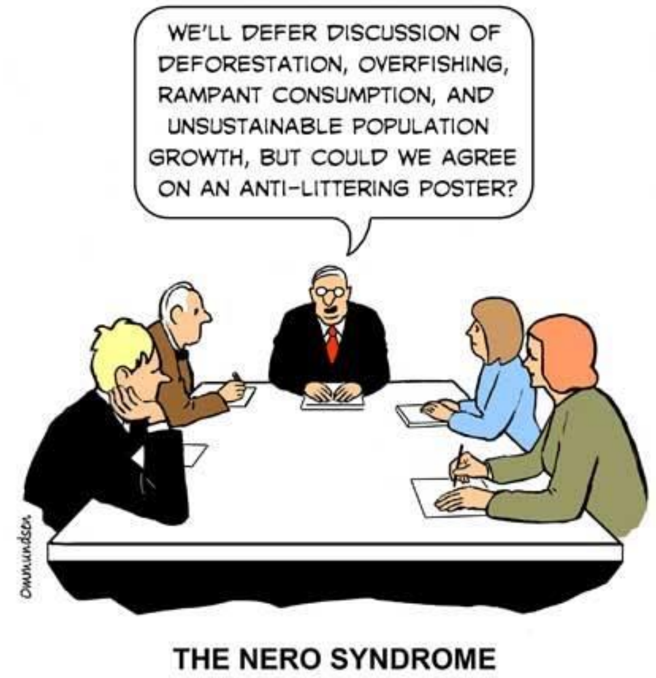
1. Guarantee access to contraceptives and family planning.
2. Ensure education through secondary school for all (with a specific focus on girls).

3. Abolish gender bias from laws, economic opportunity, health, and culture.
4. Secure age-appropriate sexuality education for all.
5. Cease all policies that compensate parents financially based on their number of children.
6. Incorporate the teaching of population, environment, ecological limits, and development into all school curricula.
7. Attach full pricing on environmental costs and impacts.
8. Adapt to ageing populations, rather than trying to hamper it through government programs intended on boosting birth rates.
9. Sway leaders to commit to ending population growth through the exercise of human rights and human development.

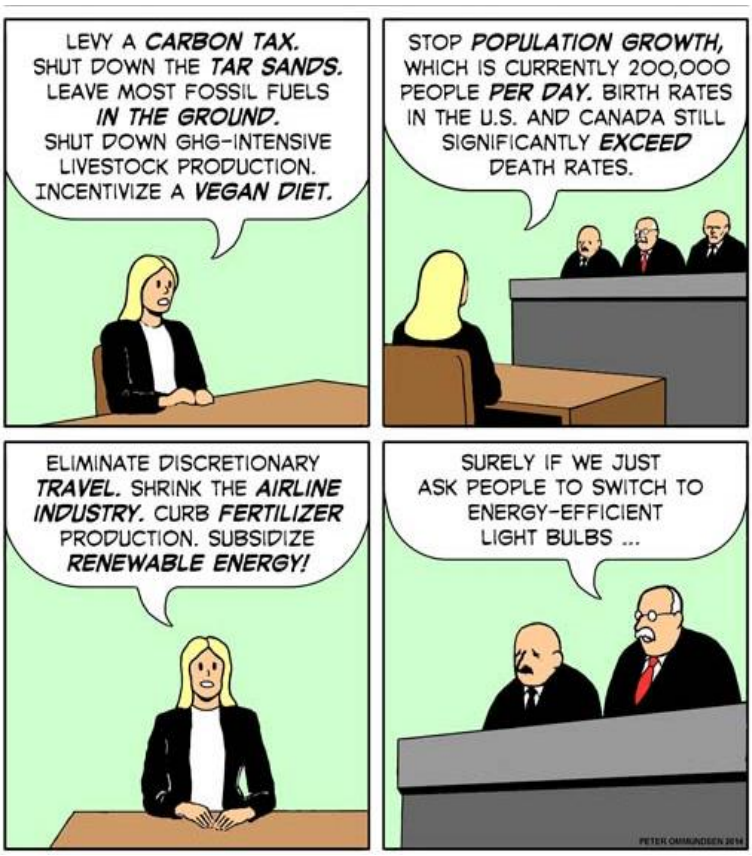
Using such methods, Iran was able to halve its population growth rate from 1987 to 1994 (Brown, 2011).

With these first three chapters, the reader is now in a position to understand the conditions that led the human population to change over time and interpret the main trajectories for the future. By having access to the latest and well-refined models and estimations the reader may recognize the challenges of the future trials. The second chapter is meant to be a gateway to the past, highlighting the contributions of people that were thinking ahead of their time, as well as the historical shifts in population awareness, which invariably led us to this last chapter, in which I lay down the events and dynamics that metamorphosed the population effort to its current state of affairs. Furthermore, I meant to draw special attention to the threats that come from within and the need to consolidate on a unified movement. The next chapter will address, in depth, this topic of biodiversity extinctions and how they are being driven by humanity's actions with a focus on ecology and paleoecology as well as anthropology.

To sum up, allow me a few last comments in the spirit of what this chapter was meant to portray. The title Judas and Elephant in the Room, as the reader might have concluded was meant to illustrate the elephantine silence on population, while Judas was meant to characterize the inconsideration, the insurrection or traitorousness on behalf of those who should champion the population directive, but instead, overlook or subvert its preponderance and momentousness. One of the drives that most weighted on me to write this work, was the fact that I constantly observed how well-meaning, praiseworthy and admirable people, institutions, environmental or ecology groups, politicians, researchers, activists, artists and the whole lot fought for a sustainability message, but simply ignored or sidestepped talking about population. My view on this is the following: I sincerely hope that, through this work, of all these collectives may acquire some insight into the realm of human overpopulation and how it is hindering every effort and resolution that they are trying to promote. If the reader is someone who worries about the environment, sustainability, pollution and the integrity and perpetuation of ecosystem and biodiversity stability then all of us have to embrace the necessary discussion on human population growth and what that will entail for individual procreative decisions.



Surely enough if humanity continues to disregard population growth and despise or dismiss any attempt to have rational, level-headed and prudent dialogues, while masking any attempt to do so under the aegis of accusations of racism, privilege, invasion of privacy and human rights as well as doom and gloom fatalism, only the worst of outcomes will become definite. As it stands - and I make sure to provide extensive examples of this throughout this work - in order to avoid a scenario in which humanity completely transfigures the planet, prompting ecological collapse and remodelling the Earth to a state that humans have never evolved with, a complete reform of our modern civilization will be required. In other words, alongside population amends, it will be necessary to shift away from fossil fuel consumption, profoundly revamp human diets, rebuild the economic system, and revise the need for air travel among many others (figure 3.8 and 3.9).



Figures 3.8 and 3.9: The Nero Syndrome. The environmental movement has markedly neglected the effects of population growth and a growth-dependent economy as catalysts of climate change, biodiversity loss, food insecurity and other topics discussed in this work. As this chapter has demonstrated, there is a fundamental need to alter the perception of the population issue in society. Author: Peter Ommundsen. Retrieved from Environmental Cartoon Commentary, 2016.

It isn't enough for the vanguard of the ecological and environmental movement, be it academic, activistic or humanistic, to solely focus or incentivize low and moderate impact behaviours such as recycling, changing light-bulbs and switching off electronics when not in use, buying local food, avoiding purchasing products with too much plastic, reducing water use in domestic activities, taking the stairs instead of the elevator and a plethora of other *commitments*. The stakes are high and real, which demands these groups and institutions to encourage real change, the one that will make every individual rethink their actions because they will entail authentic sacrifices. To demonstrate, such collectives should clarify and discuss with teenagers and young adults in their reproductive years, what will be the full extent of their procreative decisions. This is paramount. Academic institutions, NGOs, think tanks and other organizations that have environmental/ecological, socio-economic and humanitarian issues in their *curriculum*, need to step up their game and acknowledge in discussion that the most poignant decision in their student's lives (to beget another lifeform) is also the one that carries the greatest weight, as well as being the most effective in alleviating and ameliorating anthropogenic climate change, deterring the advance of habitat loss that is an after effect to the need to convert the natural world into food for us and other domestics, and overall reducing human misery and suffering in regions where the carrying capacity of the systems is clearly in overshoot, perpetuating a condition of poverty and destitution. Other crucial examinations should revolve around the need to avoid air travel (I would very much like to see these institutions specifically encouraging their attendees to bypass long-distance air travel and embolden the decisions to have local and regional vacations, by train, for example), inspire people to live car-free (many institutions already commit to carpooling or riding a bike, but it seems to cease to work when students leave *academia)*, eating a plant-based diet, adopting a lifestyle with only the necessary material wealth while circumventing superfluous acquisitions as well as opting to fix something instead of buying new ones.

These are some examples that would *really* go a long way in making a difference. If I can motivate at least one reader to appreciate the breadth of a revolution that altering these behaviours would encompass, and if that person is connected to any of the institutions referred, and he or she feels like promoting debate and constructive dialogue in population and other mentioned issues, then my intention behind this chapter has been attained.

It is now time to move on to another section of this work, but in order to do that we need first to revisit our past and the long legacy of extinction that we left in its wake, to fully grasp the extent of damage precipitated by our own species.

PART II

CHAPTER IV

WHERE THE WILD THINGS WERE

"I have often thought that at the end of the day, we would have saved more wildlife if we had spent all WWF's money on buying condoms."

– Sir Peter Scott, founder of World Wide Fund for Nature (WWF)

"The massive growth in the human population through the twentieth century has had more impact on biodiversity than any single factor."

- Sir David King, *science advisor to the British government*

Figure 4.1: A sign post at the National Aviary in Pittsburgh, PA. Retrieved from *In Defense of Animals* (2018).

> "When most people think of wild nature, they envision Africa. African wildlife and wildlands exert a powerful grip on the global psyche. The sources of such inspiration are numerous, from the vast migrations of large mammals across the East African savanna to the unparalleled floral diversity of South Africa to the ancient mammal faunas of Madagascar; African ecoregions harbor some of the most spectacular biological diversity on the planet.
>
> Unfortunately, the species and habitats so beautifully captured by wildlife photographers and television programs are under siege from a wide range of threats, including expansion of agriculture, human population growth, logging, hunting, civil unrest, and intentional burning. Nearly some habitat suffers some degree of degradation" (Burgess et al, 2004).

The outbreak of humanity has expunged many animal and plant populations, extirpated species and subspecies, precipitated collapsing ecologies, disseminated bio-homogeneity, and the depreciation and the dissolution of wild places. The virtually boundless expropriation of the natural world to serve a human scheme materializes in the reduction of ocean life to food and bycatch; rainforests decimated for meat, soybeans, palm oil, and timber; boreal and temperate forests overthrown and exsected for their wood, pulp, and energy resources; mountains and underground shale fulminated for coal and natural gas; deep-sea floors lacerated for oil; grasslands overgrazed or transmogrified into strictly human breadbaskets; and freshwaters siphoned, dumped in, and overfished. Worldwide, animals are being decimated with unprecedented celerity, either expelled or killed for their meat and lucrative body parts. Where natural areas and nonhuman beings do not writhe directly, they take indirect hits from anthropogenic climate change and pollution (Crist & Cafaro, 2012).

Environmental demand from the human population is the uppermost extirpative and lethiferous force on earth and is the principal cause of withering biodiversity (Pimentel et al, 1999). The decay of biological heterogeneity is one of the most gruesome human-caused global environmental problems, which is steering hundreds of species and incalculable populations to extinction every year (Ehrlich, 1994;World Wide Fund for Nature, 2016; Young, McCauley, Galetti & Dirzo, 2016; Ripple et al, 2014; Laliberte & Ripple, 2004; Worm & Tittensor, 2011). With approximately 50 to 70 percent of Earth's land surface currently modified for human activities (Barnosky et al, 2012) and the most recent report on the status of world biodiversity from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), claiming that value has risen to 75 percent (IPBES, 2018), patterns of biodiversity and ecosystem functions are vacillating and mutating globally (Foley et al, 2005).

From the frame of reference of geological time, Earth's most plentiful biota ever is already well into a sixth mass extinction episode (Barnosky et al, 2011; Ceballos et al, 2015; Ceballos, Ehrlich & García, 2010; Pimm et al, 2014; McCallum, 2015). On a conservative estimate, almost 200 species of vertebrates have gone extinct in the previous 100 years. If those species had had been subjected to the estimated "background" extinction rate prevailing in the last 2 million years, their obsolescence would have taken not a century, but up to 10.000, depending on the animal group analyzed (Ceballos et al, 2015). It is guessed that a 42 percentage of 3,623 terrestrial invertebrate species, and a 25 percentage of 1,306 species of marine invertebrates assessed on the International Union for Conservation of Nature (IUCN, 2018a) Red List are catalogued as threatened with extinction (Collen, Böhm, Kemp & Baillie, 2012). Ecologists presage that half of all living bird and mammal species will have vanished within 200 or 300 years (Levin & Levin, 2002).

This quota of two vertebrate species extinctions per year does not produce enough public disquietude and apprehension, especially since many of those species were obscure and had limited ranges, such as the Catarina pupfish (*Megupsilon aporus*, extinct in 2014), a tiny fish from Mexico, or the Christmas Island pipistrelle (*Pipistrellus murrayi,* extinct in 2009), a bat that evanesced from its namesake volcanic remnant (Ceballos, Ehrlich & Dirzo, 2017).

Species annihilation are unmistakably very important in the long run because such losses are irreversible and may have profound effects ranging from the degradation of Earth's inspirational and aesthetic resources to contraction of ecosystem functions and services (Daily, 1997, Naeem, Duffy & Zavaleta, 2012; Estes et al, 2011; Brosi & Briggs, 2013). This biodiversity vanquishment may pose the greatest direct menace to human survival if it thwarts the biosphere and hinders the recycling of such vital elements as carbon, nitrogen, and phosphorous (Pimentel & Giampietro, 1994). The end result of this hastened and expedited extinction of plant and animal species could be "wholesale ecosystem collapse" (Brown, 2000).

To undertake the question of environmental impacts from contemporaneous and future human populations on biodiversity, scientists focus on Biodiversity Hotspots, areas of the planet most in need of conservation protection from the perspective of unique ecosystems (Myers, Mittermeier, Mittermeier, da Fonseca & Kent, 2000). Whereas there are other ways of gauging regional patterns in environmental degeneracy and susceptibility (Bradshaw, Giam & Sodhi, 2010), today's 35 Biodiversity Hotspots are internationally acknowledged as regions encompassing the most unique (endemic) species that are, at present, undergoing the greatest hazards from human endeavours (Myers, et al 2000; Mittermeier et al, 2004). These hotspots embody approximately 44 percent of the world's plants and 35 percent of terrestrial vertebrates in an area that formerly enveloped only about 12 percent of the land surface of the planet. Due to human activities, the total range of these hotspots has been compressed by nearly 90 percent of its prototype size - meaning that this wealth of biodiversity is now restricted to only < 2 percent of Earth's land surface (Myers, et al 2000). Not surprisingly, studies have demonstrated that current human population densities and growth rates are higher on average in Biodiversity Hotspots than elsewhere (Cincotta, Wisnewki & Engelman, 2000; Williams, 2013), contributing to excessive rates of deforestation and species loss (Jha & Bawa, 2006).

Amidst the top five hotspots for endemic diversity, the Caribbean embodies only 11.3 percent of its primary vegetation, Madagascar 9.9 percent, Sundaland 7.8 percent and Brazil's Atlantic Forest 7.5 percent. When examined for its political boundaries, 17 megadiverse countries have been identified, which collectively provide refuge for the majority of the Earth's species (Mittermeier, Mittermeier & Gil, 1997).

Equally important is that fifteen of these megadiverse nations are developing countries positioned in the tropics. On top of that, much of the future population expansion will occur in biodiverse tropical regions. Presently the tropics contain about 40 percent of the global human population, but accommodate over half of all children under five. Within a 40 year period, it is anticipated that more than half the world's population will be in the tropics, containing over two-thirds of its young children, and adding 3 billion people by the end of the century (State of the Tropics, 2014).

The expanding footprint of the human enterprise is not only engendering the ruin and wreckage of habitat and biodiversity, but is also arousing effects in how animals move through fragmented and disturbed habitats (Tucker et al, 2018). The shrinkage of mammalian movements in areas of high Human Footprint Index [(urbanized environments, crop and pasture lands, elevated human population density, nighttime lights, roads and navigable waterways) (Vender et al, 2016)] emanates from two non-exclusive mechanisms (i) movement barriers such as habitat change and fragmentation (Kamler, Ballard, Fish, Lemons, Mote & Perchellet, 2002; Fahrig, 2007) and compressed movement requirements ascribable to enhanced resources [e.g., crops supplemental feeding, and water sources (Prange, Gehrt & Wiggers, 2004; Jones et al, 2014)]. The consequences of miniaturized vagility impinge on ecosystems, ergo, animal movements are essential for ecosystem functioning, on the grounds that they act as mobile links (Lundberg & Moberg, 2003) and mediate key processes such as seed dispersal, food web dynamics (including herbivory and predator-prey interactions), and metapopulation and disease dynamics (Bauer & Hoye, 2014). In due time, because of the critical role of animal movement in human/wildlife coexistence (Graham, Douglas-Hamilton, Adam & Lee, 2009) and disease dissemination (Hassel, Begon, Ward & Fèvre, 2017), the effects of reduced vagility may go beyond ecosystem functioning to directly affect human well-being (Tucker et al, 2018).

In an overview of the state of biodiversity, Peter Raven, Jonathan Chase, and J. Chris Pires (2011) write that:

> “Biodiversity is diminishing at a rate even faster than the last mass extinction at the end of the Cretaceous Period, sixty-five million years ago, with possibly two-thirds of existing terrestrial species likely to become extinct by the end of this century.”

These warnings from scientists all over the world are more than just theoretical. A precise and accurate illustration of this interspecies genocide has been properly documented in a Puerto Rican forest, where insects and other arthropods have dwindled by up to 99 percent over 4 decades (in this case the authors point to climatic changes but other studies in this work also encompass habitat destruction, insecticides and other human activities), with the implications perturbing any species that relied on them for food (Stokstad, 2018), according to a recent research published in *Proceedings of the National Academy of Sciences* under the ominous title *Climate-driven declines in arthropod abundance restructure a rainforest food web* (Lister & García, 2018). The paper found that as the biomass of insects and other arthropods lessened, anole lizard numbers fell by half and the Puerto Rican tody, a bird that eats only insects, contracted its populations by 90 percent between 1990 and 2015. The worst part detailed in the study is that all of these biodiversity recessions - that also lead to an abatement of ecological function as it is examined in this chapter – were found and studied in a national forest and protected area (Stokstad, 2018). As the researchers point out (in this case climate change) might be having a much wider and boundless effect than previously anticipated, which brings about one theme that is fairly explored in this chapter, that even protected areas aren’t safe anymore from the colossal and extensive consequences of *Homo sapiens*.

David Wagner, an expert in invertebrate conservation at the University of Connecticut who was not a part of the study reflected on its implications in an interview to *The Washington Post* (Guarino, 2018):

> “This study is a real wake-up call – a clarion call – that the phenomenon could be much, much bigger, and across many more ecosystems. This is one of the most disturbing articles I have ever read.”

If humanity is to desist from carrying out an interspecies genocide in the twenty-first century, we will have to make radical changes in how we live on Earth – including limiting how many of us inhabit it (Crist & Cafaro, 2012).

Ecosystem Services

"Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web he does to himself."

- Chief Seattle of the American Coast's Suquamish tribe (1786-1866)

"The wealth of the nation is its air, water, soil, forests, minerals, lakes, oceans, scenic beauty, habitats and biodiversity… that's all there is."

- Gaylord Nelson (1916-2005) Governor of Wisconsin, United States Senator and founder of Earth Day

Before delving further on the losses of defaunation and interspecies genocide produced by our ever-growing numbers, it might be useful to introduce the concept of ecosystem services - that might not be familiar to most readers outside of ecological circles - which comprise a cornerstone for the understanding of the relationship between humanity and the natural world, and will be paramount for this chapter and the rest of this work.

Ecosystems are defined by complex networks of interactions not only among and within species, but also between organisms and their abiotic and biotic surroundings. As Boeckh and Huckauf (2006) explicate:

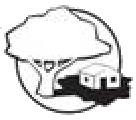
> "In the pursuit of life, organisms use energy, water, and nutrients; acquire, metabolize, and produce biomass; change the biological, chemical, and physical conditions of their environment. Such processes are essential components of any ecosystem as they contribute in one way or another to its maintenance. In turn, ecosystems provide numerous "goods" and "services" from which their members profit."

Humans are one fraction of ecosystems - alas one that has distressingly altered its 'equilibrium' - and we extract gains from them in various direct or indirect ways. These benefits are referred to as ecosystem services, whereby the term is often used in a broad sense, considering "goods", "services" and "cultural services" together. In this chapter and for the rest of the remaining work, when interpreting ecosystem services, the approach used is the one adopted by the Millennium Assessment, which is based on a functional classification scheme that encompasses four categories (Boeckh & Huckauf, 2006):

(All the following icons belong to TEEB – The Economics of Ecosystems and Biodiversity, 2012)

Regulating Services

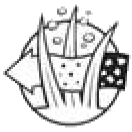
The ones that ecosystems supply by acting as regulators, for example correcting the quality of air and soil or by granting flooding and disease control. The seminal work *The Economics of Ecosystem and Biodiversity in Local and Regional Policy and Management* (Wittmer & Gundimeda, 2012) embodies and depicts what these services consist of:



Local climate and air quality: Trees produce shade while forests determine rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere.

Carbon sequestration and storage: Ecosystems balance the global climate by sequestering and locking away (for a finite period of time) greenhouse gases. As trees and plants mature, they withdraw carbon dioxide from the atmosphere and effectively concentrate it in their tissues. In this way, forest ecosystems are carbon depositories. Biodiversity also plays a crucial aspect by enhancing the capacity of ecosystems to adapt to the effects of climate change.

Moderation of extreme events: Extreme weather events or natural hazards are comprised by floods, storms, tsunamis, avalanches and landslides. Ecosystems and living organisms create safeguards against natural disasters, thereby preventing possible impairment. For example, wetlands can soak up flood water whilst trees can stabilize slopes, reducing the risk of landslides. Additionally, coral reefs and mangroves stimulate the safekeeping of coastlines from storm devastation.



Waste-water treatment: Ecosystems such as wetlands purify both human and animal waste and act as a natural buffer to the enclosing environment. Through the biological activity of microorganisms in the soil, most waste is broken down. With these natural processes, pathogens are eliminated, and the level of nutrients and pollution is abated.

Erosion prevention and maintenance of soil fertility: Soil erosion is a key consideration in the course of land degradation and desertification. Vegetation cover produces a vital regulating service by hampering soil erosion. Soil fertility is vital for plant growth and agriculture and well functioning ecosystems bestow the soil with nutrients required to support plant growth.

Pollination: Insects and wind pollinate plants and trees which is fundamental for the maturation of fruits, vegetables and seeds. Animal pollination is an ecosystem service mainly provided by insects but also by some birds and bats. Some 87 out of the 115 leading global food crops rely upon animal pollination, containing important cash crops such as cocoa and coffee (Klein et al, 2007).

Biological control: Ecosystems are paramount for controlling pests and vector-borne diseases that attack plants, animals and people. Ecosystems readjust pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural management.

Provisioning Services

The ones that describe the material or energy turnout from ecosystems. They embody food, water and other resources.

Food: Ecosystems favour the requirements for growing food. Food comes principally from managed agro-ecosystems but marine and freshwater systems or forests also contribute food for human consumption.

Raw materials: Ecosystems dispense great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly extracted from wild and cultivated plant species.

Freshwater: Ecosystems play a crucial function in the global hydrological cycle, as they improve the flow and purification of water. Vegetation and forests affect the quantity of water available locally.

Medicinal resources: Ecosystems and biodiversity provision many plants used as traditional medicines as well as stocking the necessary raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources.

Cultural Services

Constitute the nonmaterial assets people obtain from ecosystems through spiritual enrichment, reflection, recreation, aesthetic experience, art and wonder. Cultural services depend heavily on either direct or indirect human use of the service: An ecosystem provides cultural services only if there are people who attribute appraisal to the cultural heritage associated with it.

Recreation and mental and physical health: Walking and playing sports in green spaces is not only a good form of physical exercise but also lets people relax. The role that green space plays in maintaining mental and physical health is being progressively recognized, in spite of the arduousness of assessment.

Tourism: Ecosystems and biodiversity play an imperative role for many kinds of tourism which in turn yields appreciable economic benefits and is an integral source of income for many countries. In 2008 global earnings from tourism summed up to US$ 944 billion. Cultural and ecotourism can also cultivate the interest in people about the relevance of biological diversity.

Aesthetic appreciation and inspiration for culture, art and design: Language, knowledge and the natural environment have been closely intertwined throughout human history. Biodiversity, ecosystems and natural landscapes have been the provenience of exaltation and creativity for much of our art, culture and increasingly for science.

Spiritual experience and sense of place: In many parts of the world natural features such as specific forests, caves or mountains are contemplated and treated as sacred or have a religious meaning. Nature is a shared and prevalent element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging.

Ornamental resources: Plants- especially flowers – and animal products such as feathers and horns, furs, skins, and shells are used as ornaments. The value of these resources is often culturally affected.

Cultural heritage values: Societies place high importance on the preservation of either historically important landscapes (“cultural landscapes”) or culturally representative species that form the contextual underpinning of a culture.

Cultural and knowledge diversity: The diversity of ecosystems shapes the diversity of cultures. The ecosystems also work upon the types of knowledge developed by different cultures.

Educational values: Ecosystems and their elements and processes provide the basis for both formal and informal education in many societies.

Supporting Services

Mandatory for the manufacturing or the management of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their influence on humans are either indirect or occur over a very long time, whereas changes in the other categories have relatively direct short-term repercussions on people:

Habitats for species: They provide everything that an individual plant or animal needs to thrive and survive: food; water; and shelter. Each ecosystem sustains various habitats that can be indispensable for a species’ lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their vagility.

Maintenance of genetic diversity: Corresponds to the variety of genes between and within species populations. Genetic diversity discerns different breeds or races from each other thus maintaining the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock. Some habitats have a noteworthy and remarkable high number of species which makes them more genetically diverse than others and are known as 'biodiversity hotspots.'

Also among the supporting services are the following indirect services, in the way that they do not benefit humans directly:

- Soil formation. Humans do not directly manage this as a service, but variations in soil formation indirectly impinge on people through the impact on other services such as the provisioning service of food production.

- Nutrient cycling. This indirect supporting service is obligatory e. g. as the basis for crop production and plant growth.

- Biomass production. Primary production bestows and replenishes the basis of the food web for all higher consumers – herbivores as well as carnivores.

- Generation of atmospheric oxygen through photosynthesis is often asserted as a supporting service since oxygen forms the substratum for any animal life on Earth. Any impacts on the concentration of oxygen in the atmosphere would only occur over an extremely long time (Wittmer & Gundimeda, 2012). For a better understanding of how ecosystem services operate, figure 4.2 epitomizes their interconnectivity.

According to the Millennium Ecosystem Assessment (MEA, 2005):

> "Nearly two-thirds of the services provided by nature to humankind are found to be in decline worldwide. In effect, the benefits reaped from our engineering of the planet have been achieved by running down natural capital assets... Human activity is putting such strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted."

Many cultural ecosystems have languished and succumbed to atrophy due to demographic growth and external pressures of various kinds, requiring an immediate and profound program of restoration. Such a procedure normally includes the accompanying recovery of indigenous ecological management practices, in conjunction with support for the cultural survival of indigenous peoples and their languages as living libraries of traditional ecological knowledge (Society for Ecological Restoration International Science & Policy Working Group, 2004).

Figure 4.2: Ecosystem Services Diagram. Source: Bonnisseau, 2017

Modern societies inconsiderately displace, adulterate, defile, overharvest, and directly subvert natural ecosystems with little thought for their relevance in their own sustenance. Humanity has gone so far as to begin thwarting the gaseous content of the atmosphere and discombobulate global climates as well as the natural cycles of integral elements that predicate our food production systems (Ehrlich & Ehrlich, 2012). By the same token, humans not only have the most geographically wide-ranging and protracted of habitats but we also impose upon ecosystems more fiercely than any other species (Rees, 2006).

With introductions now in order, it is time to pore over the legacy of tempering that our ancestors brought into being. We now enter the realm of archaeology, paleontology, paleoecology and pre-history.

The Extinctionists

“There was a time when the countless tribes of men, though wide-dispersed, oppressed the surface of the deep-bosomed Earth.”

- Stasinos (776 - 580 BCE)

-

“The near stillness recalls what is forgotten, extinct angels.”

- Georg Trakl (1887-1914)

Earth’s history has been interspersed by mass extinction events, biotic crises that essentially altered biodiversity, biogeographic patterns (Erwin, 2001; Sahney & Benton, 2008) and transmogrified ecosystems (Button, Lloyd, Ezcurra & Butler, 2017). The fossil record has unveiled five mass extinctions episodes in the past, including the one 65 million years ago in which most of the dinosaurs were snuffed out (McKee, 2012). The end-Cretaceous major extinction event, as it became known, is perceived to have left about 50 percent of all species dead, whereas, comparatively, the end-Permian mass extinction around 250 million years ago, is rationalized to have disposed of roughly 96 percent of all life on the planet (Benton, 2015). The other ‘big five’ are suspected to have occurred at the End Ordovician, 444 million years ago, with 86 percent of species lost; Late Devonian, 375 million years ago, with 75 percent of species lost and the End Triassic, 200 million years ago with 80 percent of species lost (Barnosky et al, 2011)

Throughout our animation and continuance, humans and other hominins have poached other mammals (Yong, 2018a), first for meat, afterwards for pelts, trophies, trade, and more. Owing to this, it is estimated that since the last Ice Age, more than 300 species have been removed from existence, including mammoths, woolly rhinos, and thylacines (Yong, 2018b).

With such knowledge from the fossil record, extinction rates can be ascertained paleontologically. For example, in southern Africa, prior to 1.8 million years ago when the mammalian biodiversity deficit commenced, the extinction of four large mammals was occurring in intervals of roughly 100,000 years (McKee, 1995, 2001, 2003). In contrast, in the past 130,000 years (late Quaternary), the planet lost the bulk of its largest mammals, birds and reptiles outside of Africa (van der Kaars et al, 2017), and only in the past 10,000 years, southern Africa has seen the annihilation of at least sixteen mammal species, nine of which have been eliminated in historical times (Klein, 2000).

Diagnosing the drivers of the unplanned obsolescence of this megafauna (animals with average weights > 44 kg) prevails as a controversial and contentious subject (Barnosky, Koch, Feranec, Wing & Shabel, 2004), with climate fluctuations (Cooper et al, 2015; Wroe et al, 2013; Webb, 2008; Wroe & Field, 2006), human influence through hunting (Brook et al, 2007; Brook & Johnson 2005; Johnson, 2006) and/or habitat transformation (Miller et al, 2016; Miller et al, 1999), and/or a synergistic amalgamation of climate and human activity (Metcalf et al, 2016; Saltré et al, 2016; Miller et al, 2005) reigning as the more commonly and accepted causes (van der Kaars et al, 2017).

Notwithstanding the heated debate of the role of climatic changes or the predominance of mankind, nowhere is the argument more overwhelming than in Australia, where 85 percent of the continent’s large mammal species were phased out around 50,000 years ago (Miller et al, 2016; Miller et al, 1999; Gillespie, Brook & Baynes, 2006; Roberts et al, 2001), coinciding with the approximate date of the first evidence of human presence in the continent (Gillespie, Brook & Baynes, 2006; O'Connell & Allen, 2015).

The first intimation of atypical rates of megafaunal depletion appear in the Early Pleistocene in Africa around 1 Mya, where there was a conspicuous curtailment in African proboscidean (group of mammals that include elephants and their extinct relatives such as mammoths and mastodons) diversity (Todd, 2006) and the loss of various carnivore genealogies, including sabertooth cats (Lewis & Werdelin, 2007), which persevered to exist and bloom on other continents. Their extermination in Africa is feasibly interconnected to *Homo erectus* evolution into the carnivore niche space (Lewis & Werdelin, 2007; Werdelin & Lewis, 2013).

These proleptical megafauna abolishments were conservative in strength and speed – probably due to the coevolution that took place in Africa (Malhi et al, 2016) - when contrasted to all other continents and islands with the disembarkation of *H. sapiens*, with no comprehensive correlation with climatic variation (Sandom, Faurby, Sandel & Svenning, 2014; Surovell, Pelton, Anderson-Sprecher & Myers, 2016). This is why Africa, which is often associated as the "living Pleistocene," by virtue of the large mammals such as elephant and rhino that have endured into the present due to the gradual presence of our pre human ancestors, which slowly pierced into a hunting niche, so the likes of elephants, hippos and rhinos had more time to familiarize and readjust to the new predators. Elsewhere the advent of skilled human (and pre human) hunters had a more prompt and calamitous effect (McKee, 2012). In view of this human expansion, roughly 1 billion individual large animals were lapsed from the Earth's land surface (Smith, Lyons, Wagner & Elliott, 2015), as I shall begin to explore in this segment.

When the hypothesis emerged, that humans had induced the great American Pleistocene extinctions in the late 1960s, dissenters impugned that a few bands of Stone Age hunters couldn't possibly wipe out whole genera of large animals (Martin & Wright, 1968), even supposing, as paleoecologist John Alroy indicated (2001), the same mathematics of reproductive survival that probably foreordained the Neanderthals would have been even more detrimental to the slow-breeding big mammals that humans were butchering for dinner (Engelman, 2008).

In recent decades, a coincidental indication has robustly incriminated Paleolithic migrants to North America in the well-documented extinctions of mammalian megafauna (Kolankiewicz, 2012). Not long after their initial influx, overall mammalian diversity plunged at least 15-42 percent below the diversity baseline that had prevailed millions of years (Carrasco, Barnosky & Graham, 2009). More than half of large mammals faded an unequalled "cataclysmic extinction wave" at the close of the Pleistocene due to the direct effects of human predation, according to Alroy (2001). Alroy explains his reasoning to Elizabeth Kolbert, in her book *The Sixth Extinction - An Unnatural History* (2014):

> "A very large mammal is living on the edge with respect to its reproductive rate. The gestation period of an elephant, for example, is twenty-two months. Elephants don't have twins, and they don't start to reproduce until they're in their teens. So these are big, big constraints on how fast they can reproduce, even if everything is going really well. And the reason they are able to exist at all is that when animals get to a certain size they escape from predation. They're no longer vulnerable to being attacked. It's a terrible strategy on the reproductive side, but it's a great advantage on the predator-avoidance side. **And that advantage completely disappears when people show up.** [...] the megafauna weren't doing anything wrong; it's just that when humans appeared, the rules of the survival game changed." (Bold added)

Resorting to computer simulations to test the extinction of mammalian megafauna, Kolbert describes what Alroy came to discover:

> "When Alroy ran the simulations for North America, he found that even a very small initial population of humans - a hundred or so individuals - could, over the course of a millennium or two, multiply sufficiently to account for pretty much all of the extinctions in the record. This was the case even when the people were assumed to be only fair-to-middling hunters. All they had to do was pick off a mammoth or a giant ground sloth every so often when the opportunity arose, and keep this up for several centuries. This would have been enough to drive the populations of slow-reproducing species first into decline and then, eventually, all the way down to zero."

The Americas had formerly been full of big mammals. About 15,000 years ago, the American West resembled much as Africa's Serengeti Plains do today, with herds of elephants and horses chased by lions and cheetahs, and blended with members of exotic species such as camels and giant ground sloths. In the Americas most of those large mammals became extinct. Whereas the dying out took place in Australia, roughly 30000 years ago, they befell around 17,000 to 12,000 years ago in the Americas (Diamond, 1997). For generations, the towering mammals had seen through epochal climatic shifts, vast glacial and interglacial cycles that vacuumed away entire biomes. These deviations rivalled those of the late Pleistocene, but this time the titanic beasts could not withstand the spears, strategies, and supreme tenacity of this astute new predator (Kolankiewicz, 2012).

Conceivably, the two most meticulously dated extinctions are those of the Shasta ground sloth and Harrington's mountain goat in the Grand Canyon area. The two populations disappeared within a century or two of 11,100 BCE. Whether coincidentally or not, the date is indistinguishable to the date of Clovis hunter's arrival in the Grand Canyon area (Diamond, 1997).

Writing about the highly populated areas of North, Meso and South Americas, writer Ran Prieur (2012) chronicles in the journal *Dark Mountain* how the presence of human populations have had repercussions down the line:

> "The incredible biological abundance of North America was also a post-crash phenomenon. We've heard about the flocks of passenger pigeons darkening the sky for days, the tens of millions of bison trampling the great plains, the rivers so thick with spawning salmon that you could barely row a boat, the seashores teeming with life, the deep forests on which a squirrel could go from the Atlantic to the Mississippi without touching the ground. We don't know what North America would have looked like with no humans at all, but we do know it didn't look like that under the 'Indians'. Bone excavations show that passenger pigeons were not even common in the 1400s. 'Indians' specifically targeted pregnant deer and wild turkeys before they laid eggs, to eliminate competition for maize and tree nuts. They routinely burned forests to keep them convenient for human use. And they kept salmon and shellfish populations down by eating them, and thereby suppressed populations of other creatures that ate them. When human populations crashed, nonhuman populations exploded."

The pioneers who first entered new lands, conceivably low-status exiles from groups experiencing too-rapid population growth, were presumably not numerous themselves (Engelman, 2008). A genetic study advances that the colonizing population of the Americas was expressed by no more than seventy reproducing adults, whom, as long as 14,000 years ago, abandoned a community of about nine thousand people from Asia (Hey, 2005). Nevertheless, hunting groups could expand rapidly once they encountered a food source that had never felt the sting of human predation (Engelman, 2008).

Large-bodied species, with long generation cycles and slow breeding rates, were notably nonresistant to even steady sustained increases in predation pressure (Zuo, Smith & Charnov, 2013; Brook & Johnson, 2006; Johnson, 2006). It has been gauged that low-intensity hunting (such as the killing of just one juvenile per person per decade) could culminate in a species being obliterated over a few hundred years (Brook & Johnson, 2006).

In addition, the accompanying domestic dogs may have collided with endemic carnivores for food supplies (Pardi & Smith, 2015), and some domesticates may have imported diseases (Malhi et al, 2016). Furthermore, these ancestors of ours had to compete for the same fruits and berries as did, for example, the baboons and other monkeys. They were undoubtedly consuming the meat that other scavengers required, and it is not impractical to theorize that they may have consumed some meat that other predators craved for. Besides, *Homo erectus* did not require to have killed a single animal in order to lead to the extinction of others. They just had to get a hold of the resources first. If they were good enough at food procurement, other species would go hungry and writhe (McKey, 2005).

In Europe, *Neanderthals* lived in glacial times and were suited to the cold. They encroached no farther north than northern Germany and Kiev. They were deficient of tools and wisdom such as needles, sewn clothing, warm houses, and other technology essential for the survival that anatomically modern humans had. They (*H. sapiens*) were able to infiltrate into Siberia by around 20,000 years ago which might be accountable for Eurasia's woolly mammoth and woolly rhinoceros annihilation (Diamond, 1997).

Three species of rhinoceros - the woolly, the Merck's and the narrow-nosed - inhabited Europe at the same time as humans did. Until roughly 40,000 years ago, Russia was frequented by two gargantuan beasts, *Elasmotherium sibiricum* and *Elasmotherium caucasicum.* These were humpbacked rhinos the size of elephants. In like manner, hippopotamus, giant deer and giant aurochs, as well as lions were found in excavations as far as the UK (Stuart, 2001; Franks, 1959). These lions survived in Britain, by hunting reindeer across a frozen Europe (Bocherens et al, 2011), until 11,000 years ago (Yalden, 1999): which marked the beginning of the Mesolithic, when humans reappeared on those lands after a long absence (Monbiot, 2014).

Spotted hyenas (still thrive in Africa) survived in Europe until practically the same time (Stiner, 2004). Scimitar cats (*Homotherium* species), lion-shaped with great curved fangs, prowled perhaps entirely on young elephants and rhinos (Monbiot, 2014). Finally, until around 40,000 years ago, the straight-tusked elephant (*Elephas antiquus*), closely related to the Asian elephant, roamed across much of Europe (Mol, de Vos & van der Plicht, 2007).

These species - elephants, rhinos and the cats that preyed upon them - are likely to have reigned over the ecosystems during the previous interglacial period, which came to a close at around 115,000 years ago. Across the past 50,000, the range and diversity of these species have shrunk as humans have hunted them. Moreover, in case of the elephants, the extermination took place first in Europe, then in the Americas, Middle East and North Africa, and eventually in most of Asia and Africa (Monbiot, 2014).

In Eurasia, climate change undoubtedly had a relentless effect on populations of Irish elk, an animal with twelve-foot-wide antlers, as well as other identical large mammals. But there, as elsewhere, it was most likely members of *Homo sapiens* who in every case administered the killing blow, as they probably had done to the *Neanderthals*. They did this in diverse ways, but the common trait was presumably, that their propagation across the landscape made survival irrealizable for genera that had managed to endure strenuous times and hardship rations during several deviations in climate prior to the times modern humans settled on the scene (Barnosky, Koch, Feranec, Wing & Shabel, 2004; Stuart, Kosintsev, Higham & Lister, 2004).

Hunting by humans might have transfigured the environment of Australia. Before humanity came ashore on that continent, it pullulated with behemothian creatures. Among them was a spiny anteater the size of a pig; a giant herbivore resembling a wombat, which weighed two tons; a marsupial tapir the size of a horse; a ten-foot kangaroo; a marsupial lion with opposable thumbs and a stronger bite than any other known mammal; a horned tortoise eight feet long; a monitor lizard substantially more massive than the Nile crocodile. Most of these species, alongside many other wondrous and singular beasts, perished between 40,000 and 50,000 years ago. At roughly the same time, the dense rainforests which enveloped much of that continent began to be superseded by the grass and scrubby trees which populate it today (Monbiot, 2014).

The dispute relative to the Pleistocene extinctions in North and South America also has erupted in Australia. Were these fluctuations precipitated by natural climate change or by humans? With the mounting evidence pinpointing to humans, the question shifts to whether the extinction of the giant animals was the result of hunting or the wreckage of their habitats (Monbiot, 2014). Research published in *Science* strongly implies that humans hunted the large animals to obsolescence and that the evanescence of the large animals then led to the ruination of the rainforests (Rule et al, 2012).

By resorting to the analysis of the pollen and charcoal in cores taken from an ancient lake bed, and testing the fungus that thrives on the dung of large herbivores, in order to determine their abundance, Susan Rule and colleagues (2012) showed that the shift from rainforest to dry forest transpired some 10,000 years before the climate dried out. Henceforth, both the mass extinction and the revolution in habitat took effect while the climate was perdurable. They also divulge that fire began raging through the rainforests around a century after the large mammal populations fell apart, and that grass and scrub took over the forests two or three centuries later. When the cyclopean herbivores disappeared, they propound, the twigs and leaves that would otherwise have been browsed began to build upon the forest floor, begetting a fuel supply that allowed wildfires to deface the rainforests and catalyse the shift to grass and scrub (Monbiot, 2014).

A comparable depletion of giant marsupials, tortoises, and flightless birds has been documented in Australia after mankind barged in there, tens of thousands of years preceding the passage to the Americas. In recent past, only 800 to 2000 years ago, comparable extinction waves withered away giant birds and other large animal species in the islands of the Indian and Pacific oceans proximately to when humans first stepped ashore (Stolzenburg, 1994 cited in Engelman, 2008). Humans are the only coherent and legitimate perpetrators in the Australian extinctions, as no significant climate changes were transpiring at the time (Miller et al, 2005).

In Madagascar, carbon-14 dating has attested that twelve species of lemurs, a dwarf hippopotamus, and the half-ton elephant bird disappeared not long after humans disembarked from Indonesia (small hippopotamus must have been favoured meals for early humans) (Stolzenburg, 1994 quoted in Engelman, 2008).

A “pygmy hippopotamus” dematerialized from Cyprus in about 8000 BCE, around the time humans entered the island). In New Zealand, first settled just 800 years ago, a giant moa more than nine feet in height and twenty-six other species of flightless birds perished in a matter of a few centuries (New York Times, 1988).

The dodo of Mauritius has essentially become a symbol of extinction. It is recognized that human colonization of oceanic islands led to a dying out outburst that included the giant lemurs of Madagascar and the big flightless geese of Hawaii. Just as modern humans walked up to undaunted dodos and island seals and executed them, prehistoric humans presumably walked up to unafraid moas and giant lemurs and massacred them too (Diamond, 1997).

Human hunters might have enforced an analogous change in the great steppes of Beringia, the landmass incorporating eastern Siberia, Alaska and the area in between (now covered by the Bering Straits, but unveiled during the last Ice Age). Around 15,000 years back, hunters using small stone blades moved into the region that had previously been occupied by people hunting with sharpened bones or antlers (Zimov et al, 1995). Steadily, they decimated the mammoths, musk oxen, bison and horses that grazed the steppes. Mammoths might have been made more susceptible to extinction through hunting by the simultaneous diminution of their habitat. One paper advances that a 90 percent reduction in their geographical range took place between 42,000 and 6,000 ago (Nogués-Bravo et al, 2008).

Figure 4.3 illustrates the shortfall in current megafaunal diversity in comparison with what would be anticipated if Late Pleistocene species had continued to live to the present (Faurby & Svenning, 2015). This perdition has been most dramatic in the megaherbivores and megacarnivores.

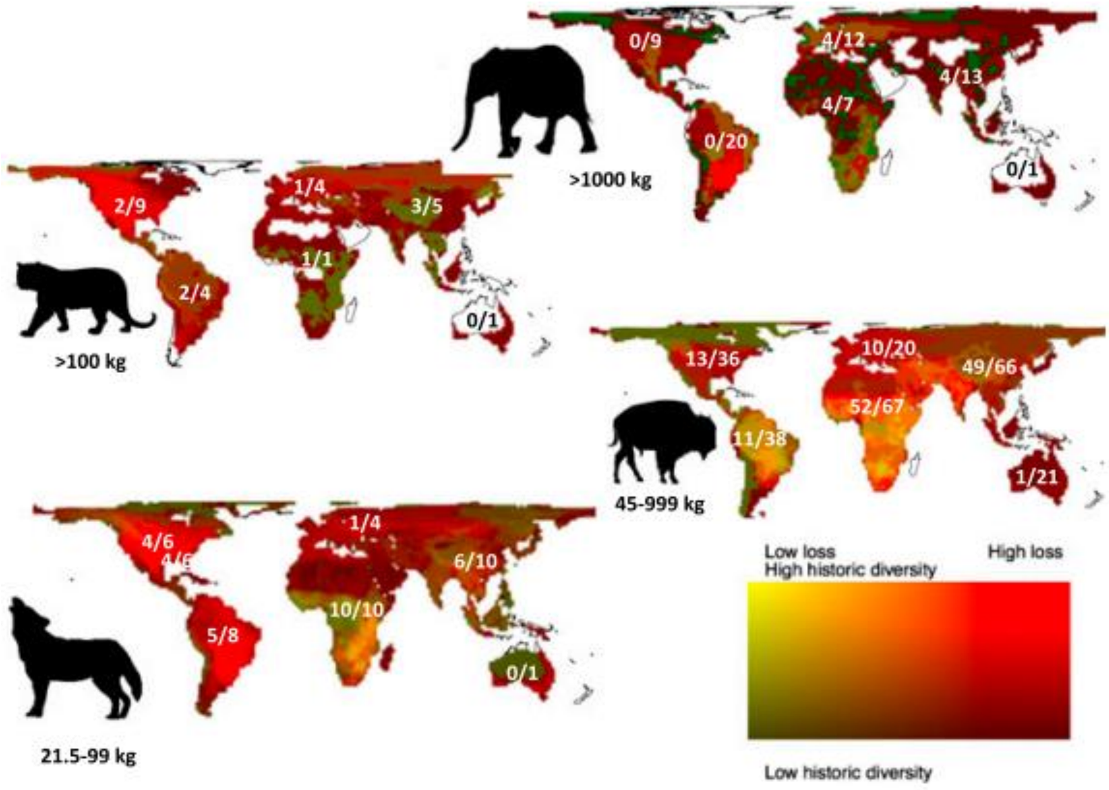


Figure 4.3: Extant and lost megafauna, divided by continent and into megaherbivores (≥1,000 kg), megacarnivores (≥100 kg), large herbivores (45–999 kg), and large carnivores (21.5–999 kg). Carnivores prey on the guilds below them, and to some extent on juveniles of herbivores above them. Megacarnivores can also limit the activity and abundance of the next-size class of carnivores (21.5–99 kg) by excluding them from prime habitat or killing them outright In each continent. The first number indicates the number of species remaining (often in greatly reduced abundance and restricted range), and the second number indicates how many would have existed in a Late Pleistocene baseline. Data from Faurby & Svenning, 2015. Background colors indicate prehistoric diversity and relative loss rate in each guild. Yellow/light green shows areas of high intrinsic megafaunal diversity and low loss (e.g., large herbivores in Africa), dark green indicates low historic diversity and low loss (e.g., large herbivores in high latitude North America), red indicates high diversity and high loss (e.g., Americas), and dark brown indicates low diversity and high loss (e.g., high latitude Eurasia). Retrieved from Malhi et al, 2016.

The Late Pleistocene maintained at least 50 species of terrestrial megaherbivores (≥ 1,000 kg) in mammal orders counting *Proboscidea* (elephants and relatives: 16 species), *Cetartiodactyla* (camels, bovids, hippopotamus: 7 species), *Perissodactyla* (rhinoceros: 9 species), and, specific to the Americas, *Cingula* (glyptodonts: 5 species), *Pilosa* (giant sloths: 8 species), *Notoungulata* (toxodonts: 3 species), and *Litopterna* (1 species), and, in Australia, *Diprotodontia* (1 species) (Malhi et al, 2016).

Of these 50 megaherbivore species, only 9 prevail worldwide: 3 elephants (African bush and forest elephants and Asian elephants), 5 rhinoceros, and the hippopotamus, with all of these survivors critically contracted in range. Of the lapsed species, 10 were bulkier than the largest remaining species, the African bush elephant, including 8 proboscideans. This calamity regarding mega herbivores was most violent in the Americas, with all 29 megaherbivore species perished (Malhi et al, 2016).

The loss of megacarnivores (≥ 100 kg) has been equally excessive. Globally, the Late Pleistocene housed 15 species of mammal mega carnivores (9 big cats, 5 bears, and the Australian "marsupial lion," *Thylacoleo carnifex*). Of these megacarnivores only 6 species linger in our present day. North America alone accommodated 9 species, where none reside today. Major Pleistocene mega-carnivores encompassed several massive sabertooths (200-300 kg), large relatives of the surviving lion (*Panthera atrox*, in North America; *Panthera spelaea*, in Eurasia and Beringia), and the bear (*Arctodus simus*), in North America. Striking casualties are also present among large herbivores (44-999 kg), especially in North America (23/36 species missing), South America (27/38), and Australia (20/21). Almost identically, the defeat of large carnivores (21.5-99 kg) has been considerable but less dramatic. This milder extinction might be possibly connected to the disappearance of mega carnivores, which competed for the similar food sources (Malhi et al, 2016).

Overhunting is a coherent suspect in all these biological recessions, and some scholars have long denoted climate change as a likely culprit in species extinctions. Almost every other likely transgressor, however can be traced to our own migrations and colonization. Infectious diseases spread by people or their domestic animals may have contributed to the destabilization of ecosystems that were unfamiliar with *Homo sapiens*, their microbiological passengers and their domestics, which became species killers (Engelman, 2008).

Habitat change almost assuredly was another reason, as it is today. Early Australians burned vegetation across the continent to attract animals to the tender green shoots that grew out of the ashes. This "firestick farming," as anthropologist Rhys Jones calls it, reduced the continent's rainfall and consequently, its greenery by as much as half. The biodiversity that relied on the prehuman immutable specific ecosystems, were soon wiped out (Jones is cited in Tudge, 1999; Cowan, 1998).

A study published in the *Proceedings of The Royal Society B* by Sandom and colleagues (2014) analysed the evidence related to the extinction of large animals during the course of the last 100,000 years and the conclusion as the authors claim, was the following:

> "The global pattern of late Quaternary megafauna's extinction presents a clear picture that extinction is closely tied to the geography of human evolution and expansion and at most weakly to the severity of climate change."

Søren Faurby, Postdoctoral Fellow at Aarhus University and co-author of the study asserts (Siem, 2014):

> "Our results strongly underline the fact that human expansion throughout the world has meant an enormous loss of large animals."

Correspondingly, a study published in *Science* (Smith, Smith, Lyons & Payne, 2018) has determined that whenever humans are found around mammals, the ones that end up perishing tend to be 100 to 1000 times more massive than those that subsist. Although this isn't entirely new science, since these trends have been settled in Australia and the Americas, this article from *Science* presents this pattern has a global phenomenon, with the exclusion of Antarctica, and throughout at least the previous 125,000 years (Yong, 2018a). Felisa Smith, author of the research says:

> "Size-selective extinction is a hallmark of human activity. In other words, when we're around, big animals die."

As demonstrated throughout this segment the debate between human responsibility and external causes is an enduring contest. Still, as Kaitlin Maguire from the Orma J. Smith Museum of Natural History defines when commenting on this reseach published in *Science* (Smith et al, 2018):

> "While it's thought that the megafaunal extinctions were a result of a one-two punch from shifting climate and human influences, this work demonstrates that the human punch was *strong* (Yong, 2018a)."

Finally, a point often overlooked is the fall of keystone large herbivores, which may have set in motion cascades of extinctions through subsequent vegetation change, inconstant fire regimes, and the shrinkage of a prey base for mega carnivores (Guthrie, 1984; Koch & Barnosky, 2006) (in the next segment, there will be a more in-depth analysis of the ecological repercussions of the deprivation of keystone megafauna and predators).

Indeed, humanity's past actions have had far more calamitous implications than previously asserted. One study (Davis, Faurby & Svenning, 2018) that corroborates this dire view has adopted a different methodology than simply focusing on animal extinctions (it is also a mistake to solely do so) (Yong, 2017), instead the authors concentrate on the *evolutionary history* they embody. The metric, which is known as phylogenetic diversity, is critical because not all species are equal. Some are notably exceptional and irretrievable. To this effect, the science journalist and author Ed Yong provides an excellent example of this dissimilarity (Yong, 2018b):

> "The pygmy sloth, for example, may be one of the most threatened mammal species, but it's also one of the youngest, having diverged from its closest relative 9,000 years ago. The aardvark, by contrast, is the last survivor of a once-large group of mammals that split off from the others *75 million* years ago. Losing the pygmy sloth would be like snapping off a tiny twig from the mammalian family tree; losing the aardvark would be like sawing down an entire branch."

To pinpoint the extent of the cuts made by humanity in the mammalian 'tree,' the authors built a family tree for all mammals past and present, dating back 130,000 years, into the late Pleistocene. By enumerating the aggregate of all absent twigs and branches, they gauged that our prehistoric ancestors siphoned mammals of 2 billion years of unique evolutionary history. As we shall see in the upcoming segment Anthropocene, this devastation has percolated into our modern day age, with the authors denoting that since the 16th century, we've eradicated out a supplementary 500 million years of evolutionary history, not to mention a further 1.8 billion years within the upcoming five decades (Yong, 2018b).

The bottom line from this segment is that we humans can expunge wildlife even at relatively low levels of population size, affluence, and technological power if good stewardship is not a precedence. Given enough time, our primordial ascendants were apparently capable of creating mayhem on biodiversity even before the advent of agriculture. They were in pursuance of instantaneous survival imperatives rather than stewardship and sustainability, doing what comes naturally to any organism (Kolankiewicz, 2012).

Recognizing and grasping the repercussions of past extinctions is beneficial for a number of reasons, in particular, as a result of the loss of megafauna, it may have set up a not so well-acknowledged legacy of dysfunctioning on the contemporary biosphere, owning to the fact that much of our awareness of ecosystem ecology and biogeochemistry has been developed in a world artificially vacant of those behemotian creatures (Malhi et al, 2016).

Only recently has work begun to address the environmental consequences due to humanity's intervention on the dramatic metastasis from a megafaunal to a non megafaunal world, on Earth's ecology, as manifested through vegetation cover (Johnson, 2009), plant interactions (Guimarães, Galetti & Jordano, 2008), ecosystem structure (Johnson, 2009; Bakker et al, 2016), trophic interactions (Estes et al, 2011), fire regimes (Rule et al, 2012), biogeochemical cycling (Doughty, Wolf & Malhi, 2013), and climate (Doughty, Wolf & Field, 2010; Smith, Elliott & Lyons, 2010).

As we move forward through the *Atlas*, please keep in mind how even small numbers of humans and proto-humans, with the primordials of what we describe as technology and tools today, were able to decimate entire populations and species of the planet. As these words are put in paper, most of the human growth is occurring in the most biodiverse regions of the Earth, and even though a considerable part of this mass of humanity lives in conditions that people in the developed world are attempting to eradicate, poverty is not a synonym of benign ecological damage. Even poor and destitute individuals have considerable local and regional impacts on the carrying capacity of habitats, for example by burning forests and transforming them into agricultural fields, taking down large swaths of forest to use charcoal for wood and fuel as well, hunting down species for bushmeat consumption, in addition to waste accumulation. When multiplying these effects by millions of individuals a pattern of ecological ruin emerges. Note that I'm not excusing the ecological impacts of the developed world that depend on the resources of the developing world to sustain their over-consumptive behaviours, I'm just trying to lift the veil of the dominant environmental narrative that poor and underprivileged people have negligible impacts on the environment. It isn't true, and the massive growth of population in these countries is only going to spell disaster for the remaining sanctuaries of wildlife.

Given these points, comprehending how previous extinctions affected the function and structure of ecosystems for the past thousands of years of human history, can also help to interpret the impacts of the extinctions that are currently underway, and that is what we shall explore on the next segment.

Key Impacts of Megafauna and Predators Loss

"I'm truly sorry Man's dominion
Has broken Nature's social union,
An' justifies that ill opinion,
Which makes thee startle
At me, thy poor, earth-born companion,
An' fellow mortal!"

- Robert Burns
To a Mouse (1785)

"In conquering the fearsome beasts, the conquerors had unwittingly orphaned themselves."

- William Stolzenburg, *in Where the Wild Things Were: Life, Death, and Ecological Wreckage in a Land of Vanishing Predators* (2008)

At the end of the previous segment, I mentioned how phylogenetic diversity might be a proper way to catalog the full depletion of life. But it isn't the only way. In this segment we look into *functional diversity*, which concentrates on what animals *do* in their environment (Yong, 2018b). Wallace was perhaps the first to recognize that megafauna was ubiquitous in near prehistory and that, not just their presence exerted an influence on their environment, but the void left by their absence was creating repercussions in his time (Wallace, 1876).

Correspondingly, it has become ever more conspicuous and palpable that the genocide of the earth's apex predators - the lions and wolves of the land, the great sharks and big fish of the sea, all so savagely and fiercely repudiated as humanity's global swarming expanded - had set in motion a cascade of ecological after effects. Where the predators no longer prowled and roam, their prey had run amok, assembling at abnormal densities, crowding out competing species, denuding landscapes and seascapes as they went (Stolzenburg, 2016).

The most instantaneous and direct environmental effect of terrestrial megafauna deficiency is on the **physical structure of ecosystems**. Bakker et al. (2016) assert that megafaunal browsers, and *proboscideans* in particular, are shapers of habitat structure by ravaging vegetation, through either their elevated scale of consumption or through breakage and trampling, and also by reducing productivity through damage to plants.

Equally important, they can reshape the competitive equilibrium between herbaceous and woody vegetation, by having negative ramifications on juvenile woody plants through trampling and feeding, together with beneficial side effects on woody vegetation through augmented nutrient cycling, extenuated competition with herbaceous vegetation, and a conspicuous shrinkage of rodent density and fire frequency (Keesing & Young, 2014). In like manner, hippopotamuses and other large semi-aquatic herbivores can also have a vigorous outgrowth on aquatic vascular plant ecosystems (Bakker, Pagès, Arthur & Alcoverro, 2015).

In many ecosystems, megaherbivores act apace with, or in competition with, an abiotic "herbivore," fire (Bond & Keeley, 2005). Depending on the amount of rainfall and ecosystem productivity, three possible ecosystem states can occur: a “green world” of tree cover dictated by a bottom-up resource circumscription (water or nutrients), and two consumer-regulated states, “a black world” governed by fire dynamics and a “brown world” structured by herbivores (Bond & Keeley, 2005).

The density of megaherbivores (and of carnivores restraining them) and the comparative abundance of grazers and browsers (especially proboscideans) intervene in the transmutation between these alternative states (Malhi et al, 2016). The loss of megafauna surges through the trophic structure of terrestrial ecosystems, reorganizing plant communities from top-down to bottom-up-regulation (Terborgh, 2009). In barren systems, or where human activity has remarkably heightened fire ignition frequency, the loss of grazers can elevate grass fuel loads and induce a shift to a fire-dominated ecosystem (brown-to-black transition). In more damp and moist systems, loss of browsing and grazing can lead to closed canopy forests (a brown-to-green transition) (Malhi et al, 2016).

As examined in this chapter, corroboration from brown-black transitions comes from periods of megafaunal decline in Australia (± 40-50 kya) and North American (± 12 kya). At Lynch’s Crater in northeast Australia, an abatement in megafauna around 40-42 kya, concurring with human influx but not with any unconventional climate variation, was supplanted by an abrupt increase in fire incidence, and an alteration of the predominant vegetation type from an assorted open woodland to a more homogeneous, dense forest overshadowed by fire-adapted trees that are more able to cope with hot and dry conditions (Rule et al, 2012; Johnson et al, 2015).

In eastern North America, megafaunal degeneracy directly anteceded and presumably provoked an enhanced fire regime and the substitution of open and patchy woodlands by forest (Gil, Williams, Jackson, Lininger & Robinson, 2009; Gil, Williams, Jackson, Donnelly & Schellinger, 2012; Robinson, Burney & Burney, 2005). In southwest Madagascar, the drop in large herbivores around 1,700 y ago was also succeeded by a heightened fire regime (Burney, Robinson & Burney, 2003).

Confirmation of brown-green conversion comes from Europe, which accommodated a selection of megaherbivores, among others the straight-tusked elephant (*Elephas antiquus*). During former interglacials, northwest European wooded landscapes resembled heterogeneous woodlands containing both densely tree-covered parts and extents with an open part-like arrangement (Svenning, 2002). In the post megafaunal early Holocene, much more of the landscape was shielded by relatively dense tree cover (Vera, 2000).

Modern tree cover in savanna territories is greater in South America relative to Africa, an asymmetry feasibly interpreted by an outright privation of megaherbivores in South America (Doughty, Faurby & Svenning, 2016). Even in closed-canopy forests, megafauna may create an imprint on forest structure and dynamics. Comparatively, in the rainforests of Gabon, Terborgh and colleagues (Terborgh et al, 2016a; Terborgh et al, 2016b) note the near omission of small trees in forests with high densities of forest elephant. This feature implies the existence of an “elephant trap” that wields a substantial constraint on the composition of the adult tree community. By way of dieting below-ground competition for nutrients, this trap may modify forest carbon dynamics, possibly broadening the longevity of mature forest trees, culminating in higher forest biomass in elephant-rich forests (Poulsen et al, 2018).

Another zone of megafaunal control of ecosystem state may be present in high northern latitudes (northern Eurasia and Beringia), that once welcomed a high biomass of megafauna, including mammoths, horses, and bison (Zimov, Zimov, Tikhonov & Chapin, 2012). Zimov and colleagues (1995) volunteered the interpretation that heavy grazing perpetuated those steppes by trampling woody growth, stimulating production by deep-rooted, grazing-resistant grasses, and stimulating nutrient cycling in this cold climate through consumption and egestion. These grasses, consecutively reinforced transpiration rates and summer warming, inflaming a drying out of upper soil layers and circumvention of waterlogging. Mammoth steppes seem to have persevered in previous interglacials but vanished in the Holocene, replaced by waterlogged landscape of unpleasantly low-diversity wet mossy tundra, shrub tundra, and forest.

The **ecosystem trophic structure** is also shaped, with large herbivores and carnivores both epitomizing a crucial function in sculpting the abundance and composition of the whole animal community (Malhi et al, 2016).

Large herbivores enforce an action in their habitats as it was described above, but they can also restrain smaller herbivore species through competition. As previously mentioned, top of the chain carnivores put in check a plethora of smaller herbivores and mesopredators by controlling their densities and actions. The mesopredators are mainly omnivores, an in the absence of large predators they strengthen in number rapidly, and through their capacity to ravage both plant and animal matter, this turns them into superpredators for smaller prey such as songbirds, reptiles, amphibians, and small mammals (Malhi et al, 2016).

Another crucial aspect connected to megafauna and top predators is what became known as the “landscape of fear,” which can be described as areas with high predation risk, which herbivores for example tend to avoid. The most well-known case took place in the Yellowstone National Park, when wolves were reintroduced after they were excised from the park in the beginning of the previous century by a national movement to eradicate predators such as the wolf, bear, mountain lions among others; and it became apparent that they were protecting the aspen trees by impeding passage of the hordes of elk (*Cervus elaphus)* that were ravaging the landscape by overgrazing it, and at the same time reducing erosion and increasing river sediment content.

William Stolzenburg describes it best in his seminal book *Where the Wild Things Were: Life, Death, and Ecological Wreckage in a Land of Vanishing Predators* (2008):

> “Aspen were dying not from any apparent lack of fire or rain but from a preponderance of elk, by way of too few wolves. In the wolves’ absence, elk had begun eating nearly every unprotected shoot in the park. [...] for elk in a neighbourhood patrolled full time by wolves, every minute lounging in the river bottom involved a gamble of lethal stakes.”

Stolzenburg supplements:

> “Ecologists and evolutionists since Darwin have recognized predation as one of the fundamental drivers of the diversity of life, a reaper of the weak.”

Writing for *The Atlantic* (2018c), Ed Yong, the author of *I Contain Multitudes*: *The Microbes Within Us and a Grander View of Life* (2016) expands on how *Humans Have Unleashed a 'Landscape of Fear'*:

> "The more humans have flourished, the biggest animals have not. We have always hunted large mammals, downsizing the fauna of whatever continent we happen to visit. Mammoths, woolly rhinos, ground sloths - all gone. In slaying these giants, we remade the world [...] Predators instil fear in their prey. Even without actually killing anything, their mere presence creates a state of simmering stress and unease [...] Open areas, with long lines of sight and plentiful paths down which to flee, offer safety. Overgrown areas, with obscuring foliage and tripping obstacles, are dangerous [...] scared prey spend more time in safe zones and less time in risky ones, which in turn affects where plants get eaten, and where nutrient-rich dung gets dropped."

This was demonstrated by Elizabeth le Roux and colleagues in a recent paper published in the journal *Current Biology* (Le Roux, Kerley & Cromsigt, 2018) in which the team set out to chop down the cover in eight selected plots in South Africa's Hluhluwe-iMfolozi Park and leave eight control locations untouched. They set up motion-triggered camera traps and waited for two years, to observe what kind of fauna would colonize the plots. Like clockwork, the team detected that medium-sized plant eaters, like wildebeests, zebras, impalas, and warthogs tended to amass in these newly cleared areas, foraging more in these slightly more safe areas, and depositing as much as three times more excrements than in wooded regions. Uniquely, these animals act as living conveyor belts, transferring nutrients far from dense areas towards open ones (Yong, 2018c).

On the other hand, herbivore megafauna like elephants and rhinos behave in a different manner. As adults, they are basically predator-proof, due to their elephantine size and bulky hides. Since they emerge unscathed from the landscape of fear, they eat and secrete wherever they please. For instance, rhinos are prone to defecate in wooded zones, thereby supplying nutrients in the opposite direction than the smaller plant-eaters.

Commenting on Le Roux's and team study, Liana Zanette from the University of Western Ontario, who has widely studied landscapes of fear mentions (Yong, 2018c):

> "The fearlessness of the larger animals stops the fear of the smaller ones from altering the land."

Taking into account that rhino poaching in South Africa, for example, has surged over the last decade, with more than a thousand animals killed in each of the last five years (Bale, 2018), one has to wonder, as the megafauna dwindles and evanesces from these territories, chances are the region will tend to be transformed from wooded areas to more patchwork habitats, dominated by medium-sized herbivory. Coupled with this, nutrients will assemble in specific areas and become impoverished in others, with reverberations that echo through local plants and animals. A world devoid of megaherbivores, will be a world shaped more by fear than fearlessness. Additionally, humans have also obliterated many of the predators that instilled fear upon the landscape, and replaced them with a super-predator that is almost ubiquitous in its range and which inspires fear in the predators that are left, such as badgers (more afraid of human voices than bears or wolves) (Clinchy et al, 2016; Lunau, 2016) or mountain lions and other large carnivores (that alter their feeding behaviours due to human presence, fleeing when they hear voices) (Smith et al, 2017; McNulty, 2017), which ultimately leads to alterations in hunting and the landscape of fear itself - since the predators are too afraid to come out, herbivores tend to dominate (Yong, 2018c).

One other aspect of the ascendancy of human jurisdiction upon the landscape of fear reflects itself in how mammals are turning to nightlife to avoid people. A recent study published in the journal *Science* (Gaynor, Hojnowski, Carter & Brashares, 2018) states:

> "As the human population grows, there are fewer places for animals to live out their lives independently of our influence. Given our mostly diurnal tendencies, one domain that remains less affected by humans is the night [...] as the global human footprint expands, temporal avoidance of humans may facilitate human-wildlife coexistence. However, such responses can result in marked shifts away from natural patterns of activity, with consequences for fitness, population persistence, community interactions, and evolution."

The *Science* study reviewed 76 other papers of 62 mammal species from six continents and established that "human disturbances" - settlement, hunting, and areas with roads or even just recreational activity - have augmented nighttime activity for these animals by more than one-third. In detail, the study clarified how antelope in Tanzania were deviating from their activity to nighttime in areas outside the protection of national parks where there are hunting and human settlements (Weikle, 2018).

In making a statement of opinion on the *Science* study (Gaynor et al, 2018), Chris Darimont, a conservation scientist at the University of Victoria in Canada observes that one of the surprising results from the study is that non-lethal activities including hiking and agriculture evoke the same responses from mammals as the lethal ones. Darimont remarks on a *Nature* news piece (Guglielmi, 2018):

> "It doesn't matter whether we're having a picnic in a park or cutting down trees, the wildlife around us perceives us as a risk to their survival."

Due to this landscape of fear, conservation biologist Ana Benítez-Lopez from Radboud University in Nijmegen, the Netherlands stresses that this change in behaviours might affect predation since most of the mammals rely on sight, which means they are more successful during day-time. Hence, if the animals have to shift gears and hunt at night, that can translate into less successful results, which ultimately leads to undernourished animals, that won't be able to feed or mate adequately, having prejudicial consequences on their long-term well-being (Guglielmi, 2018).

Conclusively, the "landscape of fear" is responsible for spatial variation in pressure that can induce the transmogrification of landscapes that are a mosaic of grasses, shrubs, and trees and as a result are richer in landscape-scale biodiversity (Bakker et al, 2016). These top carnivores play an important role in ecosystem stability by adjusting the abundance and behaviours of lesser herbivores and mesopredators (Estes et al, 2011) as well as shaping entire trophic cascades (Ripple & Beschta, 2012).

If the reader is interested in pursuing further information on the landscape of fear please check the articles and research mentioned above as well as the special issue in *The Open Ecology Journal "Landscape of Fear": Ecological implications of being afraid* edited by John W. Laundré (Laundré, Hernandez & Ripple, 2010), as well as Stolzenburg's book previously mentioned.

What is clear now, is that in the Late Pleistocene, megacarnivores were much more biodiverse as well as having ample geographic ranges. What is seen today in African protected areas is but a glimpse of the grandeur and magnificence these creatures occupied on this planet. Van Valkenburgh and colleagues (2016) assert that this abundance may have had a direct impact on megaherbivore populations through the predation of juveniles and young adults, invalidating the assumption that megaherbivores are not limited by predation.

Coupled with this, the loss of megafauna can produce a raised profusion of smaller herbivores and predators and can generate simpler ecosystems with negligible interspecific interplays, curtailed food chains, and limited functional redundancy and resilience (Elmhagen, Ludwig, Rushton, Helle & Lindén, 2010; Ritchie et al, 2012).

A study of the Hall's Cave site in Texas (Smith et al, 2015) demonstrated that megafaunal loss led to a radical reorganization of the mammal community, with a deviation from large grazers to many small frugivores, granivores, and browsers. Adjustments in the body size distribution at the site conjecture a momentous change in energy flow and ecological interactions. If the species synergies and intercommunications and connectivity within the community echo a measure of ecosystem cohesion, modern communities may be less resilient than those constituted in the Late Pleistocene (Malhi et al, 2016).

Under those circumstances, keystone species might have become immediate and crucial fatalities. Their disappearance activated a spiral of habitat change, shifts in the abundance of other species, and supplementary extinctions (Malhi et al, 2016).

Estes and colleagues (2016) present a compelling aquatic example of this type of cascade with the case of Steller's sea cow (*Hydrodamalis gigas)* in the Commander Islands in the mid-1700s. The reason that the cascade was set in motion was by the hunting to virtual extinction of sea otter (*Enhydra lutris*) for the fur trade, which tremendously lessened otter predation on sea urchins, which, in turn, led to expanded sea urchin densities and herbivory of kelp forests above a critical threshold. This cascade prompted the kelp forest cataclysm, a stand-in by urchin barrens, and the shrinkage of the food base for sea cows, resulting in their complete ruin within a few decades.

Admittingly, equivalently detailed knowledge of community interactions are in short supply for most past terrestrial extinctions, however, such trophic cascades related with the loss of keystone species and subsequent habitat change are in all likelihood to be outspread feature of extinctions past and future (Bond & Keeley, 2005; Robinson, Burney & Burney, 2005). Stolzenburg's previously mentioned book (2008) features the sea otter case and many other extinctions scenarios by the loss of keystone species.

The unambiguous outcomes of megafauna in the **vegetation community composition and diversity** can be expressed over timescales of centuries or even millennia through variation in the relative interspecific performance of key ecological processes, such as seed dispersal and plant growth rates (Malhi et al, 2016).

Many megafaunal herbivores are insatiable consumers of fruit and/or seeds. Janzen and Martin (1982) conjectured the existence of a "megafauna fruit syndrome": Several fruit species in contemporary American ecosystems appear to be too large to be eaten and dispersed by the living frugivores (Guimarães, Galetti & Jordano, 2008) and may have been suited to megafaunal dispersal (Malhi et al, 2016). For instance, elephants still play an asymmetrical role in dispersing the seeds of a specific tree in Thailand - *Platymitra macrocarpa,* according to a recent study published in the journal *PLOS ONE* (McConkey et al, 2018). For this tree, elephants are still a vital link for its reproduction, with the study pointing a 78 percent of all sprouted seedlings being at one point consumed by megafauna, and elephants answerable for 37 percent of seedling germination, notwithstanding only consuming roughly 3 percent of the available fruit. By contrast, the sambar (*Rusa unicolor*), which consumed the biggest share of fruit accounted just for 17 percent of seedlings (Erickson-Davis, 2018a).

The authors (McConkey et al, 2018) formulate in their research that:

> "The megafaunal dispersers had very different dispersal strategies, with the large-herbivore disperses (sambar deer and bears) unable to replicate the role of the megaherbivore (elephant). Indeed, the decline in SDE (Seed Dispersal Effectiveness) values with body size of most dispersers confirms that the different animals often referred to as megafauna can differ substantially in their seed dispersal roles."

Given these points, the authors also expound that the tree species is currently on the decline in their study site on Thailand and articulate that:

> "In relatively recent times, the rainforests of Thailand were inhabited by two megaherbivore taxa - rhinoceros (Sumatran and Java) and elephant. Almost no information exists regarding the seed dispersal capacity of a forest rhinoceros, and their populations exist only as relics, having disappeared from almost all of their former ranges. However, forest rhinoceroses are considered primarily browsers, compared to the grazing habits of Asian elephants, and there is anecdotal evidence for them playing a role in seed dispersal."

Ultimately, the researchers deduce that the "gap" in *P. macrocarp* proliferation could be due to the abolished rhinos (which are now circumscribed to Borneo, Sumatra and Java, while slowly marching towards oblivion) (Hance, 2017), or to contractions in local elephant populations. Regardless, the authors claim that the research demonstrates that large herbivores such as the sambar seem incapable of filling the shoes of megaherbivores such as elephants when discussing effectiveness in seed dispersal (Erickson-Davis, 2018a).

In the light of this, there is still no confirmation that any tree species have become extinct due to the megafauna being vanquished, nevertheless, distributions, abundance, and population genetic structure, most likely took a substantial toll (Malhi et al, 2016). The lack of evidence pointing to a widespread dying out is plausibly due to the capacity of plants to be scattered by water, small scatter-hoarding rodents, resprouting, and humans (Guimarães, Galetti & Jordano, 2008; Donatti et al, 2011; Pires et al, 2014). By eating, shattering and disseminating seeded fruits, megafauna were able to assist the progress of long-distance seed dispersal and gene flow. By the same token, the inhibition of such long-distance leakage leaves behind a signature on the distribution and genetic structure of remnant plant populations (Pires et al, 2014). Generally speaking, correlations between seed dispersal syndrome and tree stature and wood density would lead to adjustments in ecosystem biomass and carbon stocks as an aftereffect of the forfeiture of megafaunal seed dispersal (Doughty et al, 2015). On the other hand, the benefits of megafauna on seed dispersal are hindered by the negative effects on juvenile tree survival, leading to some dubious and inconclusive net effects on ecosystem structure and composition (Malhi et al, 2016).

In the same fashion as with seed dispersal, megafaunal herbivory can alter woody species composition by bolstering browsing-tolerant vegetation (Bakker et al, 2016). In African savannas, browsers adjust the species composition towards a monopoly by thorny acacias and chemically defended species (Wigley, Fritz, Coetsee & Bond, 2014). In boreal forests, moose and white-tailed deer scrupulously abstain from the hard-needled white spruce, designing a spruce parkland in place of the closed hardwood forest that would alternatively preponderate (Hidding, Tremblay & Côté, 2013).

Quite a few plant species have modifications to dampen herbivory by megafauna. In New Zealand and Madagascar, where moas and elephant birds (of the family *Aepyornithidae*) were the predominant large herbivores, plants separately developed several refittings to avoid being eaten, such as wide-angled branches, small leaves, and divaricate growth form, features that are not present in Africa where the major herbivores are mammals (Bond & Silander, 2007).

Furthermore, large animals play an overly crucial role in **ecosystem biogeochemistry cycling.** Nutrients that would be sealed for years in leaves and stems are unleashed for use through animal consumption, digestion, defecation, and urination (Hobbs, 1996). Nutrients potentially locked in intractable woody biomass for decades are moved to the decomposition pool through breakage and plant mortality. These effects are inferable to be particularly vital on nutrient-poor soils and in low-productivity dry or cold climates, where megafaunal guts can act as giant warm and moist incubating vats that expedite otherwise slow nutrient cycling (Malhi et al, 2016).

After the death of the megafauna in the cold Pleistocene steppes, nutrients were enclosed into slowly decomposing plant matter, making the entire ecosystem more nutrient poor (Zimov et al, 1995). In dry surroundings such as the African savannas, megafauna have likewise been shown to embolden rapid nutrient cycling by breaking down and digesting recalcitrant plant matter (McNaughton, Banykwa & McNaughton, 1997). By virtue of their high food consumption rates, long gut residence times, and large diurnal movement ranges, megafauna can also dynamize and spur the lateral movement of nutrients beyond landscapes through their faeces and urine (Stevenson & Guzmán-Caro, 2010). A world crowded with megaherbivore is likely to have had a much more energetic lateral diffusion of nutrients across landscapes (Malhi et al, 2016), as two recent studies demonstrate (Doughty, Wolf & Malhi, 2013; Wolf, Doughty & Malhi, 2013).

In the oceans, a similar megafaunal nutrient relocation exists, with whales and other marine mammals absorbing nutrients in the deep ocean and ceding them to the surface through faeces and physical mixing (Roman & McCarthy, 2010). The downfall in marine mammal abundance in recent centuries may have bankrupted this oceanic vertical nutrient pump by around 80 percent (Doughty et al, 2016).

It is conceivable that these oceanic and continental megafaunal nutrient shifts were linked by migratory anadromous (migrate from salt to freshwater) fish, such as salmon, and by seabirds. This interconnectivity reinforces the prospect of a global megafaunal nutrient from weathering continents to oceanic sediments, an interlinked system recycling nutrients, with whales moving nutrients from the deep sea to surface waters, anadromous fish and seabirds moving nutrients from the ocean to land, and terrestrial megafaunal propelling nutrients away from hotspots, such as river floodplains, into the continental interior. Doughty et al. (2016) researched the magnitudes of these nutrient flows and determined that the vertical ocean pump has weakened by 77 percent, the sea-to-land pump has receded by 94 percent, and the terrestrial diffusion of these nutrients has deteriorated by 92 percent.

In these biogeochemical cycles, sodium is a singular element on the grounds that it is needed by animals but often toxic in high concentrations to plants. In the past, megafauna may have scattered sodium into continental interiors and moderate its concentration buildup on coasts. The liveliness of animals of all sizes is generally sodium-limited; studies from Amazonia indicate that upsurges in sodium can remarkably increase the rate of litter breakdown by soil arthropods, inducing a cascading influence on the mineralization of nitrogen, phosphorus, and other key nutrients (Kaspari, Clay, Donoso & Yanoviak, 2014).

Lastly, **regional and global climate** can be shaped by animals themselves (Brault, Mysak, Matthews & Simmons, 2013). Through consumption and digestion, megafauna can have repercussions on biogeochemical cycling, not to mention the discharge of greenhouse gases. Their monumental stature can modify vegetation, soil structure and composition through trampling and browsing (Bakker et al, 2016; Zimov & Zimov, 2014), which can affect soil biogeochemical processes, alter water tables and soil methane emissions, and also modify land surface albedo and evapotranspiration (Malhi et al, 2016).

Despite the fact that domestic livestock is acknowledged as a major source of methane emissions, wild animals also produce considerable amounts of methane, and these emissions scale allometrically with body mass (Smith, Elliott & Lyons, 2010; Smith, Lyons, Wagner & Elliott, 2015; Smith et al, 2016).

Smith et al. (2010) pondered on the detectable cutbacks in the global methane budget related to the annihilation of megaherbivores and assessed the greenhouse gas effect of Pleistocene megafaunal deficiency to be a global cooling of 0.08-0.20ºC. The studies denote the abrupt end-Pleistocene megafaunal extinction could have been partly responsible for the Younger Dryas cold episode between 12700 and 11500 years ago, at the end of the Pleistocene. In addition, the deviation to the expansion of woody vegetation after megafaunal collapse (Bakker et al, 2016) would also have acted as a sink of atmospheric CO2, further contributing to a greenhouse cooling effect.

However, a more vigorous repercussion on climate after the extinctions may have been through the alteration of albedo at high latitudes through effects on tree cover. The evaluation of the net impact of tree cover on climate demands consideration of carbon, evapotranspiration, and albedo effects (Malhi et al, 2016).

In regions with profuse winter snow cover, trees tend to warm the surface (Bonan, 2008) by virtue of their dark features that peek above highly reflective snow. Two studies have attempted to evaluate the role extinctions of high latitude megafauna influenced albedo and therefore global temperatures (Doughty, Wolf & Malhi, 2013; Brault, Mysak, Matthews & Simmons, 2013) and gauge albedo-related global warming impacts of up to 0.2ºC after the extinctions. Thence, at a planetary level, the greenhouse gas and albedo side-effects of megafauna work in opposite directions. However, at lower latitudes, and local scales, if enhanced tree cover heightens evapotranspiration, surface evaporative cooling, and the formation of reflective clouds, the disappearance of megafauna may have led to a net cooling (Malhi et al, 2016).

By the same token, large animals can also reshape albedo simply through regular trampling and grazing in the absence of tree cover. A practical investigation where herbivores were imported to a Siberian ecosystem (Pleistocene Park) (Zimov, 2005) shown how abundant herbivores trample the snow in winter, decreasing soil temperatures by 15-20ºC. In addition, grazing extracts some of the darker brush from these areas, thus bringing to light bright snow and greatly increasing the albedo. This escalation in reflectivity cools the surface, helping to keep large reserves of soil carbon from decomposing (Malhi et al, 2016).

The ecological function of megafauna, notably via habitat structure and trophic cascades, is being more and more discussed in conservation contexts. Excogitating on the repercussions of past megafaunal destruction caused by the intertwined or isolated effects of our ancestry and climate change, produces sapience into the changeability of long-term ecosystems and can yield valuable clues into the ecological pressures that surface as megafauna and other animals perish from ecosystems (Malhi et al, 2016).

In the paper *Megafauna and ecosystem function from the Pleistocene to the Anthropocene,* Yadvinder Malhi and colleagues (2016) assert in their concluding remarks how:

> In looking at even wild landscapes where megafauna are long gone, imagining such landscapes as recently teeming with elephants, sabertooths, and other giant herbivores and carnivores can yield fresh perspectives on contemporary ecosystem questions, ranging from the distribution of tropical savannas and grasslands, through the natural ranges and abundance of extant animals, to the response of high latitude systems to climate change. [...] A world where animal control of ecosystem

The authors wrap up and conclude their examination by stating:

> "If we accept the increasing evidence for a strong human role in these early extinctions, it forces a look inwards and recognition of the deep prehistoric entanglement between humans and environmental change, a realization that some of the most dramatic human-induced changes to the nature of life on Earth and the functioning of the biosphere may have occurred even before the dawn of agriculture."

Since this segment is mostly focused on mammal extinctions, it is worth pointing out here how a new study published in *Proceedings of the National Academy of Sciences* (Davis et al, 2018), draws the conclusion that it will take somewhere from 3 million to 7 million years, for mammals to evolve enough novel species to restore the ones that our ancestors – and us presently – drove to oblivion. If anything, that is at least 10 times as long as humanity has endured, and under these circumstances, such a healing process will be beyond the scope of any time scale relevant to humans (Yong, 2018b).

This segment, dedicated to the extinctions of our prehistory as well as those of our more recent past is meant to describe the nexus of causality that has been building up, that connects the presence and activity of our human ancestry to a widespread and conspicuous autobiography of eradication. Regrettably, this segment is but a prelude to the main event, which has been designated with the label, Anthropocene.

ANTHROPOCENE

- A Sequel of Solitude, Seclusion, Silence and Stillness -

"Rarity precedes extinction; and we know that this been the progress of events with those animals which have been exterminated, either locally or wholly, through man's agency"

Charles Darwin, *On The Origin of Species By Means of Natural Selection* (1859, 319-320)

"Biologists guess that the result of rapid warming will be the greatest wave of extinction since the last asteroid crashed into the earth. Now, we are the asteroid."

- *Bill McKibben, "Worried? Us?" Granta, Fall 2003*

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"Deep in earth my love is lying. And I must weep alone."

- Edgar Allan Poe

In her book, *The Sixth Extinction - An Unnatural History* (2014), Elizabeth Kolbert introduces us to how the term 'Anthropocene' came about:

"The word "Anthropocene" is the invention of Paul Crutzen, a Dutch chemist who shared the Nobel Prize for discovering the effects of ozone-depleting compounds. [...] Crutzen told me that the word came to him while he was at a meeting and the chairman kept referring to the Holocene, which began at the conclusion of the last ice age, 11,700 years ago, and which continues - at least officially - to this day:

- *"'Let's stop it. We are no longer in the Holocene; we are in the Anthropocene.' "*

*Crutzen wrote up his idea in a short essay, "Geology of Mankind," that ran in Nature (*2002). "It seems appropriate to assign the term 'Anthropocene' to the present, in many ways human-dominated, geological epoch," he observed. Among the many geological-scale changes people have effected, Crutzen cited the following:

- Human activity has transformed between a third and a half of the land surface of the planet.
- Most of the world's major rivers have been dammed or diverted.
- Fertilizer plants produce more nitrogen than is fixed naturally by all terrestrial ecosystems.
- Fisheries remove more than a third of the primary production of the ocean's coastal waters.
- Humans use more than half of the world's readily accessible fresh water runoff.

Most significantly, Crutzen said, people have altered the composition of the atmosphere. Owing to a combination of fossil fuel combustion and deforestation, the concentration of carbon dioxide in the air has risen by forty percent over the last two centuries, while the concentration of methane, an even more potent greenhouse gas, has more than doubled.

The members of Geological Society of London decided to examine the idea as a formal problem in geology. Would the Anthropocene satisfy the criteria used for naming a new epoch? The answer the members arrived at after a year's worth of study was an unqualified "yes." The sorts of changes that Crutzen had enumerated would, they decided, leave behind "a global stratigraphic signature" that would still be legible millions of years from now. The Anthropocene will be marked by a unique "biostratigraphical signal," a product of the current extinction event on the one hand and of the human propensity for redistributing life on the other.

The Anthropocene, or the sixth mass extinction (for a detailed account on the previous five mass extinctions, I recommend Michael J. Benton's book *When Life Nearly Died - The Greatest Mass Extinction of All Time* (2003)), is customarily said to have begun with the industrial revolution, or perchance even on a posterior date, with the rampant growth in population that succeeded World War II (Kolbert, 2014).

Notwithstanding its genesis, one thing is clear, the ongoing biodiversity crisis is recognized as delineating another mass extinction event (Barnosky, 2011). Global homogenisation by virtue of human endeavours such as landscape simplification (Western, 2001), ecosystem disruption (Western, 2001; Vitousek, Mooney, Lubchenco & Melillo, 1997; McKinney & Lockwood, 1999), anthropogenic climate change (Blois, Zarnetske, Fitzpatrick & Finnegan, 2013, Barnosky et al, 2011, McKinney & Lockwood, 1999), and the influx of exotic species (McKinney & Lockwood, 1999; Olden, Leroy, Douglas, Douglas & Fausch, 2004; Sax & Gaines, 2008), epitomize the most urgent pitfalls to existent biodiversity (Olden, Leroy, Douglas, Douglas & Fausch, 2004, Pereira et al, 2010).

Eminent biologists and authors like Jared Diamond, E.O. Wilson, and Normal Myers all assent with one another that population growth and the forces it magnifies or releases on the landscape are overwhelming biodiversity (Kolankiewicz, 2012). Correspondingly, Diamond invokes an "Evil Quartet" of habitat destruction, fragmentation, overharvesting, and introduced species, to account for most wildlife decline, that is catalyzed by human presence and activities (Sanderson & Moulton, 1998). In the same fashion, Wilson promotes the acronym HIPPO - habitat destruction, invasive species, pollution, population, and overharvesting. He projects that at least twelve thousand wild species are being vanquished to the void, annually (Biello, 2008).

Wilson (2002) has authored:

> "Humanity, in the desperate attempt to fit 8 billion or more people on the planet and give them a higher standard of living, is at risk of pushing the rest of life off the globe."

He goes further in his argumentation and states:

> "It's obvious that the key problem facing humanity in the coming century is how to bring a better quality of life for 8 billion or more people - without wrecking the environment entirely in the attempt."

Not only prominent authors are concerned about the link regarding population and biodiversity loss but also organizations like the Conservation Measures Partnership that lists *direct* menaces to biological diversity. Their central categories include (I) residential and commercial development; (2) agriculture and aquaculture (3) energy production and mining; (4) transportation and service corridors; (5) biological resource use; and (6) human intrusions and disturbance. Evidently, each of these is an explicit action of population size and, indubitably, affluence (Conservation Measures Partnership, 2006).

One of the most perverse and wicked repercussions of these menaces has been translated in the updated version of the International Union for Conservation of Nature (IUCN) Red List of Threatened Species that now encompasses 93,577 species, of which 26,197 are considered threatened with extinction (IUCN, 2018b).

Inger Andersen, IUCN Director General morosely admonishes:

> "The IUCN's Red List update reveals the onslaught of threats that our planet's biodiversity is facing. Invasive species, changes to fire patterns, cyclones and human-wildlife conflict are just some of the many threats wreaking havoc on our planet's ecosystems. As species from Mauritius to Australia slip towards extinction we risk losing a part of our culture and our identity, as well as the life-supporting benefits these species provide by pollinating our crops or preserving healthy soils."

Yet another criterion that ascertains the degree to which *Homo sapiens* is confiscating the natural world is the human appropriation of net primary production (HANPP). Net primary production is the annual growth of all plant matter, from stalwart lichens to soaring redwoods, plus cultivated crops like corn and wheat. It is the plant kingdom's annual output (Kolankiewicz, 2012).

Austrian researchers remark at the online *Encyclopedia of the Earth:*

> "Empirical studies increasingly demonstrate that HANPP is a major indicator of human pressures on ecosystems and may have adverse effects on biodiversity" (Haberl, Erb & Krausmann, 2014).

HANPP is what is amassed by people for our own consumption, plus the share of natural production absent from environmental degradation. Another portion of HANPP is from human development that replaces living vegetation with pavement and buildings. In effect, the share of NPP seized by humans is unavailable to wildlife, which must then subsist on less. In view of an expanding number of omnivorous human consumers with growing appetites, the organic subsistence for millions of creatures that inhabit the biosphere with us is now being expropriated. The bottom line is that if HANPP continues to increase - as it is foreseen that it will (more on this in the chapter Hunger Games), more species will be snuffed out of existence permanently (Kolankiewicz, 2012).

In *Harvesting the Biosphere*, Vaclav Smil (2013) tries to gauge what portion of the biosphere's primary productivity - the amount of plant life originated each year by photosynthesis - is being devoured or applied by humans. His estimates point to roughly 17 percent, at present times, but he contemplates that it could be as little as 15 percent or as much as 25 percent. Comparatively, at the onset of the Common Era (Year 0), humans were harvesting a moderate 0.2 percent. Furthermore, the net primary productivity, (from where humans and other species acquire their sustenance) in gigatons - and from where these percentages are calculated from - has also deteriorated, from around 200 Gt, 2000 years ago, to a predicted 110 Gt in 2013 (Gates, 2013).

Smil portrays clearly how human's impact on the Earth has mutated over time. The first tremendous repercussion was around 10,000 years ago, when humanity started to burn down forests to clear land for crops. Contemporaneously, the harvest of crops is done for four main reasons: to feed animals, humans, generation of fuel and making paper and other construction materials. Smil exposes how of all these, the first two are liable for the biggest impact on the biosphere, which has materialized into about 12 percent of the Earth's land mass now being devoted to farmland (Gates, 2013).

In like manner, the biosphere's productivity has also been crippled by establishing new major cities to accommodate our growing human populace. These, in essence, phase out or dreadfully curtail any natural productivity from those areas. Smil outlines that major cities now cover an expanse of up to five million square kilometers. That is to say, if all were clustered together, they would cover an area 50 percent larger than India (Gates, 2013).

In effect, ecologist Stuart Pimm (2004) writes that humanity is hijacking up to forty-two percent of terrestrial NPP and appropriating roughly a quarter to a third of the ocean's production. For this reason, William Catton has warned in his book *Overshoot*: *The Ecological Basis of Revolutionary Change* (1982):

> "Such total exploitation of an ecosystem by one dominant species has seldom happened, except among species which bloom and crash […] having become a species of superdetrivorores, mankind [is] destined not merely for succession, but for crash."

In analyzing environmental repercussions, scientists invoke *direct*, *indirect*, and *cumulative* burdens. Human population growth impacts biodiversity in all three ways. The most symbolic direct influence manifests when we invalidate or fragment wildlife habitat by transmogrifying it into farmland to feed ever more humans and livestock and, to a greater extent, vehicles (i.e., ethanol and biodiesel derived from crops). Overpopulation-related habitat impairment and corruption also occur with the construction of reservoirs, power lines, roads, mines, logging operations, overgrazing, bottom trawling, and urban sprawl (Kolankiewicz, 2012).

It must be remembered that land use and analogous pressures have been the main drivers of terrestrial biodiversity deracination (Souza, Teixeira & Ostermann, 2015) and with an expanding and enlarged population that is getting ever more urbanized, this exertion on the natural world is not expected to be alleviated any time soon (Tittensor et al, 2014).

Biodiversity has already endured rampant net losses (Newbold et al, 2015), conceivably putting in jeopardy its contribution to the resilience of ecosystems and the provision of their functions and services, like, biomass production and pollination, that predicate human well-being (Cardinale et al, 2012; Hooper et al, 2012; Hautier et al, 2015; Oliver et al, 2015). In like manner, the pools of genetic information that may prove vital to species' evolutionary adjustment and survival in a rapidly changing global environment are being plundered and ravaged, yet again decreasing the fitness capability of populations and species (Ceballos et al, 2017). Some of these insights are also applicable to the contemporary degeneracy in smaller animals and the megafauna that still remains, which is under imminent threat (Malhi et al, 2016).

In *Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment* (2016), Tim Newbold and colleagues assert that:

> "Exploitation of terrestrial systems has been vital for human development throughout history (Ellis et al, 2013), but the cost to biosphere integrity has been high. Slowing or reversing the global loss of local biodiversity will require preserving the remaining areas of natural (primary) vegetation and, so far as possible, restoring human-used lands to natural (secondary) vegetation. Such an outcome would be beneficial for biodiversity, ecosystems, and - at least in the long-term - human well-being."

Moving on to *indirect impacts* of population growth on biodiversity, a point often overlooked is invasive species that accompany the expansion and spreading of human populations. To this effect, exotic plants, animals, and microbes released by humans are wreaking havoc on native terrestrial and aquatic ecosystems, flora, and fauna on a planetary scale. An augmenting population with more mobility than ever before, more trade, and more proliferation of exotics constitutes a major hazard to biodiversity (Kolankiewicz, 2012).

Given these points, the elimination of species caused by direct perturbation, such as a broad-scale tropical forest clearance for agriculture (Sodhi & Brook, 2006) or by indirect influence, such as the elimination of island populations by introduced predators (Pimm, Raven, Peterson, Şekercioğlu & Ehrlich, 2006), embodies the primary driver of biodiversity shrinkage at our present day (Purvis, Jones & Mace, 2000).

Yet even when these systematic hazards do not result in instantaneous annihilation, a concatenation of inescapable secondary processes and synergistic feedbacks can eventually cause extinction (Caughley, 1994; Brook, Traill & Bradshaw, 2006; Fagan & Holmes 2006; Oborny, Meszéna & Szabó, 2005). The term 'synergistic' specifies the concurrent action of separate processes that have a higher total reaction than the sum of individual effects alone. A case in point, habitat loss can lead to the death of species directly by removing all individuals over a short period of time, but it can also be indirectly accountable for lagged extinctions by expediting invasions, promoting hunter access, eliminating prey, reshaping biophysical conditions and augmenting inbreeding depression (Pimm et al, 2006; Brashares, Arcese & Sam, 2001; Johnson, 2002; Mora, Metzger, Rollo & Myers, 2007).

Equally important is what is described as the ultimate cumulative impact: anthropogenic climate change, from the unfaltering accretion of human-emitted greenhouse gases in the atmosphere. This could turn out to have the most preeminent inimical impact on the stability of the biosphere than all the other forces combined. As reported by the Intergovernmental Panel on Climate Change (IPCC), rising greenhouse gas emissions are primarily a function of expanding populations and increased affluence (Kolankiewicz, 2012).

In places such as the Arctic, where habitat loss and fragmentation are less harsh, global warming is the leading threat to biodiversity (Sala et al, 2000). Melting ice in the Arctic can be demonstrated to have consequences on species all the way through the food web (Krajick, 2001). At the base of the web are algae and plankton. With thinner ice, the algae start to establish, with less phytoplankton to feed the zooplankton. The dead zooplankton routinely rains down to the seafloor, feeding invertebrates at the bottom. Some of those are sinking into oblivion, including the clams, which successively are food for the walruses. Fish also take a toll, especially the cod, who feed the seals. Fewer seals mean less food for the polar bears, as well as for those humans who also hunt seals (McKee, 2003). These can be described are regional repercussions of anthropogenic climate change. Throughout this work other such examples are examined.

Under these circumstances, the most recent doubling of our numbers was supplemented by a depletion of over half of wildlife numbers, driven by the extirpation of natural habitats and the carnage and butchery of wildlife to accommodate human desiderata and exacerbated by environmental desecration from human activities (WWF, 2018a). Even if our human population ultimately ceases pullulating and narrows back to a sustainable size, the species bulldozed and propelled to obsolescence along the way will be forgotten (Kuhlemann, 2018).

In consonance with the Living Planet Index (LPI) wildlife copiousness on the planet has abated by as much as 60 percent between 1970 and 2016 (WWF, 2018a). This is encapsulated by the considerable number of species of mammals that were somewhat safe on or two decades ago and now are imperilled (Ceballos et al, 2017).

In 2016, only 7,000 cheetahs persevered in enduring on this planet (Durant et al, 2017) and less than 5,000 Borneo and Sumatran orangutans (*Pongo pygmaeus* and *P. abelli,* respectively) (IUCN, 2018). Populations of African lion (*Panthera leo)* subsided by 43 percent since 1993 (Henschel et al, 2014), pangolin (*Manis spp.)* populations have shrunk to the point on non-existence (Challender et al, 2016), and populations of giraffes waned from around 115,000 individuals thought to be conspecific in 1985, to around 97,000 representing what is now identified to be four species (*Giraffa giraffa, G. tippelskirchi, G. reticulata, and G. camelopardalis)* in 2015 (Fennessy et al, 2016).

In *Biological annihilation via the ongoing sixth extinction signaled by vertebrate population losses and declines* by Gerardo Ceballos, Paul R. Ehrlich and Rodolfo Dirzo (2017) compile the evidence and describe the interspecies genocide that humanity's presence and activity have unleashed. Their work focuses on the analysis of the loss of land vertebrate species (amphibians, birds, reptiles, and mammals) that are deemed as "decreasing" by the IUCN, providing an estimation of population losses on species at risk, thus, as the authors state "the disappearance of populations, always precedes species extinctions."

Considering all land vertebrates, the analysis revealed a colossal cadence of population losses, with some regions demonstrating higher aggregation of species with local extinctions than others. Conspicuously, some parts of the planet harbour low absolute numbers of vertebrate species going through a diminution, such as those of low species richness positioned in hyper-cold and hyperarid regions (Ceballos et al, 2017).

As anticipated, large masses of decreasing vertebrate species materialize in species-rich areas of moist tropical forests adjacent to mountainous regions, such as the Andes-Amazon region, the Congo basin-adjacent eastern African highlands, and the Himalayas-south Asian jungle belt (Ceballos et al, 2017).

When surveying the figures the authors first call attention to the maximum number of decreasing species in a 10,000km^2 quadrat fluctuates from a high value of 296 decreasing birds per quadrat to a low maximum of 60 fewer reptiles in a quadrat. Birds are found to be missing over large regions of all continents (figures 4.4 and 4.5). Second, mammals and birds have relatively identical distribution patterns of decreasing species, exempting that birds have more deteriorating species in the temperate zones and have diminishing species found over large regions of all continents. Third, mammals and birds have an archetypical downturn of species, quite distinct from those of reptiles and amphibians, given that the latter are rarer in the northern and southern temperate and subpolar regions (both are essentially absent from the Arctic and are missing from the Antarctic). Fourth, reptiles and amphibians distinctly contrast from each other in regions where declining species are concentrated. For example, there are more dwindling reptiles in the Eurasian and African continents and more subsiding amphibians in the Americas. Amphibians specifically are found to have the most elevated percentage of decreasing species in Mexico, Central America, the northern Andes, and Brazil's Atlantic forest in the Americas; West Africa and Madagascar; and India and Southeast Asia, including Indonesia and Philippines. Their results illustrate extremely large numbers of vertebrate populations facing extinction, compared with the number of species (Ceballos et al, 2017).

Approximately a third (8,851/27,600) of all land vertebrate species probed by the authors are claimed to be experiencing drops on local population losses of an appreciable proportion. The fraction of waning species varies, depending on the taxonomic group, from 30 percent or more in the case of mammals, birds, and reptiles, to 15 percent in the case of amphibians. Moreover, of the curbed species, many are now considered endangered (fig 4.4). Beyond that, somewhere around 30 percent of all dwindling species are still sufficiently common that they are regarded as of "low concern" by IUCN, rather than "endangered." That so many common species are sinking is a robust harbinger of the seriousness of the overall contemporary biological extinction episode (Ceballos et al, 2017).

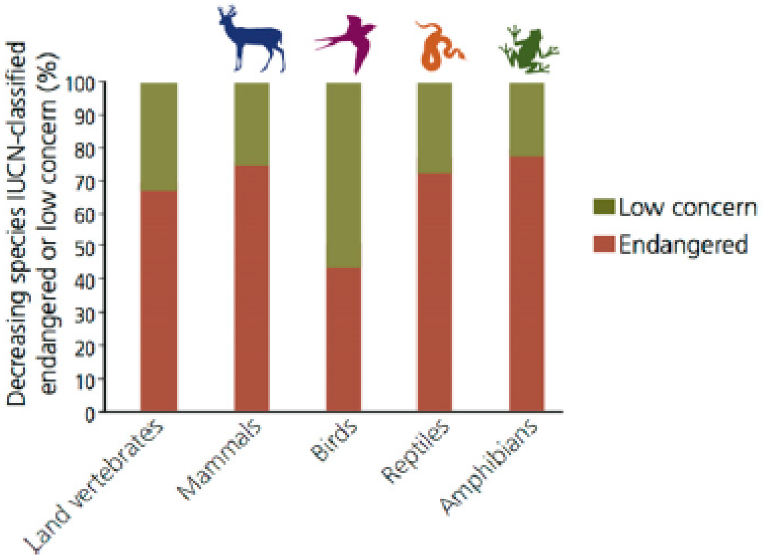


Figure 4.4: The percentage of decreasing species classified by IUCN as "endangered" (including "critically endangered," "endangered," "vulnerable," and "near-threatened") or "low concern" (including "low concern" and "data-deficient") in terrestrial vertebrates. This figure emphasizes that even species that have not yet been classified as endangered (roughly 30 percent in the case of all vertebrates) are declining. This situation is exacerbated in the case of birds, for which close to 55 percent of the decreasing species are still classified as "low concern." Retrieved from Ceballos et al, 2017.

Figures 4.6 and 4.7 illustrate the data relative to a sample of 177 mammal species. Most of the species had their geographic ranges narrowed by 40 percent in historic times, and almost half have forfeited more than 80 percent of their ranges in the period ±1900–2015. The dominant section of range constriction is ≥ 80 percent in Africa (56 percent of the sampled mammal species), Asia (75 percent of the species), Australia (60 percent of the species), and Europe (40 percent of the species). In the Americas, range condensing is less marked but still substantial: 22 percent of the species in North America and 17 percent of the species in South America have experienced range withdrawals of at least 80 percent. Nevertheless, 50 percent of the species in North America and 28 percent of the species in South America have experienced a range abdication of 41 percent or more (Ceballos et al, 2017).

The comparison of the 1900-2015 geographic dimensions showed that the 177 species of mammals have dematerialized from 58,000 grid cells. The authors postulated that on average each of the 10,000-km^2 occupied quadrats detained a single population of the species found within it, this presupposed that about 58,000 populations of the 177 mammals surveyed have been vanquished (Ceballos et al, 2017).

The symbolic case of the lion (*Panthera leo)* emphasizes thoroughly what the authors transmit in their work. *P. leo* was historically diffused over most of Africa, Southern Europe, and the Middle East, all the way to northwestern India. It is now restrained to a scattered population in sub-Saharan Africa and a remnant population in the Gir forest of India (Ceballos et al, 2017).

In any event, taking into account what is understood about genetic population's differentiation, it is envisioned that the range contractions and declines that have been documented by the scientific community entail a substantial deprivation of intraspecific genetic diversity, which, clearly requires further investigation (Ceballos et al, 2017).

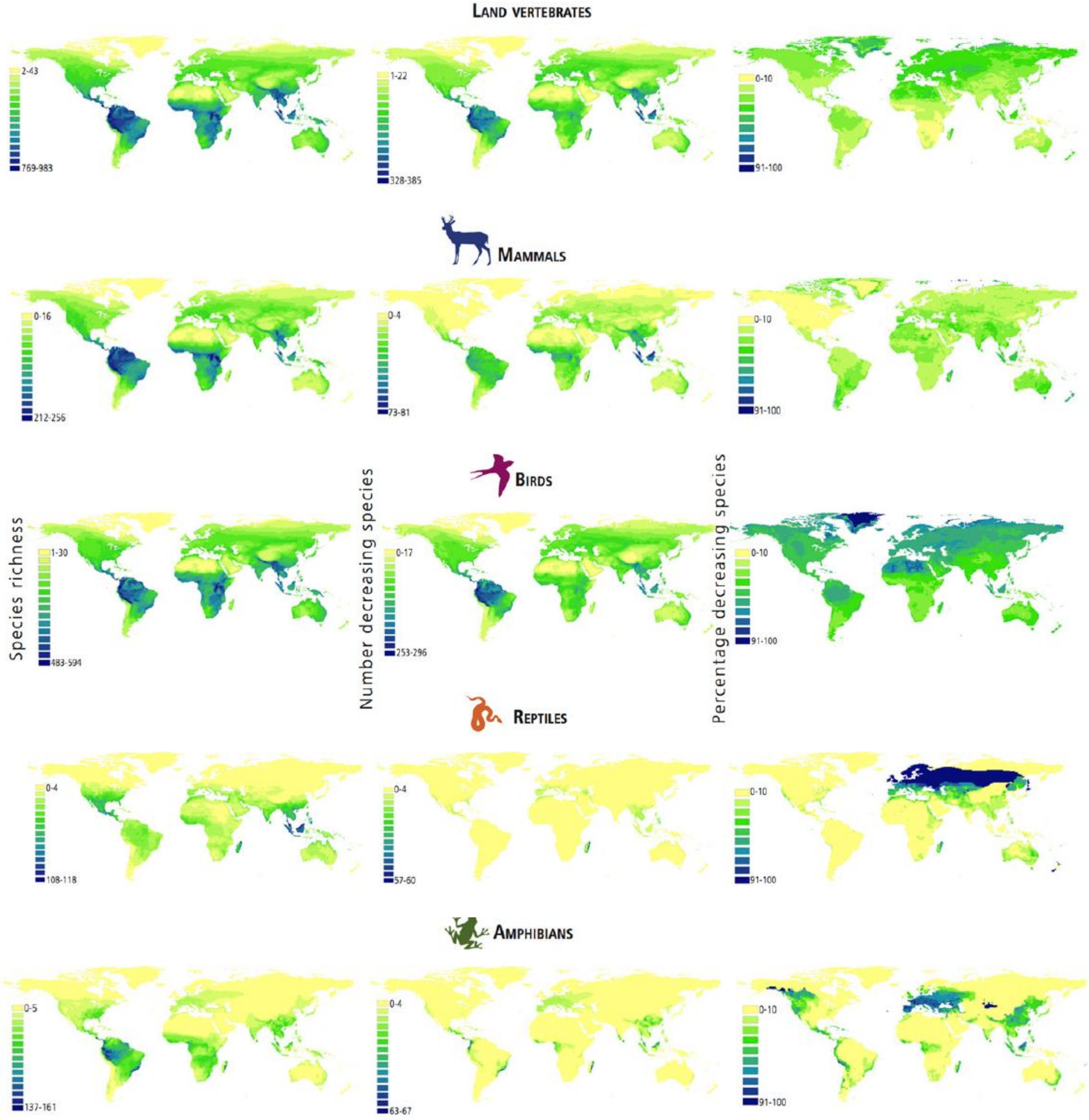


Figure 4.5: Global distribution of terrestrial vertebrate species according to IUCN. (Left) Global distribution of species richness as indicated by number of species in each 10,000-km2 quadrat. (Center) Absolute number of decreasing species per quadrat. (Right) Percentage of species that are suffering population losses in relation to total species richness per quadrat. The maps highlight that regions of known high species richness harbor large absolute numbers of species experiencing high levels of decline and population loss (particularly evident in the Amazon, the central African region, and south/southeast Asia), whereas the proportion of decreasing species per quadrat shows a strong high-latitude and Saharan Africa signal. In addition, there are several centers of population decline in both absolute and relative terms. Retrieved from Ceballos et al, 2017.

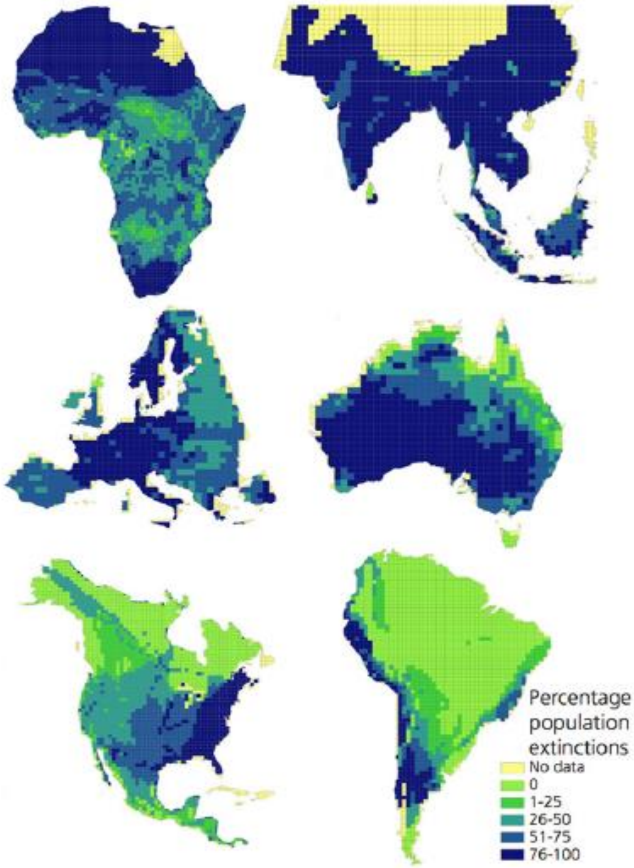
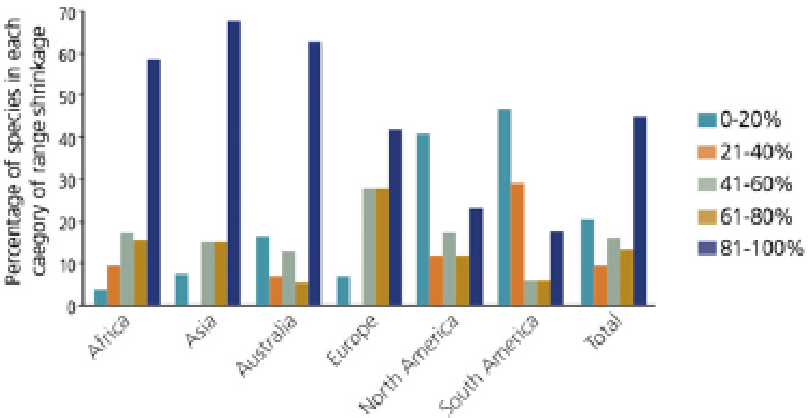


Figure 4.6: Percentage of local population extinction in 177 species of mammals in 1° × 1° quadrats, as an indication of the severity of the mass extinction crises. The maps were generated by comparing historic and current geographic ranges (Ceballos, Ehrlich, Soberón, Salazar & Fay, 2005). Note that large regions in all continents have lost 50% or more of the populations of the evaluated mammals. Because of the small sample size, biased to large mammal species, this figure can only be used to visualize likely trends in population losses. Retrieved from Ceballos et al, 2017.

All things considered, the extinction of mammal populations, although differing from species to species, has been a global phenomenon (figs 4.6 and 4.7). Markedly, the predominant colour code in the mammalian map is that of 70 percent or more of population losses, with the exception of some areas of South America and high latitudes of North America. Exceptionally but unsurprisingly hard hit have been the mammals of the south and south-east Asia, where all of the large-bodied species of mammals inspected lost more than 80 percent of their geographical ranges. The Cape and Sahara regions in Africa, central Australia, the eastern United States, and the Atlantic forest in South America have also undergone a severe deterioration of their populations (Ceballos et al, 2017).



Figures 4.7: The percentage of species of land mammals from five major continents/subcontinents and the entire globe undergoing different degrees (in percentage) of decline in the period ~1900–2015. Considering the sampled species globally, 56 percent of them have lost more than 60 percent of their range, a pattern that is generally consistent in Africa, Asia, Australia, and Europe, whereas in South America and North America, 35–40 percent of the species have experienced range contractions of only 20 percent or less. Retrieved from Ceballos et al, 2017

In addition, a deluge of studies are reporting that invertebrates and plants are displaying extensive losses of populations, species and range condensing (Thomas, 2016; Régnier et al, 2015; Burkle, Marlin & Knight, 2013; Ter Steege et al, 2015). For example, long-term monitoring of insect populations in the United Kingdom revealed that 30-60 percent of species per taxonomic order have had their ranges narrowed (Réginer et al, 2015). The standpoint with plants has been less assessed; thus it is challenging to contrast them with animals, but there is little reason to be convinced that the annihilation regarding plants is dramatically different (Burkle, Marlin & Knight, 2013).

Regarding the status of insects, the abundance of flying insects has sunk by three-quarters over the past 27 years, according to a study by Caspar A. Hallmann and colleagues published in *Plos One* (Hallmann et al, 2017), that focused on the condition of protected areas in Germany.

Insects are a vital part of life on Earth as both pollinators and prey for other wildlife, such as birds, bats, mammals, fish, reptiles and amphibians. Flies, beetles and wasps are also predators and decomposers, controlling pests and cleaning up, Lynn Dicks of the University of East Anglia, UK, comments on *The Guardian's* piece *Warning of 'ecological Armageddon' after a dramatic plunge in insect numbers* (Carrington, 2017a).

The ebbing of insects is assured to have detrimental ramifications on ecosystem functioning, as insects play a central role in a variety of processes, including pollination (Öckinger & Smith, 2006; Ollerton, Winfree & Tarrant, 2011), herbivory and detritivory (Mattson & Addy, 1975; Yang & Gratton, 2014), nutrient cycling (Yang & Gratton, 2014) and supplying a food source for higher trophic levels such as birds, mammals and amphibians. For instance, 80 percent of wild plants are predicted to rely on insects for pollination (Ollerton, Winfree & Tarrant, 2011), while 60 percent of birds turn to insects as a food source (Morse, 1971). Together with this, ecosystem services provided by wild insects, for free, have been estimated to cost $57 billion annually in the USA alone (Losey & Vaughan, 2006).

As described in the previous segment regarding the decimation of species of megafauna and predators and the ensuing ecological repercussions, experimentation has shown that the liquidation of animal populations indirectly leads to changes in plant communities (Briggs, 2014; Burkle et al, 2013; Cardinale et al, 2012), regularly precipitating the decrement of local species richness and dominance of a few plant taxa that either experience "ecological release" (population increase that is connected to when a species is released from limiting factors that were restraining its growth) in response to a cutback of herbivore pressures (Martínez-Ramos, Ortiz-Rodríguez, Piñero, Dirzo & Sarukhán, 2016; Camargo-Sanabria, Mendoza, Guevara, Martínez-Ramos & Dirzo, 2016) and/or experience population minimizations due to the overthrow of animals responsible for pollination or dispersal (Dirzo, Young, Galetti, Ceballos, Isaac & Collen, 2014; Young et al, 2016; Brosi & Briggs, 2013).

Equally vital is the current position of biodiversity and ongoing pulse of extinctions among microorganisms that is simply too poorly understood, although research has broken down feedbacks between local large herbivore defaunation and mycorrhizal richness (Petipas & Brody, 2014; Wardle et al, 2004).

An article published in *Science* by Yong-Guan Zhu and colleagues (2017a) argues that humans are transporting trillions of bacteria around the world via tourism, food and shipping, without considering the potential damage caused to bacterial ecosystems. Another paper entitled *Human dissemination of genes and microorganisms in Earth's Critical Zone* (2017b) by the same authors, claims:

> "Human activities significantly influence physical and biological processes, affecting the atmosphere, shallow lithosphere, hydrosphere, and biosphere. Organisms have an additional class of biogeochemical cycling, the flow and transformation of genetic information. Understanding human effects on microbial activity, fitness and distribution is important for examining the origins and rise of antibiotic resistance genes, their subsequent dissemination, and the ongoing colonization of diverse ecosystems by resistant organisms."

Michael Gillings, author in both studies writes for the UK's *The Conversation* (2017a) and states:

> "Bacterial population structures are definitely changing, and bacterial species are being transported to new locations, becoming the microbial equivalent of weeds or feral animals."

Gillings goes on to enumerate the several ways in which human activities are impacting on microbiological life:

- **Sewage and manure**. Animal and human faeces discharge gut microorganisms back into the environment, and these organisms are immensely distinct from the organisms of 100 years ago. This is because humans and our domesticated animals – cows, sheep goats, pigs and chickens – now amount to 35 times more biomass than all the wild mammals on land (Smil, 2011). Since human sewage and livestock manure contain very specific subsets of microbes, which translates to those populations being improved and renewed in the environment, at the expense of the native microbes (Gillings, 2017a). Not to mention, sewage and manure also disseminate tremendous quantities of genes that confer resistance to antibiotics and disinfectants (Gillings, 2017b).
- **Wastewater, sewage sludge and manure** are broadly used in agriculture. Gut organisms from humans and agricultural animals tarnish our food supplies. These food products, along with their bacteria, are shipped around the world (Gillings 2017a).
- The journeying and locomotion of **1.2 billion international tourists** per year (Bengtsson-Palme et al, 2015), which, unintentionally transfers gut microorganisms to exotic locations. Bengtsson-Palme and colleagues argue that tourism can rapidly spread antibiotic-resistant pathogens between continents.
- The boundless quantities of **microbe-laden materials** that move along with humans. Each year, approximately 100 million tonnes of ballast water are expelled from ships in US ports alone (Gillings 2017a). This mobility and transplanting of microorganisms via shipping are altering the circulation of bacteria in the oceans. It also transports pathogens such as cholera (Drake, Doblin & Dobbs 2007).
- Humans also move colossal quantities of **sand, soil and rock**. It is projected that human activities are now liable for shifting more soil than all natural processes combined (Wilkinson & McElroy, 2007). As every gram of soil incorporates roughly a billion bacteria (Raynaud & Nunan, 2014), this corresponds to tremendous numbers of microorganisms being moved around the planet (Gillings 2017a).

Similarly, regarding small animals, a study that dissects the scale and repercussions of defaunation in Amazonia (Peres, Emilio, Schietti, Desmoulière & Levi, 2016) maintains that the overhunting of seed dispersers, such as large monkeys and tapirs, will induce a long-term recession in high biomass tree species, and thereby a weakening in the carbon stock even in structurally intact forests (Malhi et al, 2016).

Humans have also hunted ocean megafauna for millennia, but only in the last few centuries has the industrialization of whaling and fishing instigated monumental defaunation and local extirpations of marine megafauna, both mammal and fish (McCauley et al, 2015). Whale densities have descended by 66-99 percent (McCauley et al, 2015; Christensen, 2006). To date, there have been few global extinctions of marine megafauna, with the exemption of some coastal aquatic species such as Steller's sea cow (Estes, Burdin & Doak, 2016), but large fish persist in facing severe exhaustion (McCauley et al, 2015; Doughty et al, 2016).

What is clear at this point in time is that marine biodiversity is already being degraded by another factor besides the numerous stressors such as fishing, habitat loss and pollution. Anthropogenic climate change that is creating global warming related to carbon emissions from human numbers and activities is a crucial factor in the current defaunation of marine environments

(Jackson et al, 2001). Populations of marine vertebrates, especially predators, have dwindled by 50 to 95 percent in most oceanic regions (McCauley et al, 2015; Valdivia, Cox & Bruno, 2017; Myers & Worm, 2003), and habitat-forming species such as seagrasses, mangroves and corals are waning by roughly 1 percent annually (Waycott et al, 2009; Bruno & Selig, 2007; Polidoro et al, 2010).

As a matter of fact, research published in the journal *Current Biology* titled *The Location and Protection Status of Earth's Diminishing Marine Wilderness* (Jones et al, 2018), evidences how humanity has decimated most of the pristine parts of the world's oceans. In the first global mapping of human impingements on marine environments, the team revealed that few corners of the globe have been left unscathed by shipping, mining and commercial fishing. As it stands, just 13 percent of the world's oceans comprise intact ecosystems and are unrestrained from the effects of those anthropogenic stressors - which the team denominated as marine wilderness. In the same way, of the remaining underwater wilderness, less than 5 percent has a protected status (Cannon, 2018a).

Kendall Jones, a conservation scientist with the Wildlife Conservation Society and lead author of the study asserted in an interview (Cannon, 2018a):

> "We know how valuable and how unique places in the ocean [are] that don't have high levels of human activity."

One conclusion taken from this study is the way in which it highlights the rarity - not complete absence at this point - of marine wilderness near dense human populations and coastal areas. Generally speaking, these are the regions where a considerable number of marine protected areas are established. The result of this roughly ubiquitous range of the human population and their close proximity to these areas as led these protected places to still harbour endangered species and threatened ecosystems, but few of them can still be regarded as wilderness (Cannon, 2018a).

Jones again:

> "We're not saying that places aren't worthy of protection or conservation. But we argue that what's also important is to save those wild places that are still functioning as they once were."

Markedly, the remaining wild places mentioned appear to be situated at the poles and in the high seas. Effectively, the trial of getting through the sea ice around Antarctica and the Arctic and the ample distances that must be traversed to reach distant points in the open ocean have, to date, sheltered these areas. Although this may be true, Jones forewarns that the advances made in technology were permitting humans to penetrate deeper into the ocean in search of fish. Moreover, climate change melting the ice and opening up new parts of the once-impassible Arctic to fishing and mining is additional cause for concern for the surviving-wilderness (Cannon, 2018a).

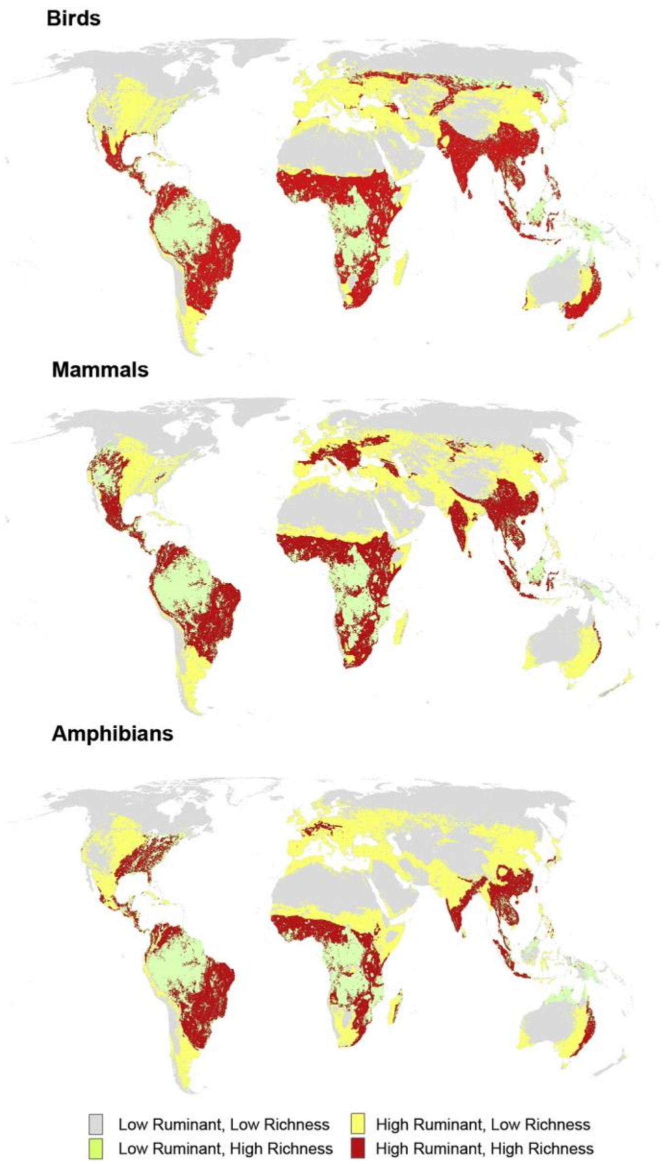


Figure 4.8: Maps indicating density (high or low) of ruminants (cattle, goats, sheep) (Wint & Robinson, 2007) and species richness (high or low) of birds, mammals, and amphibians (Pimm et al, 2014). Classification as 'high' indicate values above the mean value for all areas and 'low' indicate values below the mean value. Mean density value for ruminants = 5/km2. Mean species richness values (spp/100 km2) are: birds = 192, mammals = 56, amphibians = 16.

Given all the previous points examined, a paper in the journal *Science of the Total Environment* (2015) by Brian Machovina, Kenneth J. Feeley and William J. Ripple, declares that human consumption of meat is presumably to be "the leading cause of modern species extinctions." Livestock farming and production are wrecking natural habitats and driving the disappearance of species at multiple trophic levels with cascading repercussions on biodiversity and ecosystem function (Machovina, Feeley & Ripple, 2015) (figure 4.8).

In a study of risks to the world's largest terrestrial carnivores, 94 percent were found to be negatively afflicted by either habitat loss and/or persecution due to conflict with humans (Ripple et al, 2014). Furthermore, by being the largest motivation of global habitat loss, livestock are likely the most momentous explanation of the deterioration of large carnivores (Machovina & Feeley, 2014).

Persecution of carnivores via shooting, trapping or poisoning is more often than not a result of interactions with livestock (William Stolzenburg's book *Heart of a Lion - A Lone Cat's Walk Across America* (2016) narrates a detailed overview of this maltreatment and massacre of predators). The depletion of top predators can generate many negative trophic cascading repercussions within ecosystems (Ripple et al, 2014).

The plight of biodiversity decline that *Homo sapiens* and their ancestors initiated eons ago, still continues to this day, but what used to be by way of hunting, has now been largely revolutionized to shear displacement of habitat to produce crops to feed livestock that in turn will satisfy the voracious appetites of an ever-growing human population, as it is described in figure 4.8.

On that account, large wild herbivores are frequently facing dramatic population abatement and range contractions, such that ±60 percent are imperilled by extinction, with notable threats including hunting, land-use change, and resource depression by livestock (Ripple et al, 2015). Grazing livestock can also provoke a more direct backlash on entire ecosystems, such as riparian systems. For example, heavy grazing in riparian zones can originate vegetation loss, soil erosion and reductions of fish and wildlife (Beschta et al, 2013; Batchelor, Ripple, Wilson & Painter, 2015). The transmogrification of forests into pasture and the industrial production of feed crops also cause extensive soil erosion and downstream sedimentation of high diversity coastal habitats like coral reefs (Rogers, 1990). Manure effluent and large-scale and pervasive overuse of fertilizers for feedstock production, especially corn (West et al, 2014), also desecrate many waterways and are noteworthy contributors to the more than 400 dead zones that exist at river mouths worldwide (Diaz & Rosenberg, 2008).

The study conducted by Hallmann and colleagues in the journal *Plos One* (2017) that was briefly mentioned above, which asserts that in just three decades, insect populations have plummeted by more than 75 percent (figure 4.9) has also been linked to the agricultural and livestock revolution. Coincidentally enough, that is almost the same percentage (74 percent) of insects threatened with extinction in the Portuguese islands of the Azores, which have been assessed in the most recent update of the IUCN Red List, with habitat degradation aggravated by invasive plant species, land use shifts and a drying climate being pointed out as the main hazards (IUCN, 2018b).

The *Plos One* study (Hallmann et al, 2017) denotes that in recent years, insects have recorded a steep decline, with biomass dropping by some 82 percent in the summer, when insect populations peak. The scientists contemplated that exhaustive agriculture surrounding the nature reserves is the *raison d'être* for this insect collapse. Even though they don't have data on factors such as pesticide use in neighboring fields (Carrington, 2017a) the most likely cause of this 'Insectageddon' is that the land encompassing those reserves has become inhospitable to them: the volume of pesticides and the destruction of habitat have turned farmland into a wildlife desert (Monbiot, 2017b).

Under these circumstances, by evaluating the extent of damage already done, by relying on the total insect biomass would be a good metric for the condition of insects as a group and its contribution to ecosystem functioning, but scarcely any studies have overseen insect biomass over an extensive period of time (Shortall et al, 2009). Hence, to what length total insect biomass has diminished, and the relative contribution of each proposed factor to the deterioration, remain vague and open to question, yet relevant inquiries for ecosystem ecology and conservation (Hallmann et al, 2017).

On top of that, contemporary data indicates a comprehensive pattern of deterioration in insect diversity and abundance. As an illustration, populations of European grassland butterflies are supposed to have waned in their copiousness by 50 percent, between 1990 and 2011 (van Swaay et al, 2013). Moreover, the annual UK butterfly monitoring scheme (UKBMS) uncovered that 40 out of the 57 species studied saw numbers drop between 2015 and 2016 (Barkham, 2016), making 2016 the fourth worst year on record for the insects (Lyons, 2017).

At the same time, data for other well-studied taxa such as bees, which are a crucial and vital component of ecosystem stability (the exemplified volume of literature speaks for itself) (Goulson, Lye & Darvill, 2008; Nilsson, Franzén & Jönsson, 2008; Winfree, Aguilar, Vázquez, LeBuhn & Aizen, 2009; Potts et al, 2010; Ilyinykh, 2010; Ollerton, Erenler, Edwards & Crockett, 2014; Woodcock et al, 2016) and moths (Conrad, Woiwod & Perry, 2002; Conrad, Warren, Fox, Parsons & Woiwod, 2006; Fox, 2013; Fox et al, 2014) suggest the same trend. Climate change, habitat loss and fragmentation, and deterioration of habitat quality have been proposed as some of the prime suspects responsible for the decline (Nilsson et al, 2008; Winfree et al, 2009; Potts et al, 2010; Ollerton et al, 2014; Fox et al, 2014; Brändle, Amarell, Auge, Klotz & Brandl, 2001; Benton, Bryant, Cole & Crick, 2002; Morecroft, Bealey, Howells, Rennie & Woiwod, 2002; Biesmeijer et al, 2006).

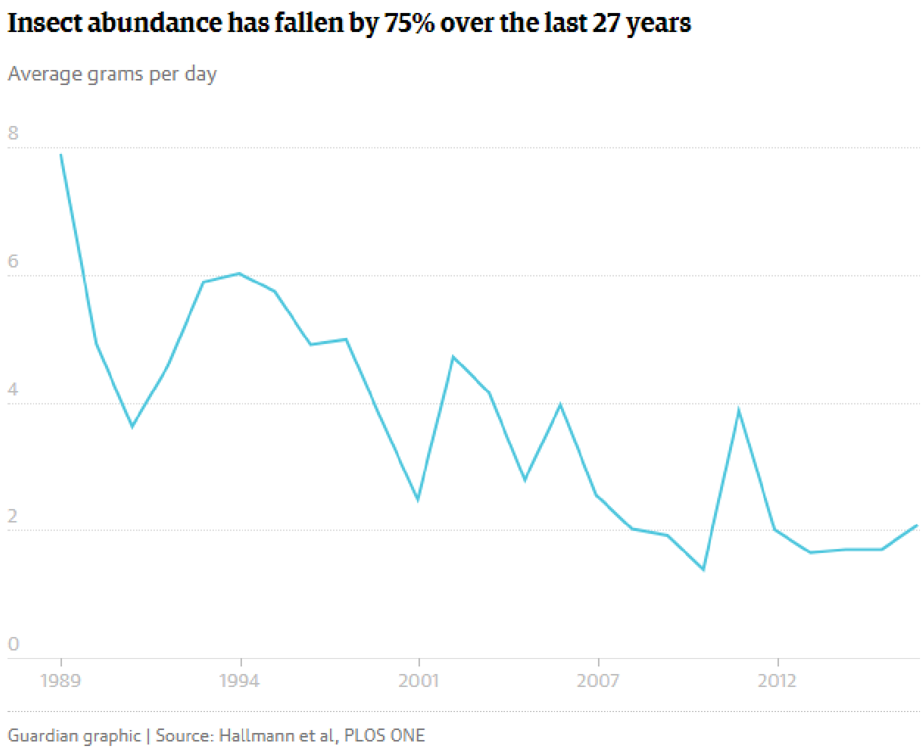


Figure 4.9: Insect abundance has fallen by 75 percent over the last 27 years. Guardian graphic / Source: Hallmann et al, 2017. PLOS ONE.

But perhaps the most disquieting aspect of this research is the realisation that these ominous drops in insect numbers were taking place in nature reserves - strictly speaking this means that areas, where the landscape received some status of protection and limitation from human activities, as well as being more inviting to insects, were undergoing profound changes. The researchers assert that conditions ought to be much worse, outside of these areas (McKie, 2018).

As the professor of entomology Simon Leather of Harper Adams University sustains in an interview for *The Guardian* entitled *Where have all our insects gone* by Robin McKie (2018):

> "There have been massive alterations to the way we use the land and it is hard not to believe these are closely involved in what we are seeing." (McKie, 2018)

As he calls attention to, intensively farmed wheat and cornfields sustain virtually no insect life, consequently as farming practices to feed an ever increasing and more rapacious population propagate, there are fewer refugees of natural habitat left to support them (McKie, 2018).

Equally important and many times left out of the debate almost entirely is the issue of urban sprawl. As human population increases and individuals settle in uncharted areas or expand their settlements, these housing schemes keep on encroaching on heaths and wooded areas, and as a result, streets and buildings produce light pollution that drives insects off course, inducing challenges for their mating rites (McKie, 2018).

Michael McCarthy writes for *The Guardian* (2017) about the cause of this "ecological catastrophe":

> "It seems indisputable: it is us. It is human activity - more specifically, three generations of industrialised farming with a vast tide of poisons pouring over the land year after year after year, since the end of the Second World War. This is the true price of pesticide-based agriculture, which society has for so long blithely accepted."

McCarthy adjoins:

> "So what is the future for 21st-century insects? It will be worse still, as we struggle to feed the nine billion people expected to be inhabiting the world by 2050, and the possible 12 billion by 2100, and agriculture intensifies even further to let us do so."

He concludes with a dire note:

> "It is the most uncomfortable of truths, but one which stares us in the face: that even the most successful organisms that have ever existed on earth are now being overwhelmed by the titanic scale of the human enterprise, as indeed, is the whole natural world."

Consequently, it seems that the consensus among many entomologists is that an insect Armageddon is underway, which is the result of a multitude of anthropogenic consequences such as pollution, habitat changes, overuse of pesticides and global warming (McKie, 2018). Still, the most likely explanation of this "Insectageddon" is that the land encompassing those reserves has become adverse to them: the volume of pesticides and the destruction of habitat have converted farmland into a wildlife desert (Monbiot, 2017b).

As the notorious Harvard biologist Edward O. Wilson echoes, [the insects] "are the little things that run the world," which follows a previous statement when Wilson vehemently affirmed:

> "If all humankind were to disappear, the world would regenerate back to the rich state of equilibrium that existed 10,000 years ago. If insects were to vanish, the environment would collapse into chaos" (McKie, 2018).

Unfortunately, coupled with the demise of insects, ripples have begun to reverberate across the ecosystems and their trophic cascades, with the first indirect victim being insect-eating birds (Vogel, 2017). Agricultural intensification (Fox, 2013; Benton et al, 2002) (e.g. pesticide usage, year-round tillage, heightened use of fertilizers and frequency of agronomic measures) may constitute a plausible cause. With this in mind, part of the justification could therefore be that the protected areas (operating as insect sources) are overwhelmed and drained by the agricultural fields in the broader surroundings (serving as sinks or even as ecological traps (Öckinger & Smith, 2007; Battin, 2004; Gilroy & Sutherland, 2007; Furrer & Pasinelli, 2016).

In March 2018, the French news media *Le Monde* ran a piece about two independent studies conducted by the French National Museum of Natural History and another from the National Centre of Scientific Research (CNRS), which pointed to the same conclusion. In the last 15 years, a third of the population of dozens of species of birds in rural areas of the interior of France have disappeared (Foucart, 2018). With around 45 percent of the EU's land area already been converted and transmogrified into farmland, the bird species that rely upon this particular niche have seen an average decline of a third (Barkham, 2018a).

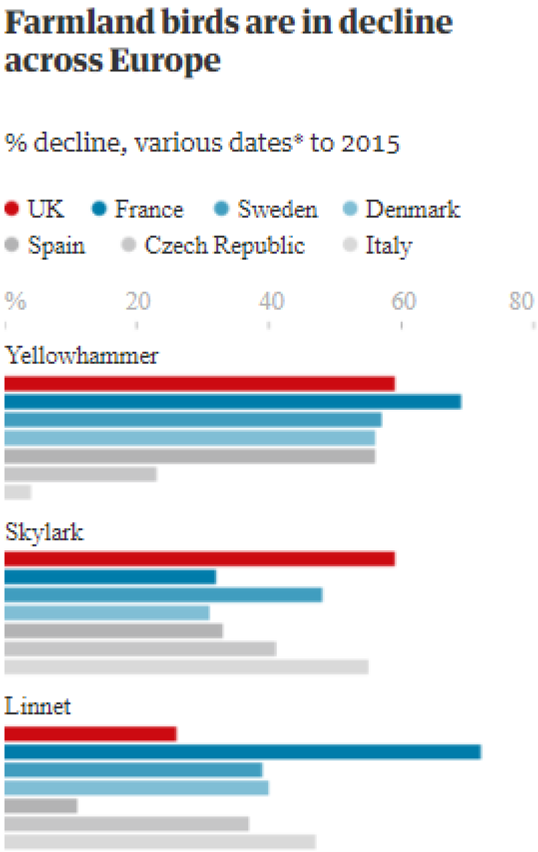


Figure 4.10: Farmland birds are in decline across Europe. *The Guardian* graphic. Source: EBCC, Birdlife International, RSPB, CSO. *1980 (UK, Sweden, Denmark), 1982 (Czech Rep.), 1989 (to 2014, France), 1998 (Spain), 2000 (Italy). Retrieved from Barkham, 2018b.

The *Agence France-Presse* is reported in *The Guardian* (2018) citing the words, "the situation is catastrophic," divulged by Benoit Fontaine, a conservation biologist at France's National Museum of Natural History and co-author of one of the studies. Fontaine discloses:

"Our countryside is in the process of becoming a veritable desert."

Species like the common white throat, the ortolan bunting, the Eurasian skylark and other once-ubiquitous species have all dwindled by at least a third, while others, like the migratory songbird, the meadow pipit, have languished by nearly 70 percent, and the partridges by 80 percent (Barkham, 2018a), according to a detailed, annual census introduced at the start of the century (Agence France-Presse, 2018), which is depicted in detail in figure 4.10. The survey also states that the disappearance of farmland species intensified in the last decade, and again over the last two summers (Barkham, 2018a). The Museum describes the celerity and extent of the downfall as:

"A level approaching an ecological catastrophe."

The researchers excogitate that the prime candidate behind the ecological meltdown is the intensive use of pesticides - such as neonicotinoids - on vast tracts of monoculture crops, especially wheat and corn (Agence France-Presse, 2018). As previously described, the insects on which the birds depend as a source of food are disappearing, thus affecting their populations. Corroborating this link between insect and bird population declines, is recent research from Aberdeen University by Chloe Denerley and colleagues (2018), which detailed how a plunge in numbers of cuckoos in areas of England is associated to tremendous contractions in tiger moth caterpillars, that the cuckoos use for nourishment (McKie, 2018).

According to Prof Richard Gregory of the Royal Society for the Protection of Birds (RSPB) Centre for Conservation Science, there is a strong correlation separating higher cereal harvests and a decrease in farmland birds (Barkham, 2018b). Gregory voices his concern:

"It's a worrying signal that ecosystem health and function is being severely impacted by the changes in farming and the drive to use more intensive methods" (Barkham, 2018b).

David Gibbon, also from the RSPB reinforced with:

"There is now a lot of correlational evidence to show that when certain insects do badly, very often the birds that feed on them get into trouble as well" (McKie, 2018).

There are hardly any insects left, that's the number one problem," asserts Vincent Bretagnolle, a CNRS ecologist at the Centre for Biological Studies in Chize. He adds, "All birds are dependant on insects in one way or another. Even granivorous birds feed their chicks insects and birds of prey eat birds that eat insects. If you lose 80 percent of what you eat you cannot sustain a stable population" (Barkham, 2018a).

Bretagnolle avows that: "What is really alarming, is that all birds in an agricultural setting are declining at the same speed of even 'generalist' birds," which also thrive in other settings such as wooded areas. "That shows that the overall quality of the agricultural ecosystem is deteriorating," he explains (Agence France-Presse, 2018).

In another piece in *The Guardian,* entitled *Europe faces 'biodiversity oblivion' after collapse in French birds, experts warn* (Barkham, 2018a), Bretagnolle defends that:

> "We've lost a quarter of skylarks in 15 years. It's huge, it's really, really huge. If this was the human population, it would be a major thing. We are turning our farmland into a desert. We are losing everything and we need that nature, that biodiversity - the agriculture needs pollinators and the soil fauna. Without that, ultimately, we will die."

Evidently, and as David Gibbons of the RSPB upholds, not every investigation about insect numbers divulged a trend of irrevocable contraction - this is just how nature works, if some populations of species decrease and seize to monopolize resources and space, an ecological niche opens up and other species better suited to handle the stress factors will take their place if these are not too aggressive for them to maintain their populations - although Gibbons asserts that the overall picture is disquieting, while stating:

> "It is hard not to see a link between some of the bird number declines and drops in insect populations we are experiencing. There are very close correlations in many cases. But proving there is a causative link - in establishing the one effect is leading to the other - is much more difficult" (McKie, 2018).

Despite the depletion of their main food source, the scientists claim there are other drivers behind the atrophy of the populations such as shrinking woodlands, the absence of the once common practice of letting fields lie fallow and especially rapidly expanding expanses of mono-crops have each played a role (Agence France-Presse, 2018).

But the calamitous decline in French farmland birds flags a deeper biodiversity contingency in Europe which ultimately imperils and implicates all humans, since it is enforced by the need to feed a growing and more affluent human populace. With intensive crop production emboldened by the EU's common agricultural policy in all likelihood driving the bird population declines, conservationists are warning that many European countries are facing a second "silent spring" - a term coined by the ecologist Rachel Carson to describe the blight in bird populations in the 1960s caused by pesticides (Barkham, 2018a).

The abatements in France epitomizes plunges across Europe: the abundance of farmland birds in 28 European countries has fallen by 55 percent in the past three decades, testified by the figures collated by the European Bird Census Council (figure 4.9 and 4.10) (De Jong, 2017). Among 39 species ordinarily found on European countryside, 24 have declined and only six have heightened in numbers, with the white stork being one of the few triumphant stories, with its revival linked to an upsurge in artificial nesting sites being provided in towns (Barkham, 2018a). In Portugal, the situation does not seem to be all that different. The plight affecting the *Streptopelia turtur* and the *Lanius senator* has not gone unnoticed, with a decrease in the respective populations between 2004 and 2014 of 54 and 65 percent, respectively (Lopes, 2018).

Joaquim Teodósio, coordinator of the Department of Terrestrial Conservation of the Portuguese Society for Bird's Study (SPEA) had the following to say in an interview for the *PÚBLICO* (2018) newspaper:

> “The state of decline of species associated with agricultural habitats is confirmed, although, by the lack of samples on the ground, it is hard to have substantial data for most of the species.”

Iván Ramírez, head of conservation for Birdlife Europe & Central Asia, disclosed that Europe is facing “biodiversity oblivion” on its farmland, with scientific literature accrediting the loss of birds to EU farming subsidies (Ramírez, 2017). Ramírez upholds that countries freshly joining the EU show declines in farmland birds (figure 4.11), while populations have managed better in non-EU states in eastern Europe, where agricultural practices became less intensive after the dismantling of the Soviet Union (Barkham, 2018a).

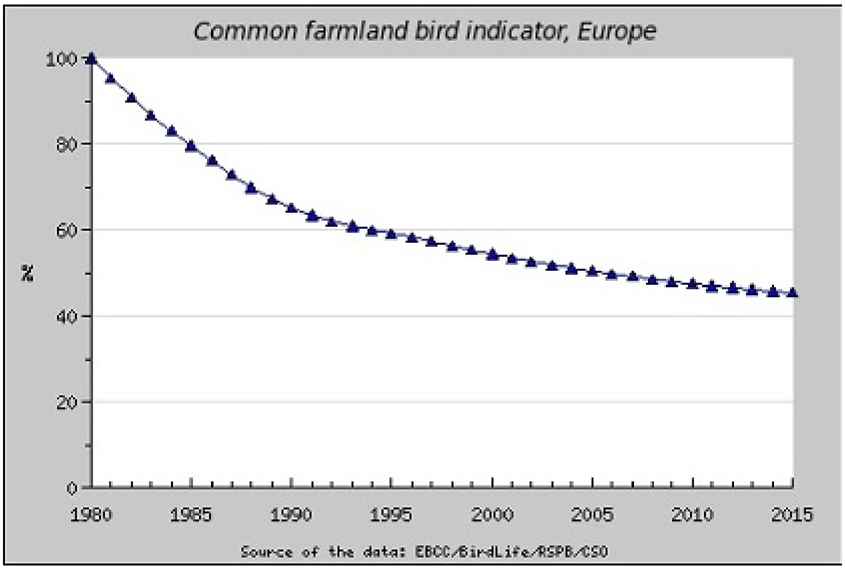


Figure 4.11: Common Farmland Bird Indicator, Europe, 2015 update. Retrieved from Birdlife International (2015)

Martin Harper, director of conservation for the RSPB in the UK, asserts:

> “In the UK the situation is just as concerning. Our beleaguered farmland birds have declined by 56 percent (figure 4.11, above) between 1970 and 2015 along with declines in other wildlife linked to changes in agricultural practices, including the use of pesticides. We urgently need action on both sides of the Channel, and this is something we hope to see from the governments of the UK as we prepare to leave the EU” (Barkham, 2018a).

Even though the French government aims to reduce by fifty percent the use of pesticide by 2020, sales have soared, reaching more than 75,000 tonnes of active ingredient in 2014, according to EU figures (Barkham, 2018a). Not only that, but Europe’s crisis of collapsing bird and insect numbers will worsen even further over the next decade due to the EU being in a “state of denial” over destructive farming methods, environmental groups are warning. They claim the European agriculture ministers are pushing for a new common agricultural policy (CAP) from 2021 to 2028 which preserves bounteous subsidies for big farmers (Harvey, 2016) and unavailing or even “fake” environmental or “greening” measures, they assert (Barkham, 2018b).

“The whole system is in a state of denial,” reports Ariel Brunner, head of policy at Birdlife Europe. “Most agriculture ministers across Europe are just pushing for business as usual. The message is, keep the subsidies flowing.” Correspondingly, farm subsidies exhaust 38 percent of the EU budget and 80 percent of the subsidies go to just 20 percent of farmers and accounting for a market of 39£bn each year (The Anglo Celt, 2018). A smaller portion - £14.22bn annually - of EU farm subsidies supports “greening” measures. These greening measures have been immensely criticized with some of their opponents voicing concerns such as Birdlife Europe saying the “greening” was mostly “fake environmental spending.” Harriet Bradley, agriculture policy officer at Birdlife Europe, holds that: "It's a massive scandal but the farm lobby is so powerful it hasn't penetrated public consciousness." (Barkham, 2018b).

Not only the Birdlife Europe, but the European Court of Auditors (ECA), the EU's independent auditor with the responsibility of protecting the interests of EU taxpayers has intervened in this affair, concluding in December 2017 that the greening measures were "unlikely to provide significant benefits for the environment and climate" because the practices were affecting just 5 percent of EU's farmland (European Court of Auditors, 2017).

The ECA adjoins:

> "Member states use the flexibility in greening rules to limit the burden on farmers and themselves, rather than to maximise the expected environmental and climate benefit."

Although a study of 60 English farms found that 12 of 17 priority farmland bird species increased in number between 2008 and 2014, against the national 56 percent decline since 1970, testifying that paying farmers to use about 10 percent of their land to support birds and other wildlife may have benefits, experts from the Royal Society for Protection of Birds say such schemes will have to be tremendously amplified in size to prevent further falls in numbers (Carrington, 2018b). Joaquim Teodósio of SPEA says (Lopes, 2018) that to invert this reality there will need to be an:

> "Incentive to agricultural practises that will contribute to the maintenance of biodiversity [and] the protection of important zones in terms of their natural value and resources."

Teodósio concludes:

> "That protection will have to stem from the proprietaries that hold the zones. But [the proprietaries] don't have the expected return from the maintenance of those areas and prefer to create intensive olive groves or almond trees. It is necessary that they have the required incentives to keep those zones" (Lopes, 2018).

Chris Packham, the beloved British naturalist, activist and presenter has declared in a piece for *The Guardian* (Barkham, 2018c) that Britain is progressively becoming "a green and unpleasant land" and that the people are supervising "an ecological apocalypse." According to Packham, British people have normalised a "national catastrophe" and only pay attention to the wealth of life in nature reserves, with the vast and immense countryside dispossessed of life.

> "Nature reserves are becoming natural art installations. It's just like looking at your favourite Constable or Rothko. We go there, muse over it, and feel good because we've seen a bittern or some acovets or orchids. But on the journey home there is nothing- only wood pigeons and non-native pheasants and dead badgers on the side of the road. It's catastrophic and that's what we've forgotten - our generation is presiding over an ecological apocalypse and we've somehow or other normalised it."

Packham has brought to attention a disquieting fact. In a cluster of *tweets* (Packham, 2018) he expounded the absenteeism of insects in his home in the middle of the New Forest national park. Packham reflected on the fact that he didn't see a single butterfly in his garden, and even sleeping with his window opened resulted in esoteric and limited encounters with crane flies or moths, even though, when he was a boy the outcome would have been completely dissimilar (Barkham, 2018c).

In the specific case of Britain, since 1970, the country has obliterated 90 million wild birds, with turtle doves subsiding by 95 percent since 1990 (British Trust for Ornithology, 2017), plunging the species to extinction. Moreover, the State of Nature 2016 report characterized Britain as being "among the most nature-depleted countries in the world," with scientific data from a deluge of more than 50 conservation and research organisations disclosing that 40 percent of all species are in moderate or precipitous recession (Barkham, 2018c).

Coupled with this, British mammals are also fighting for survival, according to the first thorough and exhaustive review of their populations, by The Mammal Society and Natural England (Mathews et al, 2018). The study upholds that 20 percent of wild mammals in the UK are facing a dying out, with 165 species in a state of critical danger (Population Matters, 2018c), with the red squirrel, wildcat and the grey long-eared bat all catalogued as facing fierce threats (The Mammal Society, 2018).

The study enlisted the usual suspects as the malefactors, with climate change, loss of habitat, use of pesticides and disease as main drivers - all of which can be associated with population growth (Population Matters, 2018c). As Professor Fiona Mathews, chairwoman of the Mammal Society maintains:

> "Now obviously we're living in a country that's changing enormously - we're building new homes, new roads, new railways, agriculture's changing - so it's really important we have up to date information so we can plan how we're going to conserve British wildlife" (Population Matters, 2018c).

Given these points, Packham contends that:

> "We need a peaceful public uprising. We need people to say we've had enough. We do that every time there's a terror attack. We need a similar movement for nature. We need people to stand up and say we want action now. We have the ability to fix our countryside" (Barkham, 2018c).

On an unusual positive note, in early May 2018, the European Union member states declared a decision to ban the outdoor use of neonicotinoid pesticides, - that have been found in honey (MacKenzie, 2017) - after an assessment by the European Food Safety Authority (EFSA, 2018), that settled the case and corroborated that their use is a hazard to bees (Wong, 2017).

Antonia Staats, senior campaigner at Avaaz, which had led a petition supported by five million signatures to ban the chemicals, proclaimed:

> "Finally, our governments are listening to their citizens, the scientific evidence and farmers who know that bees can't live with these chemicals and we can't live without bees" (New Scientist & Press Association, 2018).

Emi Murphy, bee campaigner at Friends of the Earth exclaimed, in an interview for the *New Scientist* (2018):

> "This is a major victory for science, common sense and our under-threat bees. The evidence that neonicotinoid pesticides pose a threat to our bees is overwhelming. Farmers now need the support they need to grow food without bee-harming pesticides."

"*Be[e]*" that as it may, how farmers supplant the pesticides will be crucial, says Dave Goulson of the University of Sussex, UK, again, to the *New Scientist* (2018):

> "If these neonicotinoids are simply replaced by other similar compounds such as sulfoxaflor, cyantraniliprole and flupyradifurone (all new systemic insecticides), then we will simply be going round in circles. What is needed is a move towards truly sustainable farming methods that minimise pesticide use, encourage natural enemies of crop pests, and support biodiversity and healthy soils."

Politics aside, the reality is that the CAP system is the reflection of a policy that has been pushing for an agricultural intensification in order to provide the yields for a swelling and ever more rapacious European population. The ecological deterioration and biodiversity dilapidation are but side effects of the anthropocentrism that elevates human needs to a pedestal and prioritizes their longings over the entire spectrum of life on Earth. As Tim Palmer (2012) describes regarding the havoc inflicted on endangered frogs:

> "In the end, people will demand to be accommodated; endangered frogs are no match against human suffering, real or imagined. The losses might be resisted for a while, that is what environmentalists are doing, but not for long."

Published in *Nature Ecology and Evolution*, the research, *A biodiversity-crisis hierarchy to evaluate and refine conservation indicators,* Don A. Driscoll and colleagues (2018) state clearly that human population is a key driver of biodiversity loss. *ABC News* (Kilvert, 2018) picks up on their message which stands as:

> "We need to focus on limiting human population growth, reducing resource consumption, and cracking down on government corruption, if we're going to stop the global loss of species known as the sixth great extinction."

Euan Ritchie, one of the authors of the study proclaims that:

> "Although key threats to biodiversity include habitat clearing for cattle, mining, and urban sprawl, these are all consequences of population pressure and high rates of resource consumption."

In their research, they assessed the 2020 targets of the Convention on Biological Diversity (CBD) - the world's principal conservation strategy to which 196 are signatories. The paper concludes that many of the global biodiversity conservation objectives, known as the Aichi targets, are insubstantial and impaired of key indicators to measure the effects of governments, human population size, corruption and "threat industries" like mining (Kilvert, 2018).

Subsequently, they claim the targets are failing to stall the catastrophic decline of species worldwide and require an urgent emendation to encompass all the major drivers of species loss (Kilvert, 2018). The paper (Driscoll et al, 2018) states:

> "Ignoring major drivers is a fundamental flaw of the current set of targets and indicators".

Although the paper has a global range, Euan Ritchie claims that Australia's excessive extent of mammal species loss means there is a lot of work to be made to halt biodiversity demise in the country. Euan Ritchie criticizes:

> "We have the worst record in the world on mammal conservation, with 30 species likely to have become extinct since European settlement. In terms of the big issues for biodiversity loss in Australia, they are habitat loss which is associated with urbanisation, agriculture and extractive industries such as mining."

Environment and policy researcher Saran Bekessy, from RMIT in Melbourne, Australia agrees, adjoining (Kilvert, 2018) that there needs to be a greater liability from industry for its position in species and habitat loss:

> "I completely agree that a conservation crisis is driven by people. I think we need to keep industry accountable for their biodiversity impacts. Industry is allowed to literally kill threatened species and eliminate their habitat and it's all OK because we can offset it somehow. That's a really bad policy that leads to us undervaluing the uniqueness of biodiversity."

Despite the fact that the association between corruption and biodiversity loss has been well-documented in several countries like Indonesia (Kilvert, 2017; Smith et al, 2003), Madagascar (Gore, Ratsimbazafy & Lute, 2013) as well as other African countries (Whitfield, 2003), Guatemala, Paraguay, Cambodia and Sierra Leone (Wright, Azofeifa, Portillo-Quintero & Davies, 2007), Euan Ritchie said more could be done in Australia to reduce conflicts of interest:

> "We need urgent changes to our laws relating to political donations and disclosure of potentially vested interests. Both major political parties receive large donations from fossil fuel companies and extractive industries. And if they're making decisions about biodiversity at the same time as development, then obviously there's a potential conflict of interest there."

Corruption can have a substantial effect on nature conservation by promoting overexploitation of forests, wildlife, fisheries and other resources, and by waning the effectiveness of conservation programs (Smith, Muir, Walpole, Balmford & Leader-Williams, 2003). Many ecosystems, such as species-rich tropical forests and coral reefs, which are largely circumscribed to developing countries, and temperate and boreal forests in Asia and South America, are highly susceptible (Smith et al, 2003; Myers, Mittermeier, Mittermeier, da Fonseca & Kent, 2000; Roberts et al, 2002). With the addition of Africa, these are also the regions of the globe which are experiencing the greatest population growth (UNDESA, 2017).

Coupled with all the grim research presented so far throughout this segment, on the rampant ramifications of the 'Anthropocene,' comes the latest report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2018), which was divided into four regional reports, with more than 550 experts from over 100 countries and taken three years to complete (Watts, 2018a).

The authors state in what is the most comprehensive biodiversity study in more than a decade that human destruction of nature is rapidly disintegrating the planet's ability to provide food, water and security to billions of people. Such is the rate of degeneration that the risks associated with biodiversity loss should be treated on the same scale as those of climate change, the authors evince, while calling attention to the biggest threats to nature stemming from habitat loss, invasive species, chemicals and climate change, all products of human presence and activity (Watts, 2018a), and if left unchecked will become major components in the intensification of conflict and mass human migration, forcing as many as 700 million to migrate by 2050 (Leahy, 2018).

Some of the key aspects being highlighted in the report from IPBES are:

- Human activities, primarily those associated with agriculture and urbanization, have maraud or ravaged topsoil, forests, and other natural vegetation and water resources, virtually, on a global scale, with less than 25 percent of the Earth's land surface avoiding the substantial impacts of human activity. It is foreseen that by 2050, this will have decreased to 10 percent, with future impact ramifications taking place in Central and South America, sub-Saharan Africa, and Asia (Leahy, 2018).
- In the Americas, more than 95 percent of high-grass prairies have been transmogrified into farms, along with 72 percent of dry forests and 88 percent of the Atlantic forests, notes the report (Watts, 2018a). Climate change is expected to outstrip habitat loss by 2050 as the key driver for biodiversity loss. Currently, the average populations of species in a given area are 31 percent less than when the Europeans settled in the Americas (Coghlan, 2018). This will increase to 40 percent over the next decade unless policies and behaviours are utterly changed (Watts, 2018a).
- Wetland ecosystems are among the most tarnished, with nearly 50 percent loss since 1900 (Gilbert, 2018) and 87 percent lost globally in the last 300 years. The ruination of

wetlands progresses in Southeast Asia and the Congo region, mainly to plant palm trees to extract the oil (Leahy, 2018).

- The extent of renewable fresh water available per capita has decreased 50 percent since the 1960s (Coghlan, 2018). Obviously, this water is not just a resource for humans to capitalize and gorge upon, countless other species depend on it for their survival and proliferation. If the freshwater is being appropriated solely for human consumption, and due to population growth and per capita affluence increasing, its appropriation becomes a key aspect of ecological catastrophe.
- The Amazon rainforest is still mostly unscathed, but it is expeditiously languishing and deteriorating along with an even faster-perishing cerrado (tropical savanna), owing to the doubling of the area cultivated in Brazil's northeast agricultural frontier, in an interval of ten years from 2003 to 2013 (Watts, 2018a).

With this in mind, Achim Steiner, administrator of the UN Development Programme (Watts, 2018a) has declared:

> "The world has lost over 130m hectares of rainforest since 1990 and we lose dozens of species every day, pushing the Earth's ecological system to its limit. Biodiversity and the ecosystem services it supports are not only the foundation for our life on Earth, but critical to the livelihoods and well-being of people everywhere."

- Fish-stocks along Asia-Pacific coastlines will completely collapse by 2048. This is also home to the most populous human region in the world (Coghlan, 2018). As previously mentioned, but also present in the report is Europe's excessive use of pesticides and fertilizers promoted by subsidies that instigate farmers to overproduce food (Gilbert, 2018).
- Global crop yields are foreseen to fall by an average of 10 percent in the next 30 years due to a mixture of land degradation, climate change, pollution and loss of ecosystem services and functions resulting from severe biodiversity annihilation (Gilbert, 2018).
- 90 percent of corals in the region will undergo a relentless degeneracy (New Scientist staff & Press Association, 2016) by 2050, even under moderate climate change scenarios (Coghlan, 2018).
- Human societies in the African continent will be the ones most hard hit by not safeguarding its biodiversity since 62 percent of the rural population rely directly on services provided by the ecosystems, more than anywhere else (Coghlan, 2018).

This becomes urgent in itself since the report states that 500,000 hectares have been turned completely barren by a mix of deforestation, unsustainable agriculture, overgrazing, uncontrolled mining, invasive species and climate change - which have led to soil erosion, salinisation, pollution and loss of vegetation. It is expected that by 2100, climate change could decimate half of Africa's bird and mammal species, and sap the available water from African lakes by 30 percent (Coghlan, 2018). The human population of Africa has risen from 140 million in 1900 to a billion in 2010. According to the United Nations "medium scenario" projection, this figure will rise to 2.5 billion in 2050 and more than 4 billion in 2100 (Pison, 2017c).

Robert Watson, chair of the IPBES asserted the following while being interviewed by *U.S. News & World Report* (Borenstein, 2018):

> "What is happening is a side effect of the world getting wealthier and more crowded with people. Humans need more food, more clean water, more energy and more land. And the way society has tried to achieve that has cut down on biodiversity. Crucial habitat has been cut apart, alien species have invaded places, chemicals have hurt plants and animals, wetlands and mangroves that clean up pollution are disappearing, and the world's waters are overfished."

Watson added in another statement (Georgiou, 2018):

> "Biodiversity and nature's contributions to people sound, to many people, academic and far removed from our daily lives, but nothing could be further from the truth - they are the bedrock of our food, clean water and energy. They are at the heart not only of our survival, but of our cultures, identities and enjoyment of life. We must act to halt and reverse the unsustainable use of nature - or risk not only the future we want, but even the lives we currently lead."

Watson expands on what role nations and each and one of us can have locally, in an interview to *Motherboard* (2018):

> "Those choices include choosing to eat less meat and buying food from local growers who use the most sustainable farming practices. Up to 40 percent of food is wasted globally at various points, from farms to overstuffed refrigerators. Countries also need to end their production subsidies in agriculture, fisheries, energy, and other sectors. Rich countries need to take responsibility for the impacts that their consumption of imported products may have. The country landscape of the United Kingdom is a tourist attraction because the country imports 35 to 40 percent of its food from other countries. People don't see the impacts of their consumption. Ending land degradation and restoring damaged lands would provide more than one third of the most cost-effective greenhouse gas mitigation activities required by 2030 to keep global warming to below 2°C. And doing this would cost at least three times less than doing nothing and create much better livelihoods and jobs for local people."

As I have tried to delineate throughout this chapter, this biodiversity defalcation is real, it's happening and it is the result of anthropogenic presence and activities. Fortunately enough, some people are noticing this transubstantiation of life and the evidence of foul play continues to amalgamate. Thereupon, it becomes evident that the plausibility of this rapid defaunation lies in the imminent causes of population extinctions: habitat conversion, climate disruption; overexploitation, toxification, species invasions, disease – all linked to one another in complex patterns and usually strengthening each other's consequences. Much less generally mentioned are, still, the ultimate drivers of those existing causes of biotic destruction, namely, human over-consumption, especially by the rich, and not to mention, human overpopulation and continued population growth (Ceballos et al, 2017).

As a matter of fact, the highest-ranked menaces against species listed in any precarious categories are all partly impelled by population growth, which encapsulates overexploitation, agricultural expansion, urban development, invasive species, pollution, and climate change (by that order) (Maxwell, Fuller, Brooks & Watson, 2016; Götmark et al, 2018). These drivers, all of which come back to the fable that ceaseless growth can occur on a finite planet, are themselves snowballing rapidly. All the warnings and symptoms point to ever more powerful assaults on biodiversity in the next two decades, painting a despondent and disheartened picture of the future of life, including human life (Ceballos et al, 2017).

Up next, I put up to the test, on short segments, how human overpopulation and this persistent, as well as recalcitrant population augmentation, is multiplying the threats that imperil fauna and flora (figure 4.12, next page). The coming segments will delve into conflicts and warfare scenarios, that end up affecting the local fauna and flora, as well as an examination into the deleterious state of affairs regarding poaching and subsistence hunting for an expanding populace that is literarily creating a condition called "Empty Forest Syndrome. I will come back to the ruinous after effect of livestock and land-use change in the next chapter, Hunger Games.

Afterwards, I probe over the literature on human population density and how it correlates with the contemporary defaunation. To conclude with a more upbeat note, I will end with present-day efforts of conservation, restoration of ecosystems and rewilding of species.

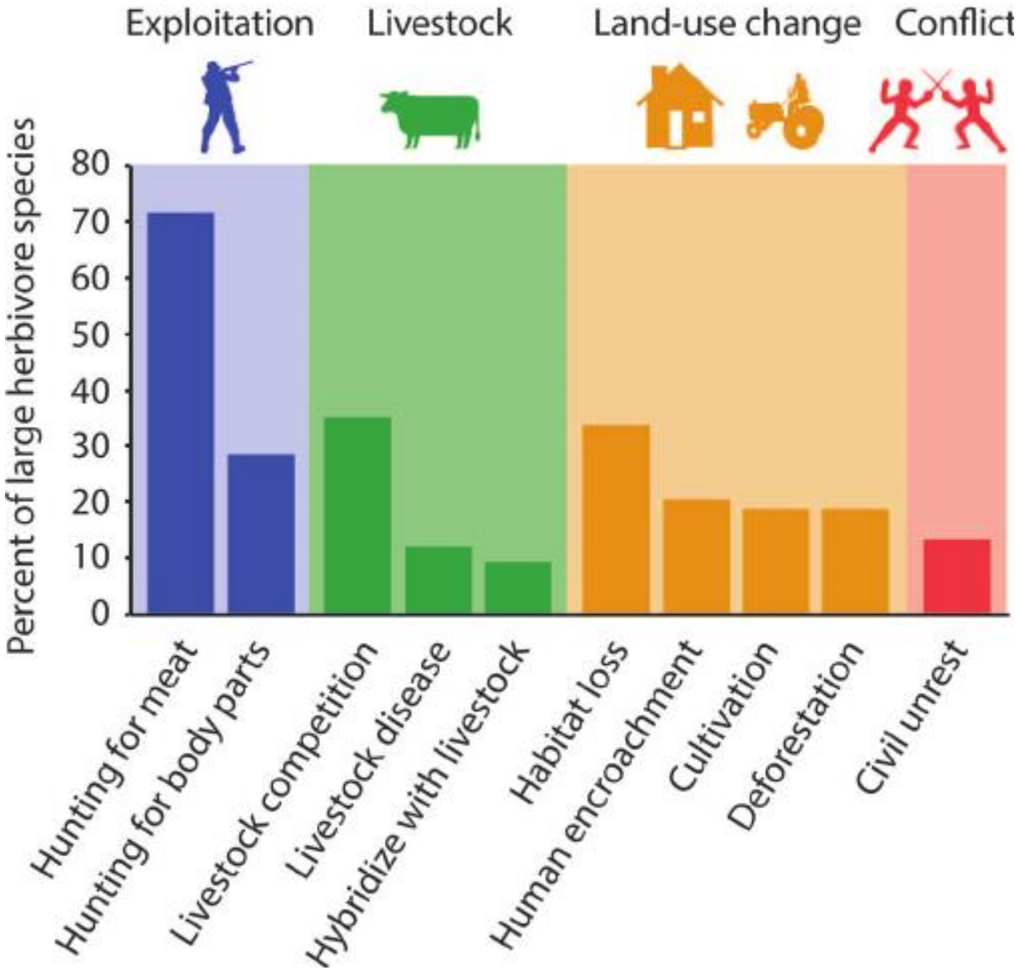


Figure 4.12: Proximate threats faced by large herbivores globally. Threats faced by each species were categorized using information in the IUCN Red List species fact sheets. The total adds up to more than 100% because each large herbivore species may have more than one existing threat. Retrieved from Ripple et al, 2015.

Scorched-Earth

- When the World of Man Violently Collides With the Natural World -

"War doesn't determine who's right, only who's left."

- Bertrand Russell

At least since Malthus (1826) it has been maintained that more sizable populations increase a country's risk of sustaining civil conflict, through a contraction in per capita output of agricultural goods due to a fixed supply of fertile land. Malthus (1798/1998, p.22) claimed that in the midst of population-induced resource scarcity a 'struggle for existence' ensues. The causal relationship between conflict and population growth is further explored in the chapter Hunger Games. In this segment, I focus solely, on the wildlife declines potentiated by rising conflict between humans and between humanity and the rest of life.

Over the past 70 years, humans have, repeatedly, waged war in the world's most biodiverse regions. Between 1950 and 2000, more than 80 percent of wars overlapped with biodiversity hotspots (Hanson et al, 2009). Collier and Hoeffler (2004) and Fearon and Laitin (2003) found robust evidence involving countries with larger population sizes to be prone to a higher risk of intra-state war. Other empirical panel-data studies strengthen this assumption, finding similarly adverse effects of population size on civil conflict (Hegre & Sambanis, 2006).

The authors say:

> "We confirm that a large population and low per capita income increase the risk of civil war, and this is consistent with many studies of civil war" (Hegre & Sambanis, 2006).

Given this overlapping of warfare and wildlife hotspots, the on-going Anthropogenic biodiversity genocide might further escalate and jeopardize the world's last remaining assemblages of diverse large-mammal populations, which play important roles in ecosystems and in many local, regional, and national economies (Ripple et al, 2015; Ceballos & Ehrlich 2002; Dirzo et al, 2014). The acknowledgement of these impacts of war on the environment have led to the creation of a subfield known as warfare ecology (Hanson, 2011).

Although cases studies have divulged that conflict can have either positive or negative local impacts on wildlife (Gaynor et al, 2016; Hanson et al, 2009; Hallagan, 1981), with some of the negative repercussions emanating directly from the use of ordnance and chemicals (Orians & Pfeiffer, 1970), bushmeat hunting by soldiers (Beyers et al, 2011; de Merode et al, 2007), and transactions in ivory and other wildlife products to finance military activity (Dudley, Ginsberg, Plumptre, Hart & Campos, 2002), they can also emerge indirectly from the crippling of local institutions and the disruption of livelihoods and norms (de Merode et al, 2007). On the other hand, war can also unwind pressure on wildlife when people avoid combat zones (Hallagan, 1981) or are tactically disarmed (Gaynor et al, 2016), or when extractive industries dwindle (Gaynor et al, 2016; Butsic, Baumann, Shortland, Walker & Kuemmerle, 2015).

Arianna Pittman, the author of *How Habitat Loss is Causing Human Wildlife Conflict around the World*, wrote in an unadorned and grim fashion in *OneGreenPlanet.org* (2017) how:

> "Animal habitats are disappearing at alarming rates, making habitat loss the biggest threat to animal's existence. Deforestation and degradation from logging, animal agriculture, and the palm oil industry have leveled massive amounts of rainforest in South America, forcing animals into ever-shrinking habitats and destroying villages. As the global human population grows, forests and grasslands around the world are cleared to build roads, housing and shopping centers. Even rural areas are impacted as small towns and villages encroach on land that was once inhabited by wildlife.
>
> As the two worlds continue to collide, the sharing of habitats creates a dangerous situation for animals as well as humans. Animals viewed as a nuisance or threat are placed in danger of being trapped or killed, threatening the existence of many species that are already vulnerable as a result of poaching and the illegal wildlife trade. Human lives are also placed at risk when they encounter elephants, tigers, bears, or other large species that feel threatened and attack in an effort to protect their territory or their young. It's an issue that is present around the world, and with massive human population placing further strain on limited land resources, it's a problem that will only continue to get worse."

In *Impacts of armed conflict on biodiversity* (2009) Bishnu Raj Upreti examines some of the impacts on mountain biodiversity in Nepal, resulting in the armed conflict within 1996-2006. Upreti asserts:

> "The main negative impacts documented from the study were a loss of unique habitats for wildlife within ecosystems once the vegetation for such specialised habitat were destroyed; loss of medicinal plant resources after the forests were used as battlefields; and severe disruption of conservation activities, leading to intensified unsustainable exploitation as law and order were broken down by armed conflict."

He adjoins:

> "National parks and wildlife reserves were one of the frequent targets of the insurgents, mainly because of being located in geographically isolated areas. There was engagement of the military in parks and reserves by insurgents."

Furthermore:

> "Forests, one of the main bases of biodiversity, became battlefields that ultimately led to biodiversity loss. Illegal hunting and trading of wildlife (e.g. five rhinos were killed in 2001 in Bardya National Park and musk deer were slaughtered by poachers in Langtang National Park) was rampant during the period of armed conflict, leading to a reduction of the composition and number of wildlife as well as habitat destruction."

A new research published in *Nature* by Joshua Daskin and Robert Pringle (2018) looks into the incessant uncertainty about the reverberations of armed conflict on wildlife decline. This need is perhaps most acute in Africa, where the high frequency, extent, and duration of conflicts (Tollefsen, Strand & Buhaug, 2012; Pettersson & Wallensteen, 2015) subverts governance and imperils the livelihoods of rapidly growing human populations and many large-mammal populations - including many vulnerable and endangered species that have declined sharply (Ripple et al, 2015; Craigie et al, 2010).

In view of this condition, figure 4.13 gives a detailed description of the mean number of conflict-years in African protected areas from 1946 to 2010, in which these ranged from 0 to 35. Continent-wide, 71 percent of protected areas overlapped at least partially with one or more conflict, and 25 percent had at least 9 mean conflict-years. For the period 1989–2010, the number of conflict-years ranged from 0 to 19, and 42 percent of protected areas lapped over with at least one conflict (Daskin & Pringle, 2018).

Daskin and Pringle (2018) demonstrate that even low-grade, infrequent conflict is sufficient to drop population trajectories below replacement.

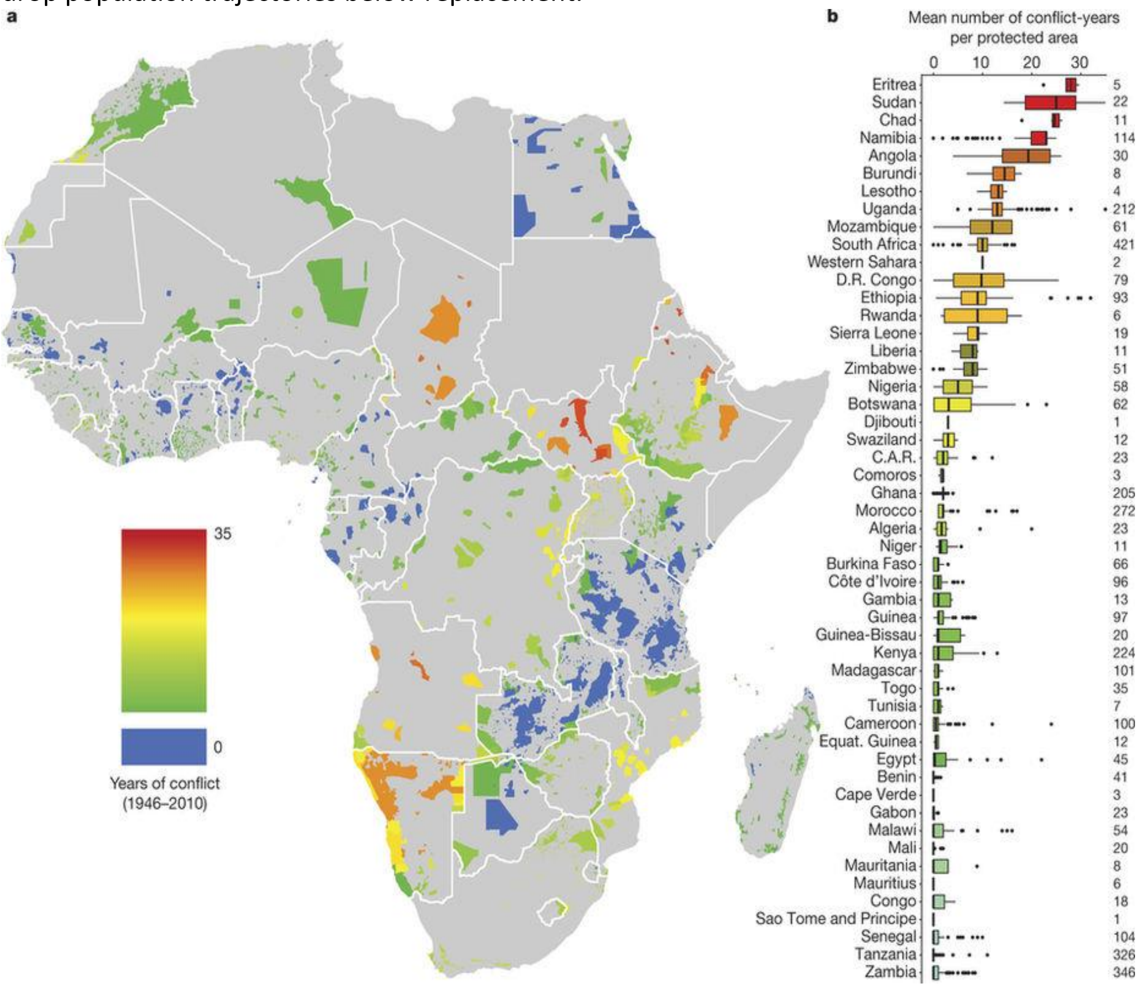


Figure 4.13: **a,** Number of conflict-years in each protected area; colours indicate average value across all grid-cells overlapping the protected area. **b**, Mean conflict-years per protected area in each country. Boxes, interquartile ranges; vertical lines, medians; whiskers, 1.5× interquartile range from the median; dots, outliers. Total number of protected areas per country, from the World Database of Protected Areas (Protected Planet, 2014) , is shown on the right; statistical analyses of correlations between conflict and wildlife population trajectories were based on the subset of these protected areas for which adequate wildlife data were available. Sudan and South Sudan are distinguished in a but combined in b; two outlying island nations, Cape Verde and Mauritius, are omitted from a but included in b. Map created in ArcGIS and R using open-access country-border data from the Global Administrative Areas database (http://gadm.org). C.A.R., Central African Republic; D.R. Congo, Democratic Republic of Congo; Equat. Guinea, Equatorial Guinea. Retrieved from (Daskin & Pringle, 2018).

In the *Nature Podcast* (2018) Joshua Daskin explains:

> "As the frequency of conflict increases the performance of mammal population's declines. At peaceful sites populations were near replacement, they were neither increasing nor decreasing, but with the onset of just a little bit of conflict the average population was declining."

Daskin adds that:

> "We included frequency and intensity of conflict to see which would affect populations and how. We infer that frequency was the best predictor, and the onset of conflict as the greatest."

In *The Impact of armed conflict on protected-area efficacy in Central Africa*, published in Biology Letters of the Royal Society (2007), Emmanuel de Merode and colleagues investigate the efficacy of park protection at the Garamba National Park (Democratic Republic of Congo) before, during and after a period of armed conflict. With Central Africa being a region enveloped and ravaged by prevalent conflict situations, as well as harbouring a considerable extent of biodiversity hotspots (Human Security Centre, 2005), that are the target of illegal bushmeat extraction (Milner-Gulland et al, 2003) the authors set out to examine the hypothesis that protected areas can still operate in full capacity, during wartime, provided that anti-poaching patrols remain in working order.

Unexpectedly, the authors concluded that poaching increased despite strong park protection, and went on to dwindle under a feeble protection, which suggests that the urban market and social institutions were the crucial factors influencing the number of hunters and illegal defaunation in the park (de Merode & Cowlishaw, 2006). Fortunately, the authors also found a link between anti-poaching patrols and the decline of bushmeat hunting. Regrettably as the authors (De Merode et al, 2007) assert:

> "A substantial increase in protection effort, which necessitates a significant investment of funds is beyond the reach of most national park in the developing world. This is especially true in the Congo Basin, where protected areas are notoriously underfinanced (Wilkie, Carpenter & Zhang, 2001)."

Recent findings published in journal *Conservation Letters* by Brito and colleagues (2018) establish some key points:

- An escalation in the number of conflicts across the Sahara and the Sahel in Africa is instigating a collapse of the region's wildlife.
- The number of conflicts in the region has surged by 565 percent since 2011.
- 12 species of vertebrates have either been eliminated or are much closer to the brink of extinction as a result of the rise in conflict.

The biologist Sarah Durant of the Zoological Society of London and author of the study said in a statement (Podder, 2018):

> "As if the harsh, arid landscape isn't enough, the growth of armed conflict in the Sahara-Sahel region is yet another serious threat that wildlife in this critical region now have to contend with."

The rise of groups like Al-Qaeda in the Islamic Maghreb, or AQIM, and Boko Haram over the past few years have thwarted Cameroon, Chad, Niger, Nigeria and Mali. These are some of the least-developed countries on the planet (the link between the overpopulation of nations and their socio-economic status and how that begets or stimulates human poverty, misery, while enhancing the appeal of alternatives such as religious extremism from groups such as ISIS and Boko Haram will be dealt with in the upcoming volumes), and they border countries like Libya where power vacuums have emerged.

José Carlos Brito, lead author of the study and ecologist at the University of Porto, Portugal pronounced in a statement from the University of Granada, Spain (Brito et al, 2018) that:

> "Areas where fauna is seriously endangered due to the rise in conflicts need to be identified, and effective policies need to be implemented in order to reduce the impact of these conflicts on biodiversity (University of Granada, 2018)."

The team compiled data on the location of conflicts and warfare as well as the paths used by smugglers and people migrating through the Sahara and Sahel (in the segment No Sanctuary there is an examination of how this might lead to bushmeat hunting for human consumption or sale in markets, affecting the health of the populations) and compared it to surveys of 10 species of vertebrates that live in the region (Mongabay, 2018).

Their results indicate that three species: first, the addax or white antelope (*Addax nasomaculatus*) that lives primarily in northern Niger has been reduced to "critically low numbers" in connection with rising conflict and oil exploration over the past 20 years; the dorcas gazelle (*Gazella dorcas)* have seen a spike in hunting*;* and the African savannah elephant (*Loxodonta africana)* has suffered continued poaching in Mali in the wake of several years of violence (Mongabay, 2018).

As has been noted, the authors explicitly assert:

> "In the Sahara-Sahel, megafauna have been almost extirpated from the southern regions, where armed conflict endured the longest and where the **highest regional densities of roads and human populations are found** [bold added]. Furthermore, the rush of extremist groups and traffickers to control remote areas promotes human presence in places that previously were only occasionally crossed by nomads. The current conflict thus adds to disturbances already caused by other human activities (mining, grazing, agriculture, and urbanization), accelerating population decline and local extinction, and leaving large-sized vertebrates with nowhere to go; a global trend observed in megafauna (Ripple et al, 2016)."

More to the South, and also in DRC's Virunga National Park, rangers and wildlife have experienced a ruthless and bloodthirsty civil conflict, with forest monitoring platform Global Forest Watch having identified more than 1,100 hectares of tree cover loss from May to September 2018 (Jones, 2018). Coincidentally, the surge in deforestation has been linked with the temporary closure of the Park after rebel forces murdered a park ranger and kidnapped two British tourists, which, unfortunately, is not new in area, since 180 rangers have lost their lives in the last 20 years, in the most dangerous conservation job there is (Burke, 2018).

The year of 2018 has witnessed near-unprecedented bloodshed (Actman, 2018), which has been highly correlated with the recent deforestation in the park. Violence and forest loss go hand-in-hand, according to Roy Bugendwa, a program manager at the World Wildlife Fund who supervises Virunga. Bugendwa asserts that rebel groups unlawfully profit and capitalize on the forest resources to fund their operations, the bigger the army, the more it is extracted (Jones, 2018).

Comparatively, recent tree cover loss appears to be associated with charcoal production, with armed forces lacerating old growth forests to produce and market the carbonized wood in local cities, since a staggering 97 percent of people living around Virunga National Park depend on charcoal for cooking fuel (Mbugua, 2016). Additionally, with the population quickly growing at an alarming rate, demand is only foreseen to expand. As an illustration, since 1990, the city of Goma, located at the southern tip of the reserve, has grown from 150,000 to more than 1 million people; in the meantime, the population of DRC has doubled (Jones, 2018).

Coupled with the charcoal market, armed groups are also known to traffic illegal timber along Route Kamango, a highway that connects DRC to Uganda, where tree loss became exceedingly conspicuous on satellite images in May 2018. Furthermore, in the southerly territory of Luberto, the hacking of trees to plant cassava, maize and other subsistence crops by locals, which take advantage of the clearings and the disorder brought about by rebel groups is considerably common, Buhendwa says (Jones, 2018).

But in the end, it is wildlife that suffer the most from the loss of forest and habitat. Virunga, Africa's oldest national park is one of just two places on the planet where critically endangered mountain gorillas can still be found, as well as being a sanctuary for dozens of other threatened species like the cryptic okapi. Not to mention, Virunga also possesses the largest population of hippopotamuses on Earth, roughly 20,000 individuals (UNESCO & World Heritage Center, 2018). Due to this precious and invaluable trove of biodiversity, and in spite of the violence, the reserve and conservation groups have remained active, and persevere on maintaining the integrity and sustainability of the park, while outside of it environmental organizations and other non-profits are trying to eliminate local dependency on Virunga's natural resources (Jones, 2018).

Brito and colleagues from the previous study suggest that there is a "vicious circle connecting arms trafficking, conflicts, migration and the extinction of animal species" and that by curbing the number of weapons that flow into the region the conflicts might de-escalate (University of Granada, 2018), unfortunately, and although the authors recognized the role of population growth in the defaunation perpetrated in the region, no mention was made that these countries, which are among the nations with the highest rates of population growth in the world (Dillinger, 2018), should stabilize and eventually reduce their enormous populations in order to stem the upsurge in conflict, as well as reducing or eliminating the market of high-value natural resources so as to alleviate the exigency of people engaging in conflict over their monopolization. These two measures would likely create more balanced and economically viable countries to inhabit, and as a result safeguarding biodiversity in the process. If this work has attempted to demonstrate anything, is that, despite the noblest and virtuous efforts of individuals and collectives to uphold conservation, without a bound and determined endeavour to cease population growth and eventually reducing populations, all will be for naught.

Expropriation

- The Human Density Footprint -

"The ecological crisis, in short, is the population crisis. Cut the population by 90% and there aren't enough people left to do a great deal of ecological damage."

- Mikhail Gorbachev

The term *footprint* has become a common expression for diverse types of human environmental impacts on both urban and natural environments (upcoming volumes will include the chapter Footprints in the Sand, which will be entirely dedicated to examining the multitudinous *footprints* linked to human overpopulation and overconsumption). What is often defective is the discussion of the *human population footprint*.

Notably, the general effects of human population growth are debated in terms of urbanization and suburban sprawl, for example, but not so much in terms of environmental repercussions and, particularly, the consequences of human population density (HPD) on biological diversity (McKee, 2012). Comparatively, the notion that even low-density populations with undeveloped technology can still have a substantial impact on other species is an omnipresent but less discussed and studied subject (Luck, 2007).

There is a growing body of academic literature (Luck, 2007) establishing a scientific connection between human population density and growth and increased extinction threats for fauna and flora, yet this key footprint lingers on the outskirts of the conservation interlocution (McKee, 2012).

The involvement of HPD in many studies is often based on the premise that a rise in density represents a hazard to conservation and rewilding projects. The ramifications of this assumption are exacerbated by recent research showing that, across various continents and spatial extents, HPD is often strongly positively correlated with species richness for a number of taxonomic groups (Hunter & Yonzon, 1993; Balmford et al, 2001; Araújo, 2003; Real et al, 2003; Gaston & Evans, 2004; Vázquez & Gaston, 2006). This translates to areas that contain the most people also harboring the greatest diversity of species, and if HPD is a menace for species and population conservation, the threat may be aggravated by non-harmonious spatial sharing between people and biodiversity (Luck, 2007).

Likewise, and although the causes of the current mass extinction are heterogeneous and propitiated by human behavior, there is clearly a strong association between the density of the human population and menaces of further extinctions. Moreover, both the human population and endangered species are growing in numbers (McKee, 2012).

For this reason, Jeffrey McKee pursues the hypothesis in *The Human Population Footprint on Global Biodiversity,* featured on *Life on a Brink* (2012) that human population density alone is a key factor in jeopardizing the continuity of other animals. McKee does not say that it is the only factor, for indeed human behavior and a host of other factors are vital as well. But population density appears to be at the center of the matter (McKee, 2012).

To this effect, Corey Bradshaw, an author and professor at Flinders University, Adelaide, South Australia discloses that population density has become a good predictor of environmental damage - with studies pointing to countries that protect more land having greater environmental footprints. As Bradshaw expounds, a more elevated population density produces a greater use of natural resources, through anthropogenic activities such as natural forest loss, habitat conversion, marine captures, fertilizer use, water pollution, carbon emissions, which all end up imperiling biodiversity (Kunzmann, 2018).

For instance, when the results of the ranking of countries with the worst environmental record were unveiled (Bradshaw, Giam & Sodhi, 2010), these did not startle Bradshaw, since the most densely-populated countries practically ranked near the top (Kunzmann, 2018).

Besides population density there is another factor that emerges as an indicator of environmental deterioration, and that is country wealth (this theme will be properly examined in the segment Diet, Affluence and China and in the upcoming volume in an upcoming volume in the chapter Prosperity without Growth, but it needs to be introduced here since it is closely associated with population density). Bradshaw elucidates that the theory of the Environmental Kuznets curve - a hypothesis from the economist Simon Kuznets defends that:

> "As you increase capital prosperity and develop a nation, your environmental damage increases as you begin to exploit more of your resources - followed by some sort of middle class achievement in education standards and access to cleaner technologies [...] we found that wealth is the only driver that predicted most variation of countries with environmental damage. If anything there was an increasing linear effect of increasing wealth and environmental damage."

Bradshaw and colleagues stated in their 2010 paper:

> "From a global perspective, the most populous and economically influential countries generally had the highest absolute environmental impact: Brazil, USA, China, Indonesia, Japan, Mexico, India, Russia, Australia and Peru were the 10 worst-ranked countries."

Throughout this chapter, the theme of populations and species has dominated the narrative, even though as it possible to ascertain in The Extinctionists, extinction rates during historic times are difficult to evaluate. Only a thousand or so species have been *recorded* as having been eliminated from the gene pool since 1600. Indeed, no good correlation has been established between known extinctions and human population densities (Luck, 2007). But as wildlife populations dwindle in the wake of our expansion, one can infer that biodiversity is being curtailed at genetic levels. So whereas we might not see species extinctions per se, we can appraise with a wide gauge the effects of human population density on nonhuman species by looking at species *threatened* with extinction (McKee, 2012).

There is a need to look at endangered species together with elements of the human enterprise, specifically human population density and expansion. Taking a broader view of current ecological trends, McKee and colleagues (2004) evaluated the data available on threatened species per nation, encompassing critically endangered, endangered, and vulnerable species of mammals and birds from the International Union for Conservation of Nature (IUCN) Red List (based on threats in 2000) and constructed the graphic in figure 4.14.

Correspondingly, data from continental nations, excluding exceptionally small nations, were also assembled on human population densities and "species richness" - defined for the analyses as the number of known mammal and bird species per unit area. Furthermore, a stepwise multiple regression analysis was used which related 88 percent of the variability in current threats to mammal and bird species per country on the basis of just two variables: human population density and species richness (McKee, Sciulli, Fooce & Waite, 2004).

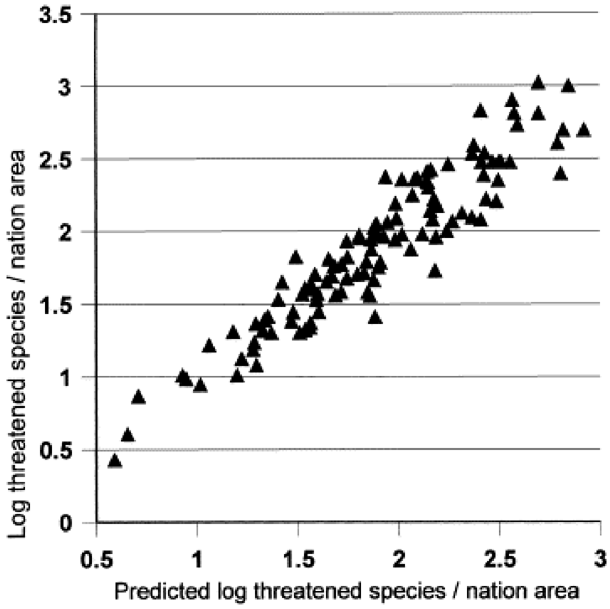


Figure 4.14: Predicted vs. actual values of log-transformed density of threatened species per nation for the year 2000 based on the multiple regression model: log threatened species per 106 km2=−1.534+0.691 × log species richness+0.259 × human population density. Retrieved from McKee et al, 2004.

Evidently, “species richness” is not the root cause of the threats - these diverse ecosystems persisted through climatic changes and ecosystem fluctuations over many thousands of years. That leaves the other variable in the equation, human population density, as the likely causal factor leading to global increases in imperiled species (McKee, 2012).

It appears that the greater convergence of species set the conditions for the human population impact to be more acute (McKee, 2012). The model predicted substantial increases in biodiversity threats for those nations with growing populations, and modest declines for the nations foreseen to experience population losses (McKee et al, 2004).

Coupled with this research (figure 4.15), McKee, Chambers and Guseman (2013) set out to examine if a decade later any substantial discrepancy would be found. As described in figure 4.15, predictions of extinction threats for mammal and bird species in 2010, on the basis of projections from the 2000 model, were firmly correlated with the observed data, with the model predicting 83.8 percent of species threat levels. When analysing how *change* over the decade might relate to the observations, the predicted change in densities of imperiled species had a 95.6 percent correlation with observed changes in human population density alone (McKee et al, 2013).

Whereas it is possible to record past extinctions and current menaces to populations and species, this criterion is not the sole indicator of an exposed and weakened ecosystem. There is also a significant depletion of genetic biodiversity, which puts species at an even greater risk of extinction, as versatility and evolvability are compromised. At the other end of the spectrum, ecosystem diversity is also laid on the line by human population growth. This stems from both ecosystem disintegration as well as homogenization of habitats due to invasive species, thereby exacerbating threats to sustainability even further (McKee, 2012).

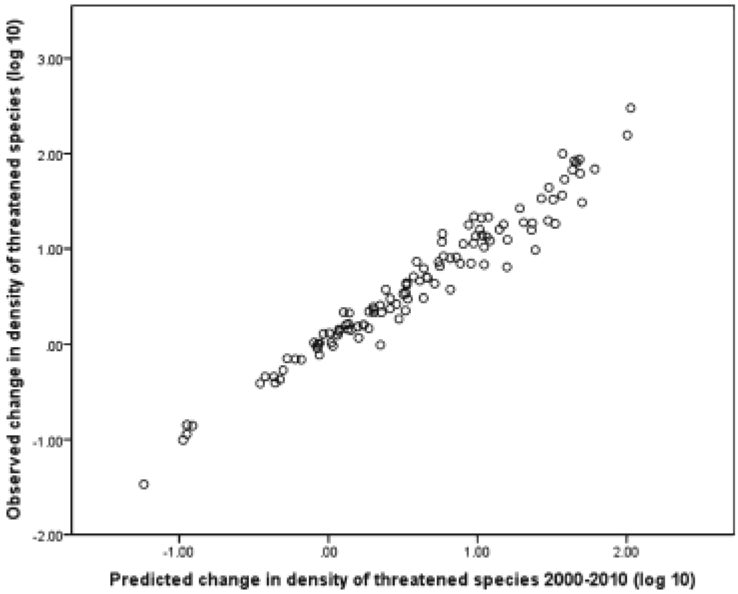


Figure 4.15: Correlation between predicted and observed changes in the density of threatened species per nation between 2000 and 2010. Retrieved from McKee et al, 2013.

All things considered, the future looks bleak for wild animals, plants, and ecosystems if we do nothing about human population growth. Using the population projections with the 2010 model, the average nation with a growing population can anticipate a 3.3 percent increase in the number of imperiled mammals and birds by 2020, based on population growth alone, and a 10.8 percent upsurge by 2050, when it is projected that the global population will surpass nine billion people (McKee et al, 2013).

Not to mention, population threats to some species by 2050 in the twenty-one countries with projected *declining* human populations are predicted to be more limited, with an average abatement in hazards of 2.5 percent; in those nations; that consists of a maximum of four fewer threatened species and a mean of only about one fewer per nation (McKee, 2012).

If the reader recalls figure 4.11 at the end of the segment Anthropocene, the image contained the anthropogenic threats of habitat loss, deforestation, cultivation and human encroachment. In reality, these cannot be attributed to one specific segment or theme, since they are quite possibly the most widespread repercussions of augmenting the human populace and the profusion of human activities associated with it. Nevertheless, since this segment is titled Expropriation, it makes enough sense that these hazards should be addressed in here.

Habitat loss presents the most pronounced menace to species. It is classified as the main threat to 85 percent of all species encompassed in the IUCN's Red List (2018) (those branded as "Threatened" and "Endangered"). The world's forests, swamps, plains, lakes, and other habitats persist on withdrawing as they are harvested for human consumption and emptied to make way for agriculture, housing, roads, pipelines and the other hallmarks of industrial development, such as the intensive harvesting of timber, wood for fuel among other forest by-products, as well as overgrazing (WWF, 2017a).

To put it another way, this land conversion rate has crystallized in a net loss in global forest area during the 1990s of about 94 million ha (tantamount to 2.4 percent of total forests). It is appraised that in the 90s, roughly 70 percent of deforested areas were transformed into agricultural land. In effect, around half of the world's original forest has been phased out, and presently, they are still being erased at a rate 10x higher than any conceivable rate of regrowth. As tropical forests incorporate at least half the Earth's species, the clearance of close to 17 million hectares every year becomes a tragic and dreadful loss (WWF, 2017a).

As the World Wildlife Fund incontestably communicates it (WWF, 2017a):

> "[Threatened Species are] Losing their homes because of the growing needs of humans."

What WWF could be asserting here is that, in order to accommodate the growing needs of a human population that is expanding in size and per capita affluence, which materializes in the depletion of the natural world. Since every new passenger on this Earth will require some measure of personal paraphernalia, and our record as a species has demonstrated that we are terrible in scaling down our consumption and material acquisition (in a ratio and percentage of the population that actually makes a significant difference), our most credible option to barricade the annihilation of the natural world is to bring fewer humans onto this planet. The proportion and extent of damage propagated by humanity on the natural world postulate that we curtail the size of the *sapiens* population.

To demonstrate, a broad scale evaluation of primate species worldwide delineated that more than half are confronting near-term extinction by virtue of unsustainable human activities, such as land cover changes for agricultural expansion, mining and fossil fuel extraction (Estrada et al, 2017).

To put things in perspective, our primate cousins have ushered in an expansive colonization of this planet, establishing residence in 90 countries. However, the majority of monkey, ape, lemur, tarsier and lorisid species live in Brazil, Indonesia, Madagascar and the Democratic Republic of Congo (DRC) (IUCN, 2015), and this is where a study, published in the journal *Peer J* by a Alejandro Estrada and more than 25 colleagues (2018) enters the fray, asserting that 62 percent of those species are facing a tremendous threat of extinction due to the increase in the amount of land converted for human food production that is substantially contracting the habitats of these species (Cannon, 2018b), and that environmental pressures employed by a swelling human population stand as a considerable driver of primate habitat and population decline in each of these countries (Crist et al, 2017).

Paul Gaber, a primatologist at the University of Illinois and co-author of the study said in an interview with *Mongabay* (Cannon, 2018b):

> "The realization that these four countries harbor 65 percent of the world's primate species made writing our current paper a priority. It was during the research and writing of the manuscript that I first realized how critically important Brazil, Indonesia, Madagascar and DRC were to avoiding a mass primate extinction crisis."

Altogether, these four countries harbour 286 species out of a total of 439 primate species and a cornucopia of imperilment prompted by human activities. Demonstrably, in Indonesia and Madagascar, over 90 percent of the primate species are listed as vulnerable, endangered or critically endangered by the IUCN (2018). Additionally, for Indonesia, Madagascar and Brazil, the forfeiture of forests as land for convertion to food production continues to be a substantial threat to primate habitat. Moreover, in the DRC, contempo research has demonstrated that traditional agricultural practices are engendering more than 90 percent of forest loss, in the first decade of this century (Cannon, 2018c). Identically, bushmeat hunting stands as the greatest jeopardy to the country's 36 primate species (more on this topic in the next segment) (Cannon, 2018b).

In this regard, Paul Garber and colleagues address the relevance of population growth (table 4.1) and its association to habitat loss, human encroachment, cultivation and deforestation in multiplying and magnifying the hazards that primate species, and many others are undergoing, in their article *Primates in peril: the significance of Brazil, Madagascar, Indonesia and the Democratic Republic of the Congo for global primate conservation* (2018).

As Table 4.1 and figure 4.16 delineate, in 2016 Indonesia was the most populous of the four countries with marginally over 263 million people, ensued by Brazil (about 211 million), DRC (roughly 80 million), and Madagascar (about 26 million). At the same time, human population density is topmost in Indonesia (145 people/km^2) and lowest in Brazil (25 people/km^2). Together with this, population growth rates for 2016 were maximal in the DRC (3.09 percent /yr) and Madagascar (2.75 percent/yr), considerably lessened in Indonesia (1.07 percent/yr) and smaller still in Brazil (0.77 percent/yr). Furthermore, population projections for the year 2050 denote persisting growth in all four countries with DRC manifesting the most abrupt upsurge, supervened by Madagascar, Indonesia, and Brazil (Estrada et al, 2018).

	Brazil	Madagascar	Indonesia	DRC
Land area km^2	8,515,767	587,041	1,904,569	2,344,858
2016 Population	207,852,865	25,566,097	263,354,770	80,071,935
2016 Population in urban areas	82%	34%	52%	39%
2016 Density (persons/km^2)	25	44	145	36
2016 Population growth rate (%) FAO	0.77	2.75	1.07	3.09
2016 Population growth rate (%) World Bank	0.82	2.69	1.14	3.28

Table 4.1: Land area, 2016 human population size, population density, and population growth rates in Brazil, Madagascar, Indonesia, and DRC. Source: FAOstats (2018), the World Bank (2018a). Retrieved from Estrada et al, 2018. DOI: 10.7717/peerj.4869/table-4.

Correspondingly, in Brazil and Indonesia, a substantial part of this population growth is foreseen to take place in urban areas (Table 4.1). Moreover, despite the fact that in the short term rural populations are envisioned to proliferate expeditiously, prognostications adumbrate that by 2050 their urban population (69 percent of the population of DRC and 55 percent of the population in Madagascar) will overthrow their rural counterparts (Estrada et al, 2018).

Evidently, the large size and anticipated increase of the population in all four of these countries are expected to exponentially broaden the human and urban footprint on primate and other species habitats, near and beyond cities. By all means, the negative impacts that will emerge, such as demand for energy, space, food, water, minerals, oil, construction material, forests products, and transportation, as well as from environmental deterioration caused by pollution and the enlargement of road and rail networks to satisfy food and non-food urban needs, all stem from the concomitant rise in the human populace (Estrada, 2013; Estrada et al, 2017; 2018).

Given these points, the authors sum up their rationale by stating:

> "The forecasted future human population and economic growth of Brazil, Indonesia, DRC, and Madagascar along with increased global and local demands for food and non-food products will heighten pressures on primate populations in these countries,"

Gaber and colleagues arrive at the conclusion in their study and illustrate the large-scale, local and global pressures, their repercussions and the key challenges for the conservation of the primate species (which could be recycled for basically every other population or species discussed throughout this work) and are illustrated in figure 4.17:

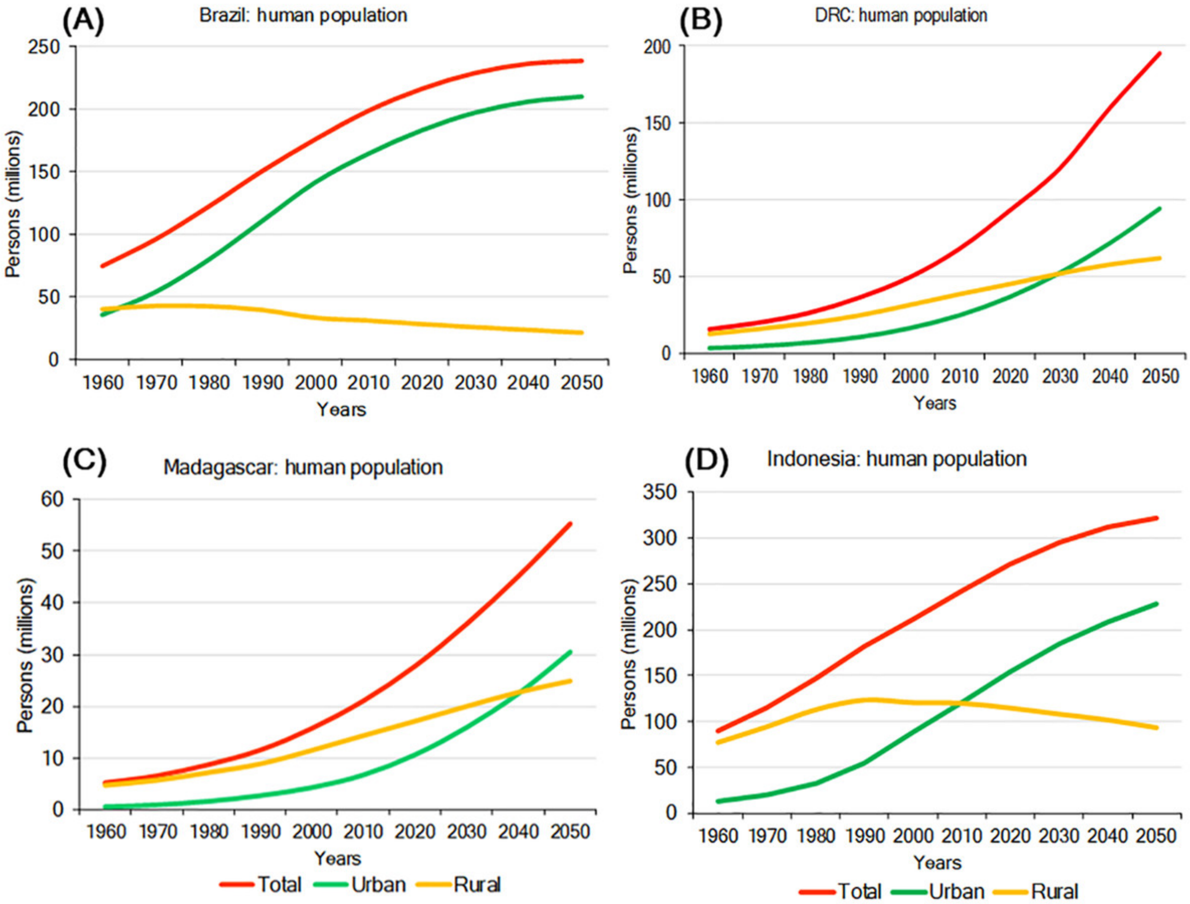


Figure 4.16: Total urban and rural population growth and projection for (A) Brazil, (B) DRC, (C) Madagascar, and (D) Indonesia. Steep growth is forecasted for the next few decades with urban populations significantly increasing, while rural populations are expected to decline. Source: FAOSTAT, 2017. Retrieved from Estrada et al, 2018 DOI: 10.7717/peerj.4869/fig-5

> "Each country differs in its history, societal and economic needs, and current environmental and governmental policies that are driving primate habitat loss and population decline. These four countries face unprecedented environmental and social challenges in implementing effective primate conservation. **They have rapidly growing human populations** (bold added) and low human development indices compared with more developed nations. Each has also experienced large-scale losses of native vegetation and other natural resources plus high levels of corruption and weak governance."

In a final analysis, the Millennium Ecosystem Assessment (2005) established unequivocally the dire state of many of our ecological systems and undoubtedly implicated humans as the main drivers of change. With this in mind, future growth of human populations will surely exacerbate the further global decline in ecosystem health. It should go without saying that the stabilization and gradual reduction of human numbers on this planet are crucial and vital to avoid the perpetuation of the non-human genocide and ecosystem collapse (Luck, 2007).

Yet, simply reducing human population size and density in certain areas without understanding the human-environment ecology and processes already in place may lead to unforeseen consequences (Luck, 2007). For example, Fisher et al. (2003) testified that a reduction in HPD in the Lake Patzcuaro Basin in Mexico created severe land degradation owing to turmoil in the management of a human-modified environment dependent on human labour for maintenance. Likewise, in Puerto Rico, forest cover has increased despite rises in HPD, as agricultural land has been replaced by forest by virtue of changes in the economy and land management policy (Lugo, 2002).

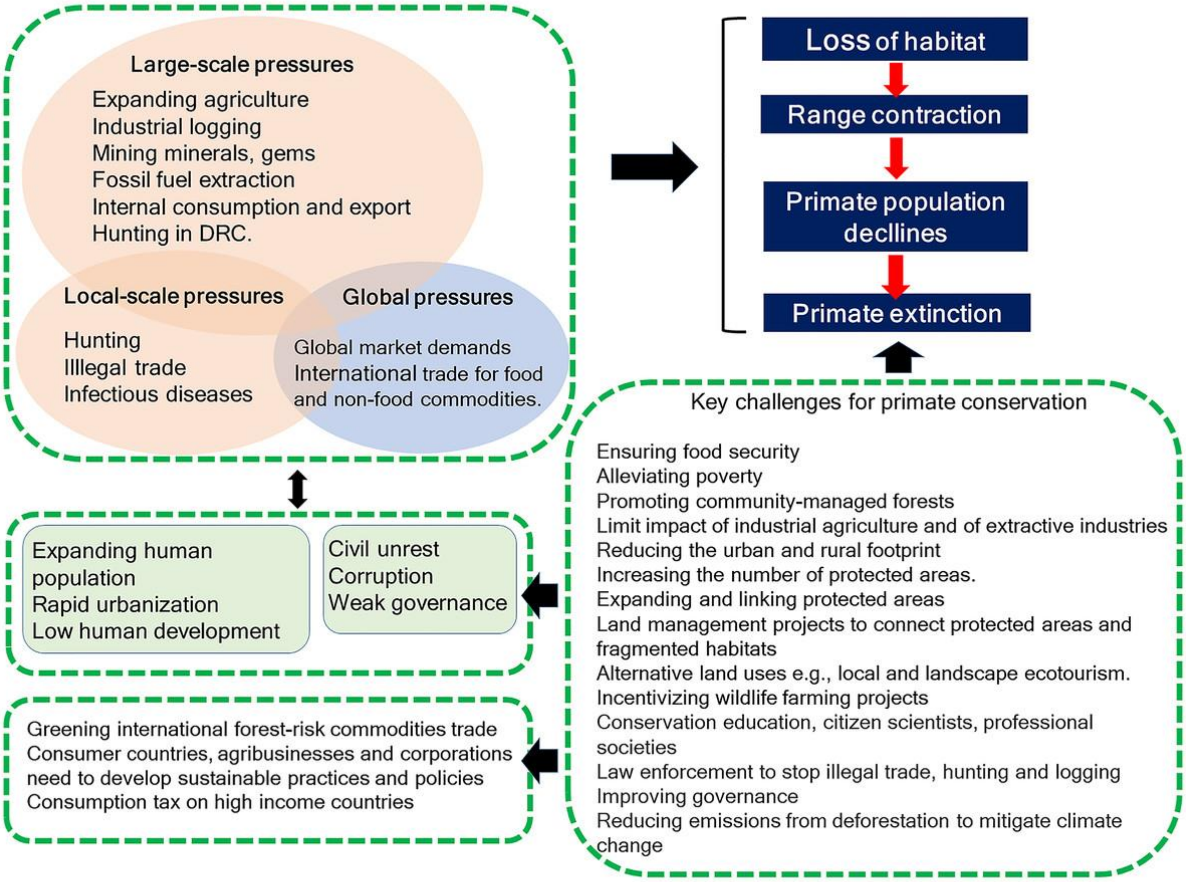


Figure 4.17: Diagram summarizing key environmental challenges common to Brazil, DRC, Madagascar, and Indonesia that affect conservation of their primate fauna. The relative importance of some pressures and population aspects vary from country to country. For example, hunting in DRC is a large-scale pressure because the local human population has little or no access to domestic meat (more on this in the next segment). Because of their large size and low population density relative to the size of the country, Brazil and DRC are in a better position to anticipate the direction of these pressures and prevent primate declines and extirpation. However, in contrast to Brazil, DRC is particularly poor, its human population is rapidly growing, and human development is very low, whereas civil unrest is predominant and corruption and weak governance are an ever-present condition. Madagascar differs from these two countries, and from Indonesia in having a very small percentage of its original forest left. A rapidly expanding human population and high levels of poverty and weak governance are predominant. Indonesia is a developing country with a large human population that has embarked on a policy of rapidly replacing its forests with commercial plantations and expanding industrial logging at the expense of biodiversity. Retrieved from Estrada et al, 2018; DOI: 10.7717/peerj.4869/fig-11

By the same token, Guyette & Spetich (2003) discovered that in Arkansas, fire frequency initially heightened with HPD during the early stages of European settlement, but as human population kept on increasing, fire became less frequent as a result of cultural and land management changes.

Given these points, when stating that landscapes have been severely modified by human activity we also need to take into consideration the conjunction between Man and its surroundings. Simply resorting to removing humans from these places may create more problems than originally intended to avoid. To bypass these scenarios, a comprehensive understanding of the human-environment relationship needs to occur, as well as enforcing management strategies that aim to address mitigation circumstances (Luck, 2007).

But by no means misunderstand my words and position here, human population growth is mostly noxious and corruptive to ecological function, processes and continuity of biological diversity. With the expected rise of the human population to 9.9 billion by 2050 (PRB, 2018), with 95 percent of growth occurring in developing nations, and an almost instantaneous rise in the percentage of humans living in urban areas, from 47 percent in 2000 to close to 60 percent in 2030, it will translate into a movement to urban centres with greater pressure on species-rich and highly productive areas, as well as further deracination of people from nature. Consequently, the appropriate management of urban areas to safeguard species preservation will turn out to become even more essential over the coming years (Luck, 2007).

Before wrapping up this segment it might be informative to recapitulate (and open up some points that were not covered so the reader might investigate if interested) some of the main threats and aspects posed by the rise in HPD (figure 4.18).

At a broad scale, there is a strong positive link between HPD and the richness of many taxonomic groups leading to spatial conformance between human developments and diverse ecosystems. Such an expansion is considered a hazard to species conservation, as well as an opportunity to promote the interaction between people and nature, given the appropriate oversight.

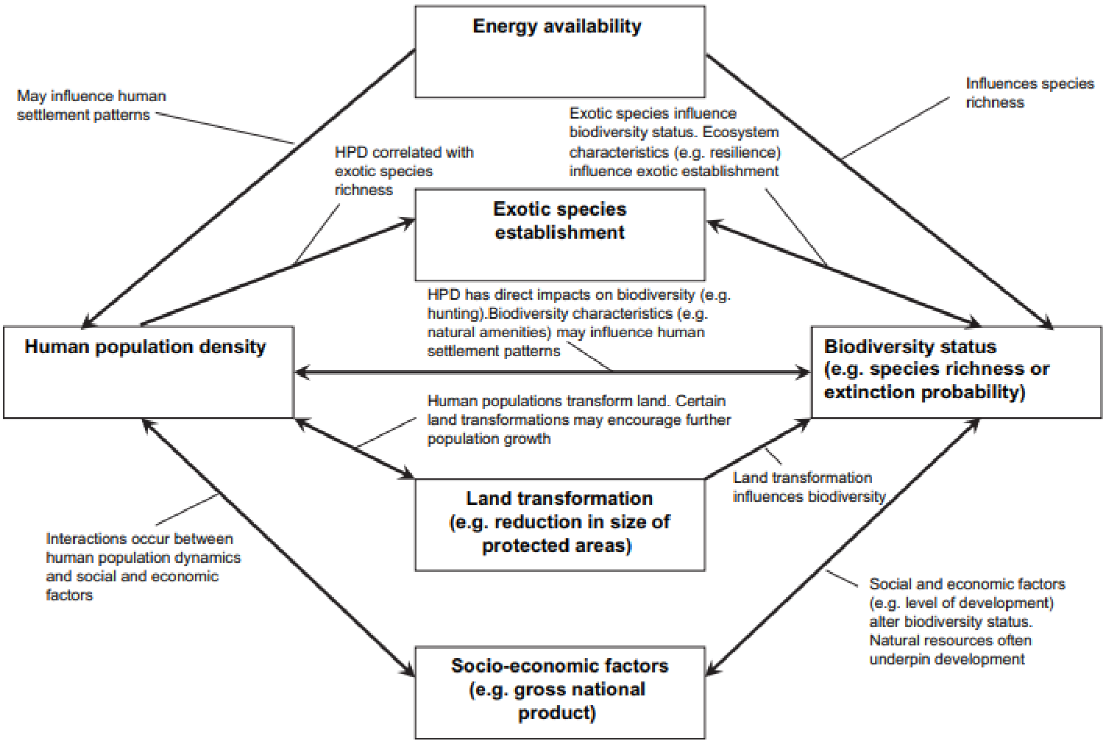


Figure 4.18: A schematic representation of the proposed relationships between human population density and biodiversity focussing particularly on the negative impacts of population growth. The evidence for each of these relationships varies in the literature. The diagram includes biodiversity feedback loops, but not interconnections between energy availability, exotic species establishment, land transformation and socio-economic factors. Retrieved from Luck, 2007.

One such side-effect of an inflated populating is the increasing land transmogrification and the introduction of exotic species. Henceforth, land designated for conservation is considerably reduced near human settlements. Consequently, HDP affects the biodiversity status, by making species sensitive to anthropogenic change being lost or deteriorate in abundance, while disturbance-tolerant and generalist species may thrive (Luck, 2007).

As Gary W. Luck concludes in his fundamental work, *A review of the relationships between human population density and biodiversity* (2007):

> "Ultimately, we must ensure management for the environment given the ambitions of the human enterprise. This requires greater emphasis on the key anthropogenic drivers of environmental change. In the end, it will be the appropriate management of people, not plants and animals, which determines the future state of our planet."

As a last word, it just appears to be a loss of opportunity for all of these invaluable and seminal works to not contain in their discussions/conclusions and/or policies for implementation, a distinctive exhortation for countries to manage their fertility rates, and securing a stabilization of their human populations, if they are serious in safekeeping the biodiversity contained within their borders by an eventual reduction of their human populace. Researchers involved in all of these areas that are affected by human overpopulation need to step up and start a discussion, it is imperative that we do so.

No Sanctuary

**"And I think in this empty world there was room for me and a mountain lion.
And I think in the world beyond, how easily we might spare a million or two humans
And never miss them.
Yet what a gap in the world, the missing white frost-face of that slim yellow mountain lion!"**

- D. H. Lawrence (1885-1930), *in Mountain Lion*

Tropical rainforests are some of the most species-rich ecosystems on the planet and yet, many across Southeast Asia and Central Africa, for example, are denuded and vacant of the wildlife that once burgeoned in there. Although deforestation, habitat conversion for agriculture and urban sprawl are crucial problems affecting these and other regions, there is still a small number of pristine and intact forests that provide a suitable habitat for endemic species but stand eerily silent and desolated of life. Unsustainable levels of hunting are the root cause of this intricacy (Gray, 2017).

Hunting of wildlife as a direct meat source is often thought-out to be a more paramount and significant menace to the conservation of biological diversity in tropical forests than deforestation (Wilkie et al, 2005). The multibillion-dollar trade in bushmeat, especially critical in Africa and southeastern Asia, is among the most immediate threats to tropical vertebrates (Brashares et al, 2004), which also provokes many cascading trophic effects (Dirzo, 2013; Ripple et al, 2014). Hunting, habitat transmogrification and denial of access to water and other resources by humans, in combination with competition and disease transfer with livestock, are driving serious contractions of wild ungulates populations in Africa and southeastern Asia (Daszak, Cunningham & Hyatt, 2000; Prins 2000; Ripple et al, 2015).

According to Robert Nasi and colleagues (2011, p. 104) who wrote in the journal *International Forestry Review* the article *Empty forests, empty stomachs? Bushmeat and livelihood in the Congo and Amazon Basins:*

> "Protein from forest wildlife is crucial to rural food security and livelihoods across the tropics. The harvest of animals such as tapir, duikers, deer, pigs, peccaries, primates and larger rodents, birds and reptiles provides benefits to local people worth millions of US$ annually and represents around 6 million tonnes of animals extracted yearly."

They add:

> "Vulnerability to hunting varies, with some species sustaining populations in heavily hunted secondary habitats, while others require intact forests with minimal harvesting to maintain healthy populations. Some species or groups have been characterized as ecosystem engineers and ecological keystone species. They affect plant distribution and structure ecosystems, through seed dispersal and predation, grazing, browsing, rooting and other mechanisms"

Irrespective of the region, larger-bodied and longer-lived species with low intrinsic rates of population increase, such as apes, other large primates, carnivores and antelopes, as well as tapirs, buffaloes or elephants are more susceptible to exhaustive hunting than species with high reproductive rates, such as rodents (Robinson & Redford, 1991).

Primates and large carnivore populations fall extremely fast to the pressures of intensive hunting (Henschel et al, 2010; Oates, 1996). Hunting has been proven to be a major cause of the decline in the apes in Gabon, accounting for a decrease in 50 percent of the population within two decades (Walsh et al, 2003). Populations of the black colobus (*Colobus satanas*) in the Congo Basin, spider (*Ateles* sp.) and Woolly monkeys (*Lagothrix* sp.) in the Amazon basin have all suffered an abatement of their numbers (Bodmer, Fang, Moya I & Gill, 1994; Kümpel et al, 2009).

Additionally, overhunting also has repercussions on ecosystems. The loss of wildlife from forest ecosystem can generate the interruption and severance of ecological and evolutionary processes, alterations in species composition within ecosystems and most likely a general curtailment in biological diversity (Emmons, 1989; Redford, 1992), creating what came to be known as "Empty Forest Syndrome." (Nasi, Taber & Vliet, 2011).

An exceeding share of ecosystems processes are driven by the linked activities of many species. Plant regeneration (stimulated by pollinators, seed dispersers and predators) and plant diversity (influenced by changes in herbivory patterns or pest augmentation) are often contingent upon the presence of specific species or groups of species (Beck, 2006; Keuroghlian & Eaton 2009; Nuñez, Iturri & Howe 2007; Terborgh et al, 2008; Vanthomme, Göhler & N'Deckere-Ziangba, 2004; Wright et al, 2007).

On top of that, the removal of populations of 'keystone species', 'ecosystem engineers' (organisms that create, modify and maintain habitats, more on Haemig, 2012), or other species or groups of crucial relevance in the ecological communities is contemplated to have an asymmetrical effect on the ecosystem compared to the decline of other populations of species (Campos-Arceiz & Blake, 2011; Fragoso, 1997; Keuroghlian & Eaton, 2009).

Seeing that hunters preferentially target large animals whenever they are accessible (recall research examined in The Extinctionists segment), and these usually are keystone species, like top predators (e.g. large cats, raptors, crocodiles) which regulate available biodiversity by providing resources that would otherwise be scarcely obtainable (e.g. carrion) or by initiating trophic cascades (Sergio et al, 2008; Terborgh & Estes, 2010), it can be inferred that overhunting is a hazard for ecosystems. The segment Key Impacts of Megafaunal and Predators gives a detailed account of the role these species have on ecosystems, so it is advised for the reader to recapitulate if in need of reminiscing.

In some places, the long-established lifestyles of indigenous people who flourished in forests for centuries are no longer sustainable and quite possibly never were. In an interview in *The New York Times* (Dreifus, 2006), Elizabeth Bennet, who at the time was the director of the Wildlife Conservation Society's Hunting and Wildlife Trade Program, which focuses on mobilizing governments and citizens against what Bennet claims to be a fast-paced growth of international commerce in wild animal parts, skins and meat - in particular, the hunting of threatened and imperiled animals for human consumption (bushmeat). The following is an excerpt of the interview between Elizabeth Bennet and *New York Times* staff writer Claudia Dreifus:

"[Bennet] - I remember once in the mid-1980, hiking in Kubah National Park, just outside Kuching (Malaysia). It was this beautiful green forest, though eerily silent. All the primates had been hunted out. Even small birds were rare. I wondered, "If this 'protected' park is empty, what's happening elsewhere?

[Dreifus] - Were you able to pinpoint the culprit in Sarawak?

[Bennet] It was hunting, triggered by a logging boom. Timber concessions were rushing into remote areas and putting in logging roads. Behind them came waves of commercial hunters with high-tech ammunition and trucks. They'd kill or capture whatever they encountered. On top of that, the loggers hunted for their own food, as did local people. Animals can survive a certain amount of logging. But this was annihilation.
This scenario was being replicated all over Southeast Asia. One of the saddest things I ever saw was the Luang Nam Tha Park in northern Laos. It was just trees and insects. The local markets were selling frogs and songbirds because all the bushmeat species had been wiped out.

In my work now, whenever I'm assessing the state of a country's wildlife, the first place I visit is the market. If they're selling large things like deer and pigs, I know they have fairly healthy populations. Whereas, if they are only selling frogs, bats and songbirds, it means nothing is left.

[Dreifus] Do you oppose all hunting?

[Bennet] I'm not against deer hunts in New Jersey, where the animals are overabundant. What I oppose is the slaughter of endangered tropical forest species by commercial hunting. If they are hunted in this systematic way, they die out.

People need to be aware that these wildlife populations - apes, turtles, many birds - are just on the brink. Consumption needs to go way down, or stop.

[Dreifus] Hunter-gathers have been taking animals from forests since prehistory. Are you going to tell tribal people in places like the Congo and New Guinea they have to stop?

[Bennet] That's a complicated issue. It's rarely sustainable. I and my colleague John Robinson once worked out how many subsistence hunters one square kilometer of tropical rain forest can support. It's one person per square kilometer!

More than that you're depleting the resource. In Sarawak, the indigenous people have the legal right to hunt. But there's been a population explosion, and there are three of them for every square kilometer of forest. That's three times the sustainable number. If they all employ their rights, they'll hunt out the forest diversity."

All things considered, and according to Robinson and Bennett (2000), the carrying capacity of tropical ecosystems such as the Congo Basin and the Amazon, for hunting activities translates into one subsistence hunter per square kilometer, although, in much of the Congo Basin, bushmeat, is the primary source of protein (Wilkie & Carpenter, 1999), especially where livestock husbandry is not a practical option and wild fish not available. Eating bushmeat is, therefore, a matter of survival with few if any alternatives (Nasi et al, 2011). Alternatively, when wild fish is available it can outweigh the relevance of bushmeat (Wilkie et al, 2005), still, the consumption of fish and/or bushmeat does appear to be closely linked to both availability and/or price of substitutes. This means that a decrease in one wild resource tends to drive up the unsustainable abuse of the other (Brashares et al, 2004).

Unlike rural or forest dwellers, urban consumers usually have a choice of several sources of protein, but in several African cities, bushmeat is still *perceived* as the 'lower cost' protein since it can be captured instead of purchased (Kümpel, 2006). This is due to rights to wildlife being poorly defined or unsatisfactorily enforced, which will lead to a continuous expansion of hunting efforts as long as the activity remains more profitable than alternatives, or until there are zero profits to be made (either by changes in policy or by the annihilation of the present fauna (Bulte & Horan, 2002).

By contrast, in large cities of Equatorial Guinea, Gabon and Cameroon, bushmeat is more of a luxury product (Nasi et al, 2011).

Furthermore, there is also a cultural significance of bushmeat use, especially for traditional indigenous people. In Gabon, bushmeat is affiliated with the village, with rituals and with ceremonies, such as men's circumcision (Van Vliet & Nasi 2008; Van Vliet et al, 2012). The traditional role of bushmeat has also been found to be central in Equatorial Guinea, where some species are considered to have magical and medicinal properties (Kümpel, 2006).

In like manner, the commercial trade of wildlife and their parts for cultural and 'medicinal' ends is considered to be the major source of species imperilment and a main hazard to animal welfare in China and its adjacent countries, for example. Driven by consumptive use for food and traditional medicine, the extensive volume of both legal and illegal trade in wildlife has precipitated tremendous destruction to ecosystems and pushed many species to the brink of extinction (Zhang, Hua & Sun, 2008).

Zhang and colleagues (2008) set forth to inquire the populace of several provinces in China and through surveys they reached the conclusion that about half the respondents agreed that wildlife had to be protected, and although that could be true, 60 percent of them had consumed wildlife at some point in the last 2 years. Their survey also demonstrated that the current situation of wildlife consumption in major cities in China in indeed quite problematic. Their data revealed that the main consumption groups are male and young people with high education levels and good incomes.

Equally important are the findings of Chardonnet and colleagues (1995), who reported that urban populations in Gabon, Democratic Republic of Congo (DRC) and the Central African Republic (CAR), consumed on average 4.7 kg/person/year; consumption in Libreville (Gabon) is estimated at 7.2 kg/person/year (Wilkie et al, 2005), in Bangui (CAR) at 14.6 kg/person/year (Fargeot & Dieval, 2000), in Mbjanjock (Cameroon) at 2 kg/person/year, etc (Nasi et al, 2011). According to Nasi and colleagues (2011) assessment, 6 million tonnes of wildlife are removed from the Congo and Amazon Basin every year.

Despite the fact that urban bushmeat consumption per capita appears significantly lower in rural areas compared with urban ones, according to most available studies (Nasi et al, 2011), the contribution of urban areas to the overall bushmeat consumption and devastation is inclined to increase as the population of Central African countries expands and becomes more urbanised (UNDESA, 2017; UNDESA 2014).

In *Accelerated Human Population Growth at Protected Area Edges* (2008) George Wittemyer and colleagues examine how an expanding population bordering Protected Areas frequently creates:

> "Significant negative effects on biodiversity (Luck, 2007). The scale of human settlement around PA's is a strong predictor of illegal timber and mineral extraction (Karanth, Curran & Reuning-Scherer, 2005), bushmeat hunting (Brashares, Arcese & Sam, 2001), fire frequency (Hudark, Fairbanks & Brockett, 2004), and, more generally, species extinction within PA's (Brashares et al, 2001)"

They conclude:

"If protected areas are expected to serve as refuges for the "last of the wild" (Sanderson et al, 2002), the patterns we document here are cause for concern."

In Ghana, as in much of West and Central Africa, wildlife is a common source of food, and large mammals are hunted throughout the nation and sold in markets (Asibey, 1971, 1974; Struhsaker & Oates, 1995). Under this assumption, Brashares and colleagues (2001) examined how population size was an estimator of demand for meat acquired by hunting. They found a marked positive relationship between the size of the human population and the rate of elimination ($r2$= 0.87, $F_{1,4}$= 25.9, p =0.007) (figure 4.19).

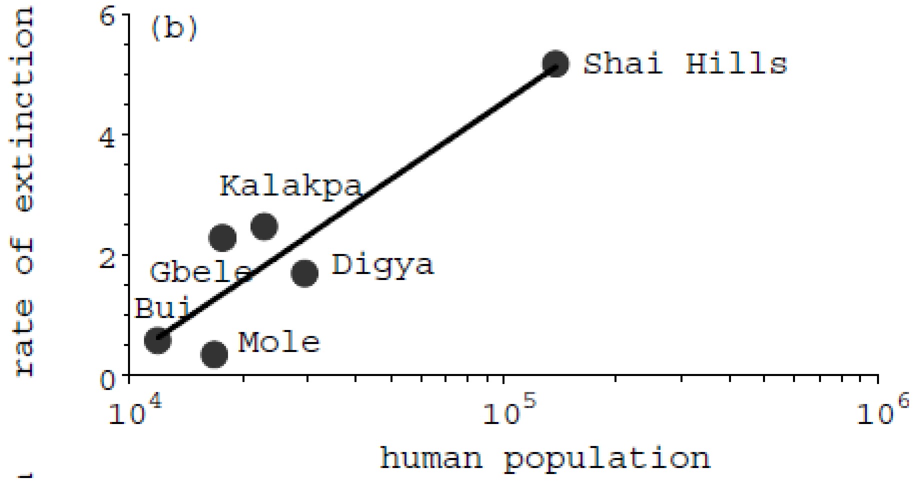


Figure 4.19: Rate of local extinction, $k2$, of large mammals in Ghanaian reserves in relation to the total human population within 50 km of the reserve. Retrieved from Brashares et al, 2001.

Their results are consistent with the knowledge that hunting is most severe along reserve edges, and that the width of this edge-effect zone is determined by the size of the local human population (Terborgh & Van Schaik, 1997). Overall, the conclusion of the authors is that humans have markedly altered the persistence of large mammals in reserves in Ghana (Brashares et al, 2001), a country that still rewards women with a sheep on their 10th child (Ohene, 2018).

Unfortunately, as the authors state, few studies have identified links between the size of the local human population and species extinction. Despite that, some points remain unaltered. First, the threat to biological diversity in West Africa is high relative to other countries in sub-Saharan Africa, and this has been ascribed to high population density and habitat loss (Sayer et al, 1992; Struhsaker & Oates, 1995; Kramer, Schaik & Johnson. 1997; Oates, 1990; Terborgh, 1999). Second, the human population in the developing world continues to expand rapidly (Urban, 1993; UNDESA, 2017; UNDESA 2014), implying further strains on reserves and the remaining pockets of wildlife.

Third, it has been suggested by researchers that conservation efforts should focus on creating habitat corridors between existing reserves [no mention of reducing local fertility rates as a conservation effort] (Newmark, 1987, 1996; Saunders & Hobbs, 1991; Soulé & Terborgh, 1999) to augment habitat available to wildlife, facilitate dispersal and gene flow, and reduce population and species extinction (Brashares et al, 2001). However, where hunting and other human activities are dominant and a major catalyser of extinction in reserves, animals that resort to corridors may simply be exposing themselves to hunting (Simberloff et al, 1992; Woodroffe & Ginsberg 1998).

Lastly, from the authors analysis of Ghana's protected areas that were envisioned as strongholds against the disintegration of biological activity (Bruner et al, 2001), these reserves are not living up to the wildlife refuges and sanctuaries they ought to be since they are too small and hunting levels are tremendously unsustainable for these areas to maintain healthy populations of their species (Brashares et al, 2001). Other authors claim the scenario is evident in other reserves in Africa, South and Central America, and Asia (Whitmore & Sayer, 1992; Noss, 1997; Kramer et al, 1997; Robinson et al, 1999; Terborgh, 1999).

As the *Poaching Facts* (2018a) website reveals:

> "Reported wildlife trafficking and seizures of animal parts have increased dramatically the past few years. The illicit wildlife and plant trade (illegal logging industry included) is estimated to be worth $70-213 billion a year (UN Environment, 2014) and infringes on the natural resources of countries and wealth of businesses around the world. It's also contributing to the extinction of tigers, bears, elephants, rhinoceroses, and hundreds of other incredible species while criminal organizations (Poaching Facts, 2018b) and rebel militias profit."

To demonstrate this, the tallest mammal in the world is silently facing oblivion. The four species of giraffe numbers have dwindled by a whopping 40 percent from 140,000 in 1999, to close to 80,000 in just 15 years, according to the Giraffe Conservation Foundation (GCF, 2018). Julian Fennessy, Executive Director of the GCF claims that giraffes are slow and considerably prodigious in size which makes them "an easy target that represents a lot of meat" for poachers, specifically in the Democratic Republic of Congo. The diminution of the size of the herds is also partly to blame due to hunters shooting them down and removing their brains, which is due to utter superstition of tribes, such as in Tanzania, that believe that consuming their brain will keep HIV at bay (Zuckerman, 2018), likewise, the tail of a giraffe, which is manipulated to make bracelets, fly whisks, and thread, is a valuable commodity for many African cultures (Chalcedony, 2018).

Additionally, *The Rainforest Site Blog* (Chalcedony, 2018) veers the culpability to human population and activities:

> "As the human population grows, the population of the world's tallest mammal declines almost by default. A stronger human presence means more settlements, roads, and destruction of the giraffe's natural habitat and main source of food, the acacia tree. A large portion of giraffe's habitat is now being used for agricultural purposes, depriving these gentle giants of even their homes."

By the same token, hornbills in Ghana's forests are being eradicated according to the first study of its kind published in *Biological Conservation* named "*Uncontrolled hunting and habitat degradation decimate and extirpate forest hornbills in Ghana, West Africa*" (2018) by Lars H. Holbech and colleagues. In line with their conclusions, Ghana is losing hornbill species to unchecked hunting for meat consumption and the bushmeat trade, in some cases prompting their disappearance from zones known to harbour those (Cannon, 2018d). The situation is not very different in Southeast Asia's forests, where the helmeted hornbill is being pushed to extinction, as *National Geographic* details in their September issue (Bale, 2018).

The ecologist Lars H. Holbech of the University of Ghana and lead author of the study remarked that hunters have deviated from large mammals, now scarce in many parts of the country, to large-bodied birds like hornbills (figure 4.20), prompting their demise. As a matter of fact, Holbech and colleagues reported that populations of six of the eight forest hornbill species were all found to be contracted since 1990.

The team used data surveys in 26 forested areas, ranging from virtually unscathed national parks to recently logged stretches of the Upper Guinea rainforest, which has been regarded as a biodiversity hotspot that contains not just 936 species of plants and animals that are globally threatened, but also, roughly 85 million people that inhabit its outskirts, encroaching on their habitat (Critical Ecosystem Partnership Fund, 2018).

Holbech narrated to *Mongabay* (Cannon, 2018d) how he perceived the change taking place since he arrived in 1990:

> "At that time, I saw them quite often, even in logged areas. The main problem here is hunting."

FIgure 4.20: An African pied hornbill in Kakum National Park in Ghana. Image by Francesco Veronesi via Wikimedia Commons (CC BY-SA 2.0). Retrieved from Cannon, 2018d.

In other 'walks of life', our primate cousins are facing a tremendous imperilment. Generally speaking, hunting (for meat and culturally valued body parts) negatively decimates 54 to 90 percent of primate species in the Neotropics, Africa, Madagascar and Asia (Estrada et al, 2017). In consonance with the IUCN, roughly 85 percent of primate species in Indonesia are persecuted, 64 percent in Madagascar, 51 percent in DRC and 35 in Brazil (IUCN, 2017), but there is a need to acknowledge that their assessments are now reaching 10 years of age and often many did not specify the threat of hunting (Estrada et al, 2018).

In reality, for example, almost all primates in the DRC are hunted - even the smallest monkey, the talapoin has been documented as being sold at bushmeat markets (Bersacola, Svensson, Bearder, Mills & Nijman, 2014). This commercial bushmeat industry is a major driver of primate population degradation and shrinkage and, in the case of the Brazilian Amazon, it has precipitated the annihilation of highly endangered taxa such as spider monkeys (*Ateles* spp.) and woolly monkeys (*Lagothrix* spp) (Effiom, Nuñez-Iturri, Smith, Ottosson & Olsson, 2013; Peres, Emilio, Schietti, Desmoulière & Levi, 2016; Stevenson & Aldana, 2008). Moreover, this hunting has contributed to the destruction of smaller and imperiled primates in Brazil's Atlantic Forest such as the yellow-breasted capuchin monkey (*Sapajus xanthosternos*), Coimbra-Filho's titi monkey (*Callicebus coimbrai)* (Canale, Peres, Guidorizzi, Gatto & Kierulff, 2012; Hilário, Jerusalinsky, Santos, Beltrão-Mendes & Ferrari, 2017*)*, as well as the largest Neotropical primate species, the southern muriquis (*Brachyteles arachnoides*) (ICMBio, 2011).

Identically, in the DRC hunting has considerably contracted the numbers of gorillas and bonobos (Hickey et al, 2013; Plumptre et al, 2016). As an illustration, in wild meat markets in Kisangani (DRC) roughly 65 primates were traded per day over a 131-day period (Van Vliet, Nebesse, Gambalemoke, Akaibe & Nasi, 2012). In Basankusu (DRC), the rate was 17 primates traded per visit (Dupain et al, 2012). Furthermore, in the DRC, the Endangered or Critically Endangered L'Hoest's Monkey (*Allochrocebus lhoesti),* Dryas monkey (*Cercopithecus dryas*) (Fa et al, 2014), Grauer's gorilla (*Gorilla beringei graueri)* and the eastern chimpanzee (*Pan troglodytes schweinfurthii)* undergo elevated levels of poaching and are an integral part of the commercial bushmeat trade (Plumptre et al, 2016a; 2016b; 2016c; Spira, Kirkby, Kujirakwinja & Plumptre, 2017).

Correspondingly, hunting has culminated in scenarios of literally devoided forests, with the exception of small-bodied faunal species. To emphasize, a generous area of the Sankuru Natural Reserve has virtually no bonobos remaining (Liengola, Vosper, Maisels, Bonyenge & Nkumu, 2009), with conducted surveys not finding a single bonobo closer than 10 kilometers from nearby villages (Maisels, Nkumu & Bonyenge, 2009, quoted in Estrada et al, 2018). In view of the fact that only 21-27.5 percent of bonobos inhabit protected areas (Hickey et al, 2013), their continuity into the next century is projected to be undetermined, since even those primates living in protected areas are in jeopardy. Indeed, most of the remaining 3,800 Grauer's gorillas and all mountain gorillas (*Gorilla beringei beringei* with a predicted population size of 880) are tethered to protected areas (Plumptre et al, 2016b).

By virtue of the population density of lemurs, monkeys, and apes living outside of protected areas having staggeringly dwindled, this has resulted in an escalation of the price or value of primate bushmeat, leading ever more hunters to risk prosecution by infiltrating protected areas (Rovero, Mtui, Kitegile, Nielsen, 2012). There is no sanctuary.

In Madagascar, in the forested northwestern Makira landscape, poorer households depend more on wildlife than their wealthier counterparts (Golden, Gupta, Vaitla & Myers, 2016). The rampant and unrestricted hunting of black-and-white ruffed lemurs (*Varecia varecia)*, diademed sifakas (*P. diadema*) and the brown lemur (*Eulemur fulvus*) in eastern Madagascar, has thrown these primates into heightened risk (Jenkins et al, 2011).

Political crisis and instability in the country have produced periods in which lemurs were traded as prized sources of meat (Barrett & Ratsimbazafy, 2009). Together with this, the taboos that once surrounded species such as the black-and-white ruffed lemur, indri (*Indri indri),* and sifaka (*Propithecus* spp.) have swiftly crumbled, eliciting the hunting of these larger diurnal animals (Jenkins et al, 2011; Golden, 2009). Not to mention, even small species such as mouse lemurs (*Microcebus* spp.) are being consumed, with hunters able to capture up to 50 a night, with ample effects on their populations (Gardner & Davies, 2014).

In southern Sumatra, the scenario is similar, with primate bushmeat consumption and trade reaching the hundreds of macaques killed monthly to accommodate the demand from wild meat restaurants (ProFauna, 2002). Other primates that are consumed this way are the Sangihe Island tarsiers (*Tarsius sangirensis*); (Shekelle & Salim, 2009) and Bornean orangutans (*Pongo pygmaeus*) (Meijaard et al, 2011).

In Borneo, between 1,950 and 3,100 orangutans are mutilated annually for consumption (including 375-1550 females), considerably impacting the continuity and maintenance of many small isolated populations (Meijaard et al, 2011; Ancrenaz et al, 2015; Ancrenaz et al, 2016; Santika et al, 2017). In Indonesia, even subsistence hunting can lead to tremendous repercussions on primate populations already obliterated by land conversion and habitat loss (Fuentes, 2002; Paciulli, 2004).

(These examples only incorporated subsistence and hunting in general. For a deep and expansive analysis of the legal and illegal primate live trade it is advisable that the reader continues the examination in Estrada et al, 2018).

Besides the ethical questions raised by hunting endangered animals, even if it is for subsistence, there are other issues, such as ecological ones, that arise from the absence of these primates in their ecosystems. A vast array of primates in the countries of Brazil, Indonesia, DRC and Madagascar consume ripe fruits that function as crucial agents of seed dispersal, engaging in forest regeneration (Chapman et al, 2013). The extermination of primates due to hunting evokes a change in dispersal dynamics, the size and distribution of seed shadows, a dwindling in plant genetic diversity and seeding recruitment (Caughlin et al, 2014; Pacheco & Simonetti, 2008; Brodie, Helmy, Brockelman & Maron, 2009).

Evidence is also starting to accumulate denoting that as lemur populations contract that results in reduced viability of several species of Malagasy trees (Federman et al, 2016). Comparatively, the population breakdown of larger-bodied primates echoing the over-hunting in the Brazilian Amazon has impacted the reclamation of long-lived and hardwood tree species, which will prompt a reduced ability for these forests to store carbon (Peres, Emilio, Schietti, Desmoulière & Levi, 2016; Stevenson & Aldana, 2008). Moreover, this overhunting of primates produces a reduction in the recruitment of trees whose seeds they scatter, which urges a reduction of food sources to other local mammalian and avian communities (Abernethy, Coad, Taylor, Lee & Maisels, 2013; Nunez-Iturri, Olsson & Howe, 2008). Primates mentioned throughout this segment are portrayed in figure 4.21.

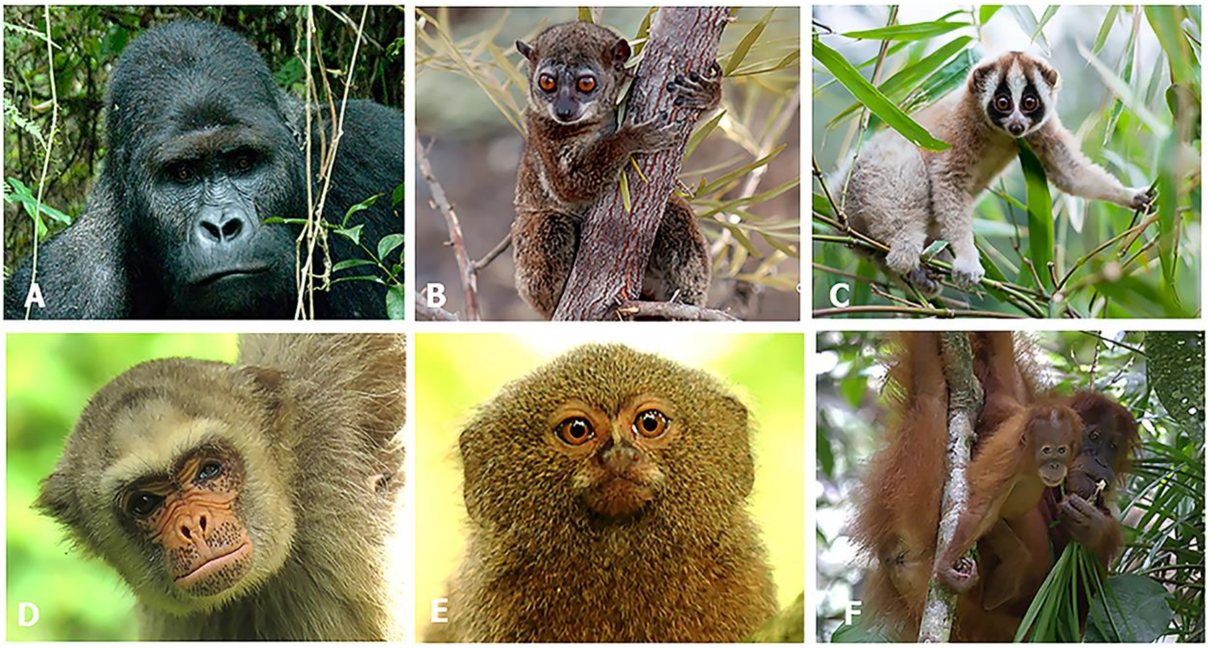


Figure 4.21: Photos of selected primates from each country. Conservation status and photo credits include the following: (A) DRC, Grauer's gorilla (Gorilla beringei graueri), Critically Endangered, (Photo credit: J. Martin), (B) Madagascar, Sahafary sportive lemur (Lepilemur septentrionalis) Critically Endangered (Photo credit: R. A. Mittermeier), (C) Indonesia, Javan slow loris (Nycticebus javanicus), Critically Endangered (Photo Credit: Andrew Walmsley/Little Fireface Project), (D) Brazil, northern muriqui (Brachyteles hypoxanthus), Critically Endangered (Photo credit: Raphaella Coutinho), (E) Brazil, pygmy marmoset (Cebuella pygmaea), Vulnerable, (Photo credit: Pablo Yépez), (F) Sumatran orangutan (Pongo abelii), Critically Endangered (Photo Credit: Perry van Duijnhoven). Retrieved from Estrada et al, 2018. DOI: 10.7717/peerj.4869/fig-10.

Another symbolic case study is the Bengal tigers (*Panthera tigris ssp. tigris* (Chundawat, Khan & Mallon, 2010), which have been victims of rampant poaching, habitat loss and fragmentation (Ghosh, 2018). Presently, there are roughly just 2700 to 4000 tigers in the world, while a century ago there may have been close to 100,000. On the other hand, there are 7.6 billion humans roaming this planet. The discrepancy in itself is distressing. As a matter of fact, over the previous 100 years, tigers have forcefully relinquished 95 percent of their former habitat, which were appropriated by the expansion of the *H. sapiens,* in the regions of India, Bangladesh, Nepal, Bhutan, China, and Myanmar (WWF, 2016b). Dave Foreman sums it up perfectly when stating in his book *Man Swarm – How Overpopulation is Killing the Wild World* (Foreman & Carrol, 2015):

> "As the human population shot through the roof in India, the population of tigers fell through the floor."

As it was previously discussed in this chapter, one of the main reasons for concern is the failure of maintaining continuity of populations of species, which are rapidly declining (e.g. Ceballos et al, 2017), and one of the factors that is leading to this swift deterioration is the incapacity of populations preserving their genetic diversity (Buncombe, 2013; Watson, 2013; Thapa et al, 2018), due to small populations being splintered and disunited by habitat loss and fragmentation (Ghosh, 2018; The Hindu Business Line, 2013).

Michael W. Bruford, co-author of *Demographic loss, genetic structure and the conservation implications for Indian tigers* (Mondol, Bruford & Ramakrishnan, 2013) published in the journal *Proceedings of the Royal Society B*, commented in an interview for the *Hindu Business Line* (2013) the status to the Bengal tiger:

> "This is due to loss of habitat and habitat fragmentation, meaning lower population sizes, and the prevention of tigers from dispersing as they once would have, which means their gene pool is no longer mixing across the subcontinent. This is important because tigers, like all other species, need genetic diversity to survive - especially under climate change - so what diversity remains needs to be managed properly so that the Indian tiger does not become inbred, and retains its capacity to adapt."

If all these threats weren't enough, vulnerable populations of tigers are under the permanent and looming menace of poaching, which interferes with their conservation efforts (figure 4.22). This is due to traditional Chinese medicine from China and Southeast Asia that have prolonged the profitability of this scheme, by virtue of people believing that the tigers hold supernatural, restorative powers, and so, practically all parts of the animal are considered a prized possession (Poaching Facts, 2018c).

Tiger's skins have a substantial value to traditional Buddhist monasteries but also to present-day Asian celebrities who have adopted their skins as tantalizing status symbols (Poaching Facts, 2018c). Demonstrably, and in accordance to *Walker's Mammals of the World* (Novak, 1999) a tiger skin would sell for roughly $4,250 in 1977, which is close to $16,880 in 2015 dollars. Furthermore, a report by the Environmental Investigation Agency (EIA) from 2004 denoted that tiger skins were being sold for up to $10,000 (Banks & Newman, 2010) in Tibet, essentially to Chinese, Taiwanese and European tourists (Poaching Facts, 2018c).

Regarding the situation in India, the *Poaching Facts* website (2018d) expresses:

> "Due to the immense size and population of India, inadequate anti-poaching efforts, and a huge demand of animal parts by neighbouring countries the exact number of tigers and other wildlife illegally killed and trafficked is difficult to determine. In October of 2003, the Environmental Investigation Agency (Banks & Newman, 2010) reported that a shipment of skins from 581 leopards, 31 tigers, and 778 otters heading from India to Lhasa, Tibet had been intercepted at the border. An incident in July of 2004 in Kanpur, India saw the seizure of 456 leopard and tiger claws and $13,000 in cash."

A discussion regarding the nauseating wickedness of poaching would not be consummated if it didn't include the most trafficked animal in the world, the pangolin (figures 4.23 and 4.24). According to the IUCN (Challender et al, 2017), more than a million pangolins were snatched from the wild in the past decade, with the four Asian species having been hunted to near annihilation, and the four African species being poached in tremendous record levels (Guynup, 2018).

As severe as the crisis surrounding the pangolin is, with about a million of these solitary, nocturnal mammals having been killed, due to their meat, blood, scales and fetuses, most people on this planet have no idea what a pangolin is, and if current unrighteous and nefarious poaching practices continue, the last critically endangered Chinese (*M. pentadactyla*) and Malayan (*M. javanica)* could be wiped out (Guynup, 2018) and humanity, in general, would be oblivious to the loss that is occurring beneath their pervasive geographic predomination (colloquially speaking, right under their noses).

Figure 4.22: Bengal tigers in India. Photo by Karthik Easvur/Wikimedia Commons/(CC BY-SA 2.0). Retrieved from Ghosh, 2018.

Moreover, and to a lesser degree, the animal is consumed as bushmeat in Africa - and quickly becoming an expensive delicacy sold in markets and restaurants. Additionally, the mammal is a favorite ingredient in traditional medicine on a continent where roughly 80 percent of individuals rely on such "treatments." As a matter of fact, a survey of traditional healers in Sierra Leone unveiled that 22 different pangolin body parts were used to nurse 59 conditions, with most practitioners completely incognizant that they were popularizing the extinction of the animal (Guynup, 2018).

The absurdity is revealed when we see the extent and dangerousness of having more people believing and resorting to this madness:

> "For millennia, pangolin scales have been cooked in vinegar, oil, boy's urine, or roasted with dirt or oyster shells to treat a long list of health problems. These pangolin-based remedies are believed to calm hysterically crying children, stimulate lactation in nursing mothers, free women possessed by devils and ogres, drain pus, treat liver problems, malaria, deafness and more. In Taiwan, some drink a concoction of pangolin blood and wine for its purported health benefits. Paul Thomson, vice Chair of the International Union for the Conservation of Nature (IUCN) Pangolin Specialist Group, has heard reports of people using it to treat cancer, which, he worries could take pangolin poaching to a whole other level. Pangolin scales are made of keratin, like human fingernails. They have no scientifically proven medicinal value" (Guynup, 2018).

A recent study published in the *African Journal of Ecology* (Mambeya et al, 2018) predicates that hunters in Gabon are selling ever-growing numbers of pangolins to Asian workers, who are more likely to seek these animals (Guynup, 2018). As Thomson argues:

> "The connection between a rise in poaching and trade of pangolins and other wildlife seems to coincide with a larger Chinese presence in Africa."

In light of this, one could venture a guess that this must be a recent phenomenon, but far from it. An article in the journal *Nature* from 1938 already explicitly admonished the need for greater protection of the Asian species (Guynup, 2018).

Of course, the circumstance has only escalated since then. With the global human population having more than tripled since 1938, with virtually all human growth in Africa and Asia, the people who harbour the preposterous and nonsensical beliefs that pangolins have herbal properties, as in traditional Chinese medicine to cure conditions such as psoriasis and poor circulation, or eating their meat as a luxury food, as it is happening all over the East (IUCN, 2014), have all but surged incredibly in number, amplifying the already strenuous status of the pangolin and other creatures that are hunted due to these barbarous notions that have survived until the 21st century, and that should really be relinquished to humanity's past.

If most people are not serious in their commitment to stabilizing and eventually reducing the human populace on this planet, they should at least abandon and forsake these 'traditions' that are just simply atrocious, and as Professor Jonathan Baillie, Co-Chair of the IUCN Species Survival Commission of the Pangolin Specialist Group and Conservation Programmes and Director at the Zoological Society of London declares (Vaughan, 2014):

> "All eight pangolin species are now listed as threatened with extinction, largely because they are being illegally traded to China and Viet Nam. In the 21st century we really should not be eating species to extinction - there is simply no excuse for allowing this illegal trade to continue."

Figure 4.23: To defend itself against predators, a pangolin rolls itself into a ball, making it easy for a poacher to pop in a bag. Photo credit: Wildlife Alliance on Visual hunt / CC BY-SA 2.0). Retrieved from Guynup, 2018.

Figure 4.24: The best-side of humanity. The Tikki Hywood Foundation sanctuary team in Zimbabwe. Every rescued pangolin is assigned its own minder who takes it out to forage for food each day. Image courtesy of the Tikki Hywood Foundation, Zimbabwe (2018), CC BY-SA 2.0 . Retrieved from Guynup, 2018.

Together with all these cases, a research paper published in *Royal Society Open Science* (Ripple et al, 2016) identified the endangered land mammals that are mostly at risk from the activities described in this segment. The team resorted to the International Union for Conservation of Nature (IUCN) red list to conduct the study, which revealed that 301 species – 7 percent of all land mammals assessed by IUCN and about a quarter of all endangered mammals are imperilled by habitat loss or hunting. Their vast list of victims includes 168 primates, 73 hoofed animals, 27 bats, 12 carnivores, 26 marsupialsm, 21 rodent species and all of the 8 species of pangolins (Carrington, 2016c).

In an interview for *The Guardian* (Carrington, 2016c), Prof David Macdonald, at the University of Oxford and part of the international team behind the study asserted:

> "The number of hunters involved has gone up, and the penetration of road networks into the remotest places is such that there is no refuge left […] There are a plenty of bad things affecting wildlife around the world and habitat loss and degradation are clearly at the forefront, but among the other things is the seemingly colossal impact of bushmeat hunting."

The researchers attest that to counteract these trends of over-hunting will demand greater protection for the species, empowering local communities to see the advantages of having wildlife conservation in their midst, presenting other sources of food and better education and family planning to supress population growth (Carrington, 2016c).

Fortunately, and at least in this case, the team of scientists understands the crucial preponderance of subduing the increase in population to vanquish this assault on wildlife. But there are those who claim that population has an "alleged" role to play in this problem. In *Does Human Population Growth Increase Wildlife Harvesting? An Economic Assessment* (2002) Erwin H. Bulte and colleagues claim the following:

> "Allegedly, one of the main culprits responsible for this problem is human population growth. [...] The results indicate that the population pressure myth needs revision and refinement [...] population growth does not affect wildlife populations at all. Rather increasing stress on wildlife stocks may be explained by other factors such as technical change in hunting methods."

Facing such an allegation, a thought experiment is in order. Let us start by examining how the population has changed in some of the countries already referred throughout this segment and how are the projections for the coming decades looking, by resorting to the United Nations *World Population Prospects* document (UNDESA, 2017).

1. Cameroon (1950) - 4,3 million; (2017) - 24 million; (2030) - 32,9 million; (2050) - 49,8 million
2. Central African Republic (1950) - 1,3 million; (2017) - 4,6 million; (2030) - 6,1 million
3. Dem. Republic of the Congo (1950) - 12 million; (2017) - 81,3 million; (2030) - 120, 4 million
4. Gabon (1950) - 0,4 million; (2017) - 2 million; (2030) - 2,5 million; (2050) - 3,5 million
5. Singapore (1950) - 1 million; (2017) - 5,7 million; (2030) - 6,3 million; (2050) - 6,5 million

One quick glance and the reader will detect a conspicuous pattern. Not one of the countries in which bushmeat hunting and poaching have been revealed to be generalized and detrimental to the fauna and flora, have decreased or maintained a stable population. The reverse is actually the case. Since 1950, several dozen million individuals have been added to these nations, and more are expected to arrive in the coming years. All of these million people will need to be fed, and as I have reviewed, bushmeat is an essential source of protein in these societies, additionally, they will need some sort of livelihood, and subsistence hunting for consumption and/or sale is of paramount relevance has we could read from Elizabeth Bennet's experience. Together with this, we still have to account the augmented population that will believe in the pernicious fictitious conviction that animal parts have magical properties, and how this wildlife trade is one major cause in the endangerment of species in China and its neighboring countries, for example.

It should be safe to assert that that the expansion of the human population has brought a concomitant extension of these markets since they have been a traditional source of revenue and social interaction, with the only restriction in its diffusion being all of these animals and plants removed from their habitats, incapacitating its reproductive wherewithal, leading to their eventual contraction and demise.

On top of this, the expeditious rise in affluence (examined in the next chapter) of an already colossal human population throughout China, for example, will lead to more events such as the horrendous one described in the *Mongabay* news website (Guynup, 2018) regarding the pangolin:

> "Pangolin fetus soup or meat is often the most expensive item on the menu at Asian restaurants and is served as a delicacy to flaunt wealth and influence. At special dinners, the animal is sometimes brought to the table alive, then fileted and cooked in front of guests."

By denying the pressure exerted by an ever increasing population, even if a substantial share of that population is moving into urban areas and therefore relying less on bushmeat for survival, and more on livestock farming, in the end, none of those are remotely sustainable, since the transmogrification and conversion of habitat into agricultural fields for feeding livestock has been shown in this chapter to be a major element in the genocide of populations and species.

Furthermore, one other point that requires focus, especially in this segment is the narrative that overconsumption and monopolization of resources by the richest in the world is what is engendering our ecological collapse. Without any doubt, wealth is closely related to environmental damage, but to assert that the poor, regardless of their numbers, amount to no marked ecological repercussion is to be intellectually dishonest and misleading. We have to be able to have this conversation and stating clearly that it isn't an average citizen of the West that is hunting, selling and consuming endangered species, but the unfortunate poorest of the poor in Africa and Asia. Metrics such as the carbon and ecological footprints are not taking into account these discrepancies when analysing, for example, the difference between the United States and an inhabitant of the DRC. It is crucial that we face the fact that no human added to this planet, regardless of its individual wealth, has (at the moment) the possibility to lead a neutral or negative carbon footprint life, or vacant of an environmental and ecological fallout.

In the end, in a world with incessant population growth, we cannot expect an attenuation and ceasing in the tension and demand on the ecosystems and their inhabitants.

All things considered, the examples supplemented in this segment are but the tip of the iceberg, and to that end, I hope I have stimulated enough interest on part of the reader to continue to nurture an independent search and examination in this regard, since I would argue it to be a worthy subject demanding of attention.

Roosevelt's Legacy

"For one species to mourn the death of another is a new thing under the sun. The Cro-Magnon who slew the last mammoth thought only of steaks. The sportsman who shot the last pigeon thought only of his prowess. The sailor who clubbed the last auk thought of nothing at all. But we, who have lost our pigeons, mourn the loss. Had the funeral been ours, the pigeons would hardly have mourned us"

- Aldo Leopold

"Here is your country. Cherish these natural wonders, cherish the natural resources, cherish the history and romance as a sacred heritage, for your children and your children's children. Do not let selfish men or greedy interests skin your country of its beauty, its riches or its romance."

-Theodore Roosevelt

We have finally arrived at the last stop of this chapter. I realize it mustn't have been a pleasant trip since death and the void left by it dominated the narrative. For that reason I intended to conclude this last segment on a more positive note, and although our current crisis is not to be trifled with I didn't want to leave out the many contributions and hallmarks in conservation science, the rewilding effort and other institutions and individual or collectives that are fighting everyday to hamper the loss of ecosystems and populations of species.

In contrast to the abominable story of extinction and loss in human prehistory, the recent past and contemporary defaunation there is also a memoir of qualified success in wildlife conservation, that started in America and disseminated throughout most of the world which demands not to be forsaken (Kolankiewicz, 2012).

Since President Theodore Roosevelt set aside Pelican Island National Wildlife Refuge in Florida in 1903, more than 550 national wildlife refuges have been established throughout the country, conserving more than ninety-five million acres under the slogan "Wildlife Comes First". While a dedicated conservationist himself, Roosevelt was also answering back to the popular outrage at the carnage taking place in America at the time (Kolankiewicz, 2012).

It must be remembered that a century ago, whitetail deer had been all but extirpated from many states, wild turkeys were scarce, and market hunters were terrorizing edible waterfowl for their flesh and elegant wading birds for their feathers. Populations of charismatic birds like the California condor, ivory-billed woodpecker, trumpeter swan, and whooping crane were plummeting. The passenger pigeon, the single most abundant bird in North America and perhaps the world was on the verge of obsolescence. The American buffalo (bison) had joined this fate as railroads and ferocious gunners pushed them westward into Indian Territory. Mountain lions, wolves, elk, and bison had been phased out in the East, and the grizzly bear all but eradicated out of the Golden Bear State (California). In the second half of the twentieth century, majestic birds of prey - the American bald eagle, peregrine falcon, brown pelican, and osprey - were all imperiled with annihilation from the widespread use of DDT and its chemical analogues (Kolankiewicz, 2012).

Today, several decades after the worst pesticides were banned and ambient concentrations have diminished, these raptors have all rebounded. Whitetail deer have become so numerous that they are considered a scourge to gardeners and a hazard to motorists in many places. Protected wading birds (herons and egrets) and managed waterfowl are far more abundant and enjoy stable populations. Bison, grizzly, and wolf populations, while not recapturing their former glory, have at least stabilized and their continued survival, for the time being, seems assured (Kolankiewicz, 2012).

What a difference a genuine commitment to conservation makes! America acknowledged the moving prose and pleas of venerated activists and authors like John Muir, John Burroughs, Aldo Leopold, Olaus Murie, Rachel Carson, and many other naturalists and a revolution was launched (Kolankiewicz, 2012). Four decades of environmentalism have altered America and the world. The citizens immersed in this historic development have safeguarded landscapes and rivers, cleaned up air and water, and think about their relationship with the Earth (Palmer, 2012). Of course, one also needs the economic means and technical resources to convert commitment into action and results. And in the twentieth century, as America grew wealthy and more literate and informed, specialized new fields like wildlife management and conservation biology were able to develop into full-fledged professions (Kolankiewicz, 2012).

Owing to one of the most crucial assets of the human species, the incisive ability to become versed with the way the world changes and through adaptability, figuring out solutions, we have changed the paradigm. Our society appears impregnated in denial, but we can become skilled by our ecological barbarities (Weyler, 2012).

“We’re winning a lot of battles,” Greenpeace Executive Director Kumi Naidoo said at the 40th anniversary of Greenpeace, “but we’re still losing the war.”

Regrettably, this is indubitable. Every day, our planet is poorer, impaired and shortened of forests, species, freshwater and arable soil. Comparatively, a substantial and bountiful increase in deserts, toxins and CO_2 in the atmosphere shows every sign of being our reality (Weyler, 2012).

For no matter how well we outshine as managers, the extent of wildlife we can defend is constrained by the amount of uncontaminated, uncompromised, intact habitat remaining. If we continue to increase the number of people, levels of consumption, and aggregate demands on the land, we will inevitably diminish the abundance and diversity of wildlife. Enlightened management and cutting-edge technologies can only do so much (Kolankiewicz, 2012).

This is not to say that common conservation policies cannot be effective. There are a number of countries, such as Kenya, that have attained some sort of success, with declining numbers of threatened species in spite of lingering population growth. These countries can temporarily withstand the trends relating biodiversity loss to increased population density by enforcing sound and scientifically based conservation strategies. But there is always a potential for the annulment of such an ensample since human population growth carries with it a heterogeneous and complex web of repercussions that mount further pressure and become hard to predict and foresee. It must also be remembered that many countries do not have the economic incentive of nations like Kenya, where ecotourism is crucial, to do all they can for the species that inhabit their lands (McKee, 2012). Additionally, it has been evidenced that the post-conflict rehabilitation initiatives in Mozambique's Gorongosa National Park and Rwanda Akagera National Park have successfully linked poverty alleviation and human development with an improved protected-area administration, ranger training, and wildlife monitoring to enhance conservation outcomes (Pringle, 2017; Carroll, 2016).

Once we become better stewards, seeking to avoid adverse impacts on wildlife, allowing for only sustainable rather than unrestrained harvests and so forth, then we have the potential to really enhance the situation, as we have to some degree. However, at a point, we then reach a plateau in the pursuit of sustainable conservation (Kolankiewicz, 2012).

With this in mind, it is vital that we recognize that today, as Rex Weyler (2012) sketches it:

> "We have more environmental groups and less forests, more "protected areas" and less species, more carbon taxes and greater carbon emissions, more "green" products and less green space. These failures are not necessarily the fault of environmental groups, who have helped slow down the destructive impacts of the industrial juggernaut, but the failures do demonstrate that all our collective efforts are not yet remotely enough."

Weyler supplements his rhetoric by calling attention to the Living Planet Index (2018) and says:

> "We find that after 1980 - even with the creation of new endangered species regulations, parks, and protected areas - terrestrial and marine species have declined. For the last thirty years, even with a massive increase in wilderness groups, species diversity has plummeted and the rate of decline has accelerated."

Tim Palmer goes straight into the heart of the question in *Life on a Brink - Environmentalists Confront Overpopulation* (2012*):*

> "Working for efficiency, better resource management, the "greening" of development, and other reforms are all important. But the immediate conclusion is that little can be accomplished in the long term if the most fundamental pressure behind the problems - population growth - continues."

To put it another way, for every species aside from humans, without any doubt, the most colossal environmental issue on Earth is Humanity. If we don't veer from our annihilative praxis, then nature will ultimately, relinquish our presence and endure without us (Weyler, 2012). Some examples of contemporaneous conservation efforts might become elucidative to understand the extent of the quandary we are currently facing.

In the U.S: Virgin Islands, managers and concerned citizens are working hard to protect Sandy Point, Green Cay, and Buck Island National Wildlife Refuges. Population growth is not helping as it is noted in this comprehensive conservation plan (CCP) from the U.S. Fish and Wildlife Service (Kolankiewicz, 2012):

> "[The Caribbean] ecosystem is home to 78 threatened and endangered species (29 animals and 49 plants), including species of birds, reptiles, and amphibians, as well as unique and diverse habitats ranging from coral reefs, sandy beaches, and mangrove forests to limestone hills and forested mountains… Since the end of the Second World War, human population has increased dramatically on almost every island… negative ecological trends have all accelerated as a result of the demands explosive human growth has placed on the environment. Within the U.S. Virgin Islands, the demands for space and land created by a rapidly growing human population of over 100,000 have resulted in extensive loss and degradation of natural ecosystems, especially on densely populated St. Thomas (USFWS, 2009)"

Three decades ago, the world's surviving population of the tiny, critically endangered St. Croix ground lizard (*Ameiva polops)* on the fourteen-acre Green Cay National Wildlife Refuge was regarded to have been left to this fate due to human disorder, land development, and the introduced Indian mongoose, which preyed on it. Determined recovery efforts at the refuge and nearby Buck Island Reef National Monument, to which it has been relocated, offer hope that *A. polops* will yet sustain a healthy population and maintain its continuity. Even so, it is unsettling that the entire existing population still probably weighs less than a single adult human. Globally, the ratio of our species' aggregate biomass to theirs exceeds seven billion to one (7,000,000,000:1) (Kolankiewicz, 2012).

The lumbering leatherback turtle (*Dermochelys coriacea)* nests on beaches at Sandy Point National Wildlife Refuge. At up to eight feet in length and a ton in weight, the leatherback is the largest, deepest diving, and widest ranging of all sea turtles. It is imperiled by virtue of overexploitation for its eggs and meat, incidental take by commercial fisheries, disorientation of hatchlings by beachfront lighting, and exaggerated nest predation (US Fish & Wildlife Service, 2015). Yet, at Sandy Point National Wildlife Refuge, nesting leatherbacks have increased from less than twenty in 1982 to more than a hundred in recent years; average hatchling production has quintupled. (Kolankiewicz, 2012).

In either case, curbing human numbers both locally and globally is crucial to saving these two endangered reptiles. Locally, population stabilization would scale down pressure to poach sea turtle eggs and trample the ground lizard's habitat; it would give them the vital amplitude and expansion they require for their biological activities. Globally, it would help curtail the ceaseless buildup of greenhouse gases that threatens the Caribbean and other marine protected areas (MPAs) with more frequent and ferocious hurricanes, sea level rise, coral-killing warmer waters, and coral-dissolving acidifying waters (Kolankiewicz, 2012). With the oceans absorbing more than 90 percent of the additional heat trapped by anthropogenic greenhouse gases, it is causing a widespread rise in ocean temperatures, even in the deep sea (Gleckler, Durack, Stouffer, Johnson & Forest, 2016).

On that account, a paper published in the journal *Nature* called "*Climate change threatens the world's marine protected areas"* (2018) by John F. Bruno and colleagues asserts that by 2050, 42 percent of areas with fishing bans will be exposed to warming and decreasing oxygen levels that exceed natural variability. With persistent business-as-usual emissions (as shown in previous chapters human numbers and activities are directly correlated to levels of emissions present in the atmosphere and naturally absorbed by the oceans. This will be thoroughly examined in the chapter Category: Chaos), mean sea-surface temperatures within MPA's are foreseen to augment 0.035ºC per year and warm an additional 2.8ºC by 2100.

The authors also argue that species largely confined to marine reserves could be especially vulnerable to anthropogenic climate change due to their typically small populations and low genetic diversities (Peters, 1985).

All things considered, humanely stabilizing and reducing the human population is a vital requirement for saving biodiversity and halting the brutal wave of extinction breaking over the Earth (Kolankiewicz, 2012).

Let us stay on the topic of the efficiency of Protected Areas for a while longer. Human impact on terrestrial and marine natural resources culminates in marine and coastal degradation.

Population growth, urbanization, industrialization and tourism are all components and ingredients conspiring to perpetuate that degeneration (WWF, 2017a).

Camilo Mora, from University of Hawaii and Dalhousie University, and Peter F. Sale, from the UN University in Ontario, Canada, published "*Ongoing global biodiversity loss and the need to move beyond protected areas"* (2011). Their report demonstrated that since 1965, land-based "Protected Areas" (PAs) have expanded by 600 percent to 18 million km^2. Marine PAs have widened by 400 percent to about 2.1 million km^2. Nonetheless, in both cases - on land and in oceans - biodiversity has languished, and the rate of diminution has escalated. Since 1974, terrestrial biodiversity has fallen hard and fast by about 40 percent and since 1990, in twenty years, the marine index has abated by 21 percent (Weyler, 2012).

Sale and Mora (2011) declare unequivocally:

> "Protected areas are a false hope in terms of preventing the loss of biodiversity."

They allude to the 2010 global biodiversity protection agreement signed in Nagoya, Japan, which bounded its signatories to preserve 17 percent of land area and 10 percent of oceans (Convention on Biological Diversity, 2017). Sale evinces it is "very unlikely those targets will be reached," due to the augmentation of human demand for every available resource. Furthermore, "Even if those targets were achieved, it would not stop the decline in biodiversity" (Weyler, 2012).

The authors encourage the institution of protected areas but admonish that these areas alone will not stop the degeneration of biodiversity without larger, and ingrained programs. Mora points out that most protected areas are really just "paper parks" in name, but not truly protected (Weyler, 2012).

In 'paper parks,' flora and fauna abscond silently to poachers, development, and industrial pressure from logging and mining. Regularly, without competent enforcement, industrial developers plainly overlook conservation rules (Laurance et al, 2006). Furthermore, park confines cannot hamper pollution and global warming effects. Normally, when a forest or coral reef is sheltered, the neighbouring area is over-harvested by industry and often annihilated, breaking natural ecosystem links (Churchill, 2012).

In the 2018 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2018) report, the authors stress that even with the number of conservation areas having increased, most governments are failing to carry out the biodiversity commitments set out at the 2010 UN conference in Aichi, Japan (Watts, 2010). In the Americas, for example, only 20 percent of key biodiversity areas are protected (Watts, 2018a). The report stresses that some progress has been made, for example, terrestrial protected areas between 2004 and 2017, widened by 13.8 percent, unfortunately, as the report maintains, simply establishing protected areas is a defective strategy (Gilbert, 2018).

In like manner, recent research by Kendall R. Jones and colleagues, published in *Science* under the ominous title "*One-third of global protected land is under intense human pressure"* (2018) testifies to the pervasive influence of human presence and activity. The authors demonstrate that about one-third of the world's total protected area - close to 6 million square kilometers (2.3 million square miles) - exhibits substantial degeneration at the hands of the human species (Cannon, 2018e).

Roads, ranches, mines, and cities are penetrating many of the world's parks, reserves and wilderness sanctuaries, resulting in a third of the planet's protected area - almost three and a half times the size of Alaska - with the scars of an unbounded dissolution (Cannon, 2018e).

That is one of the main conclusions drawn by James Watson, ecologist and author of the study, who said:

> "What we're showing is at least one-third of the protected area estate is relatively worthless [...] (protected areas aren't) giving biodiversity a break from humanity [...] I saw many, many protected areas are just getting smashed."

In their study, Watson and his colleagues assert that the parks and reserves which are under more sturdy and tough standards did better than those with lenient controls. They remarked that Niassa National Reserve in Mozambique, Keo Seima Wildlife Sanctuary in Cambodia, and Madidi National park in Bolivia are all places where governments and NGOs are managing to keep wild spaces as pristine and untarnished from human contact as possible. Lamentably, on a global scale, only around 10 percent of the PA's that were the target of the study do not show what the authors call "intense human pressure"(Cannon, 2018e).

As an illustration, the authors (Jones et al, 2018) examined the average human footprint [(combination of data on built environments, intensive agriculture, pasture lands, human population density, nighttime lights, roads, railways and navigable waterways (Venter et al, 2016)] and arrived at the following denouement that is represented in figure 4.25:

> "We find that the average human footprint score within protected areas is 3.3, almost 50 percent lower than the global mean of 6.16 (Venter et al, 2016). Despite this, human activities are prevalent across many protected areas, with only 42 percent of protected land free of any measurable human pressure. Areas under intense human pressure make up 32.8 percent (6,005,249 km^2) of global protected land, and more than half (57 percent) of all protected areas contain only land under intense human pressure (concentrated in Western Europe, southern Asia, and Africa). Just 4334 protected areas (10 percent of analysed areas) are completely free of intense human pressure and these primarily occur in remote areas of high-latitude nations, such as Russia and Canada."

By the same token, Sri Lanka and the Indian Western Ghats (also known as Sahyadri Mountain Range) constitute one of the 36 Biodiversity Hotspots, besides being considered one of the eight "hottest hotspots," hinging on their substantial plant and animal endemism (Myers et al, 2000). They comprehend an extensive range of ecosystems: moist and dry deciduous forests, montane rainforests, evergreen forests and the unique Shola grasslands. On top of it, the 332 globally imperiled species call the hotspot their home, and it accommodates populations of endangered mammals such as the tiger (*Panthera tigris*), Asian elephant (*Elephas maximus*), Asiatic wild dog (*Cuon alpinus*) and gaur (*Bos gaurus*). Ultimately, the hotspot encompasses more than 30 percent of all plant, fish, reptile, amphibian, bird and mammal species encountered in India (Dérer, 2018b).

Synchronously with its high conservational relevance, the region has the uppermost human population density among all biodiversity hotspots (average 350 people/km^2) (Cincotta, Wisnewski & Engelman, 2000). Confronting such immense population pressure, the hotspot's forests have been fiercely overwhelmed by arrogations of timber and agricultural land (Dérer, 2018b). As a matter of fact, between 1920 and 1990, 40 percent of the region's natural vegetation was transmuted into coffee and tea plantations, and, at present, roughly 6.3 percent of primary vegetation endures (Sloan, Jenkins, Joppa, Gaveau & Laurance, 2014).

A recent study, *Parks protect forest cover in a tropical biodiversity hotspot, but high human population densities can limit success* (2018), Krishnadas and colleagues analyze the correlates of forest deficit ensuing the region's expeditious economic expansion (Dérer, 2018b). Equally important is that between 2000 and 2016, the Western Ghats lost upwards of 750 km^2 of forest (Krishnadas, Agarwala, Sridhara & Eastwood, 2018). On a positive note, these rates are the region's lowest in the previous 100 years, and are considerably lower than for other forested parts of India (Reddy, Jha & Dadhwal, 2016). Notwithstanding, the adverse repercussions of this erratic type of small-scale deforestation on biodiversity can be consequential, and remain predominantly unexamined (Dérer, 2018b).

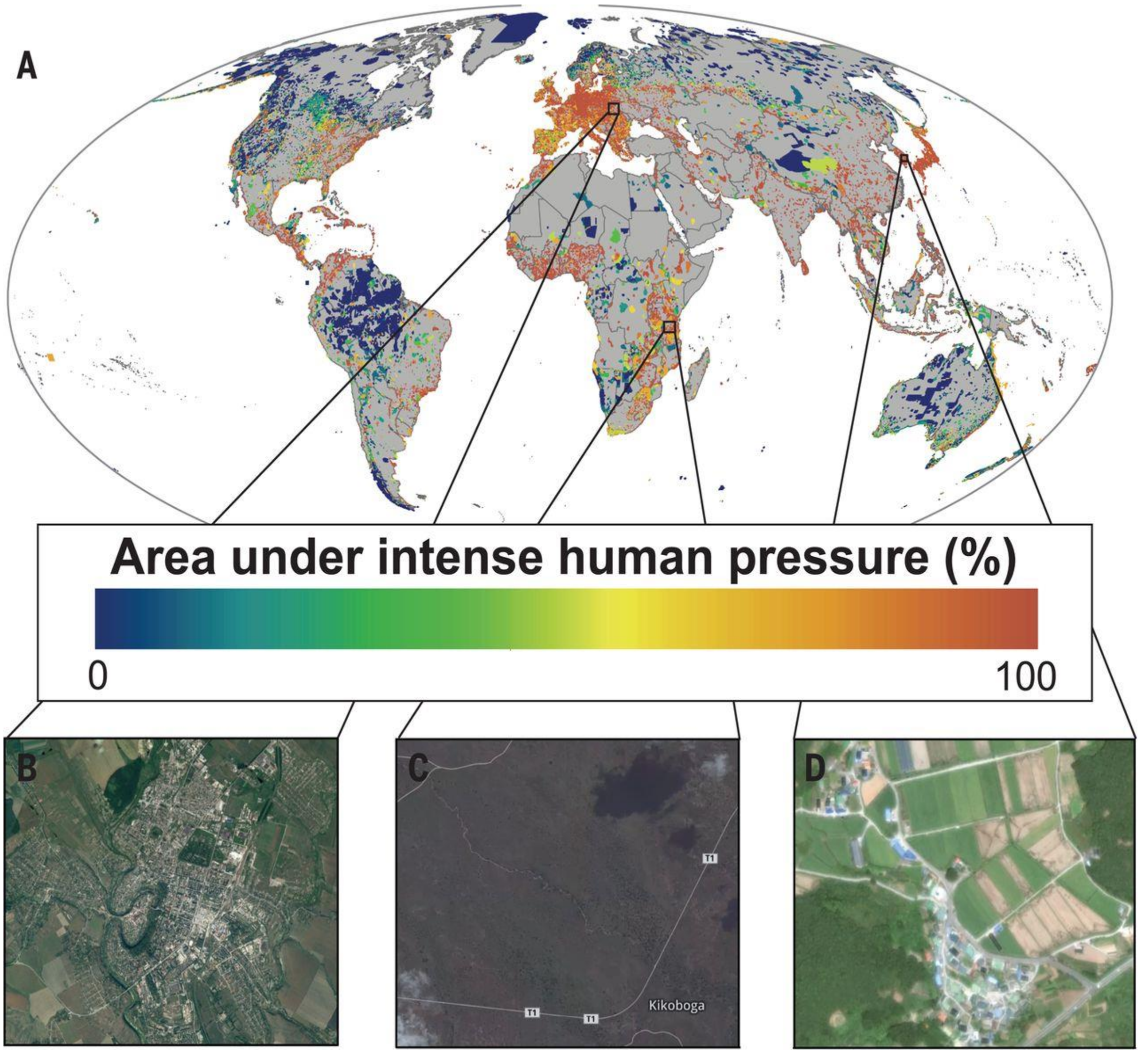


Figure 4.25: Human Pressure within Protected Areas. (**A**) Proportion of each protected area that is subject to intense human pressure, spanning from low (blue) to high (orange) levels. (**B**) Kamianets-Podilskyi, a city within Podolskie Tovtry National Park, Ukraine. (**C**) Major roads fragment habitat within Mikumi National Park, Tanzania. (**D**) Agriculture and buildings within Dadohaehaesang National Park, South Korea. [Photo credits: Google Earth]. Retrieved from Jones et al, 2018.

The authors of the study stated above arbitrated that deforestation took place essentially outside protected areas (PA's), and that the forest protection - in the form of wildlife sanctuaries and national parks - fortuitously contracted forest loss by 30 percent. Moreover, the authors identified that by every 22 km increase in mean distance to human settlements, forest loss subsided by 16 percent, with a lesser impact still for protected areas. To this effect, PA's were 36 percent less inclined to lose forest than non-protected forests when contiguous to human habitations. Equivalently, with every 4 km in increased distance from roads, forest loss abated by 21 percent, and 33 percent for PA's (Dérer, 2018b).

Be that as it may, the benefits of formal protection waned by 32 percent with every increase of 24,000 people above mean local population densities. Strictly speaking, where local human populations were higher in the Western Ghats, PA's were 70 percent more subject to forest cover loss than non-PA's. This presupposes that the difference in forest loss between PA's and non PA's is highly correlated with local population densities (Dérer, 2018b).

Coming back to the research on primate extinction inaugurated in the previous segments (Estrada et al, 2018), the authors also address the overlap between protected areas, primate distribution, human population density and the inflation in human activities with corruptive repercussions for the primate's habitats. By modelling the distribution of protected areas and primate presence in the four countries of Brazil (A); Democratic Republic of Congo (DRC) (B); Madagascar (C) and Indonesia (D), the authors uncovered that on average, primates had only 38, 14, 38 and 17 percent of their ranges (respectively) included among the borders of the protected areas, which ultimately leads to the stark conclusion that the majority of primate populations occur in more defenseless and unguarded areas.

When we take into account that subpopulations of the same species are already confined and secluded from each other, and to make matters worse these areas are undergoing tremendous conversion and transformation by human activities, such as deforestation and fragmentation by agricultural expansion, logging, and even illegal hunting, as well as an augmenting urban footprint (Gouveia et al, 2017; Mascia et al, 2014; Rovero et al, 2015; Spracklen, Kalamandeen, Galbraith, Gloor & Spracklen, 2015; Waeber, Wilmé, Mercier, Camara & Lowry II, 2016), it comes as no surprise that an increase in human population density within 50 km of a protected area is a vital factor that stimulates illegal activities. Ultimately, meeting global goals for protected-area coverage will be inadequate to safeguard biodiversity unless these areas are well managed, properly located (Butchart et al, 2015), and humanity takes a serious and committed position in stabilizing and reducing its geographical range and size.

In light of this research, it also becomes apparent how these influences are more conspicuous in areas of the developing world with growing human populations, as well as on the not so often considered 'overpopulated continents', such as Europe. As a matter of fact, developed nations such as Australia are not immune to humanity's long and corruptive reach. For example, a mining company is currently extracting uranium from Kakadu National Park (Davidson, 2015), as well as on the Barrow Island Nature Reserve - home to an amalgamation of endemic species and often described as Australia's Galapagos, has been perforated by Chevron for oil and natural gas (Toohey, 2015).

Even though extractive activities are a major contributor to the degeneracy of protected areas, other smaller and chronic exertions such as tourism have their share of responsibility. Indeed, the strenuous undertaking of combining use with preservation [of parks and other natural areas] is often referred to as the dilemma of national park management (Catton, 2012). Looking at national parks as areas for human recreation and perceiving the concept of recreational carrying capacity, in view of the number of visitors tending to rise, with greater publicity, improved transportation and roads as well as ongoing population growth (Laurance & Salt, 2018; Sontag, 1990; Simon, 1995). The expansion of urbanization/infrastructure and the link with protected areas and tourism will be reassumed in the upcoming volume, in the chapter Crowded Eden.

Which takes us to what conservationists consider their most tremendous challenge. Lands allocated for nature to conduct its services recurrently have to concede to “progress” as we search for food and energy. Even if human population growth were to surcease tomorrow, such lands would eventually be pierced, for we would still be consumers of the land. As the soil on existing farms deteriorates and erodes away, and likewise, the fossil fuels are exhausted, new proveniences of nutrients and energy must be hunted. The forest and the prairies accommodate the resources that could *support* our population. As rivers and lakes become feculent and desecrated from our persistent use of them as garbage disposal systems, new waters will be tapped. It is the only way to *sustain* our current population - but it is no way to sustain a healthy planet full of biodiversity at every level (McKee, 2003).

Jeffrey K. McKee writes in his book *Sparing Nature, The Conflict Between Human Population Growth and Earth’s Biodiversity* (2004)*:*

> *“*Much of the land our civilization has reserved for wildlife is just a pittance compared to what formerly existed, and is grossly fragmented. In order to maintain wildlife habitats in a functioning capacity, we have to intervene.”

McKee adjoins with:

> “This is the downside of the ecological transition, because now we must take care of not only our agricultural and urban communities, but natural communities as well.”

And concludes:

> “The only way conservationists can ensure the perpetuation of their efforts is if we halt our population growth, or perhaps even reduce our numbers. Population ‘control’ is the price we have to pay for nature’s services.”

Even so, Mora, Sale and many other biologists and ecologists have cautioned that we cannot halt biodiversity dilapidation without constraining the human population to some circumscription, and restraint on patterns of individual consumption (Weyler, 2012).

Mora & Sale (2011) warn:

> “There is a clear and urgent need for additional solutions,” the authors warn, “particularly ones that stabilize… the world’s human population and our ecological demands.”

George Monbiot, long time ecologist, environmentalist and activist as well as columnist for *The Guardian,* outlines in *Feral - Searching for Enchantment on the Frontiers of Rewilding* (2013) how the natural and protected areas in England, Wales and Scotland have fallen ‘prey’ to the ravages and ransacking of what Monbiot describes as the most disseminated and publicized invasive species to roam those lands, the sheep.

Regrettably, I have witnessed *in-situ* how every word from Monbiot falls perfectly into place. The ‘ruminant culture’ is so strongly entrenched into the Welsh culture - according to the *BBC* (2017)*,* their numbers have surpassed 10 million in 2017 - that sheep freely peregrinate through endless green pastures - called natural parks - devoid of any meaningful and observable ecology, on account of their voracious appetites that forfend and intimidate any natural ecological succession. Monbiot also argues that most of this lamb meat is exported - and something close to 7 percent is consumed by the inhabitants in the country (2013), and one could argue that they are simply responding to an ever-expanding market of more consumers and higher consumption rates of meat around the globe. In other words, Wales natural patrimony is being ‘slaughtered’ and transmogrified into a feeding lot for an ever-increasing flock of domesticated species, with the ultimate goal of sustaining an unquenchable human populace.

Still, those of an exceptionally acute speciesist or anthropocentric moral outlook may believe that there is no inherent wrong in causing other species to go extinct. Let us assume, for the sake of the argument, that the interests of human beings are the only moral considerations that count. Even then, humanity's impact on the natural world is a significant moral wrong of imprudent risking of livelihoods and safety nets. Many millions of people in Africa, Asia and Latin America depend on wildlife resources for their livelihoods and as a cushion to see them through times of hardship, such as unemployment and crop failures (Nasi et al, 2008; Ntuli & Muchapondwa, 2015). More broadly, the world's poor are often profoundly contingent on natural resources for their sustenance, consequently, they are the most vulnerable to the repercussions of defaunation and environmental degradation (Organisation for Economic Co-operation and Development, 2008).

On the other hand, for those of us who renounce the anthropocentric standpoint, or at least do not sanction or condone such an extreme version of it, the everlasting deprivation of biodiversity is an abysmal moral transgression to the species being phased out by humanity's reckless expansionist enterprise. It is also a moral infringement to future generations, sentenced to live in a biologically barren, desolate and sterile world where such iconic fauna as elephants, sea turtles, snow leopards, orangutans, rhinos, gorillas and tigers no longer exist in the wild, or at all (Kuhlemann, 2018). For one thing, and as it is discussed in the segment *Lebensraum*, human hegemony has become obvious, when we ponder on the fact that 77 percent of land (excluding Antarctica) and 87 percent of the ocean bear the markings of direct human activities. To make matters worse for wildlife, twenty countries embrace 94 percent of the world's wilderness (excluding Antarctica and the high seas), with the top 5 alone encapsulating more than 70 percent of these inestimable troves of natural wonders, while being at the complete mercy of their governmental whims (Watson et al, 2018; Cockburn, 2018).

As Stewart Brand declared in his TED Talk *The dawn of de-extinction. Are you ready?* (2013):

> "The fact is, humans have made a huge hole in nature in the last 10,000 years. We have the ability now, and maybe the moral obligation, to repair some of the damage. Most of that we'll do by expanding and protecting wildlands, by expanding and protecting the populations of endangered species. But some species that we killed off totally we could consider bringing back to a world that misses them. We interfered in a big way by making these animals go extinct, and many of them were keystone species, and we changed the whole ecosystem they were in by letting them go."

One such movement that deserves praise and being highligted here is the great ape personhood movement, which seeks to extend legal personhood to apes, a characteristic that perceives these non-human animals as beings with the readiness and capability to hold rights such as life, liberty and the prohibition of torture. Such an admission is expected to promote a crucial role in saving these beings from extinction, by altering the way humanity considers and contemplates these species (Ortolani, 2018).

Markus Fraundorfer, a research fellow at the University of São Paulo's Institute of International Relations deems the mission of the movement paramount in changing and promoting the emanation of new concepts about how we, as human animals, examine ourselves in relation to non-human animals and the planet as a whole. Fraundorfer is convinced that such a profound change in our values might help engage with global challenges like climate change and ecological meltdown. In the light of these events, the world-renowned philosophist and ethicist Peter Singer said in an interview with *Mongabay* (Ortolani, 2018):

> "If we were to recognize that some non-human animals are persons, it would radically change the way we see ourselves and our relationship with the other beings with whom we share this planet."

But Fraundorfer is also a pragmatist. He falters at the thought that it might be too late to act due to the human-animal chasm and the neoliberal market ideology being too acutely rooted in the mold of modern society. In effect, since our system is one impelled by market dynamics, where regulations to shelter nature are regularly seen as blockades to 'progress,' and even "too late for saving us from ourselves," Fraundorfer concludes (Ortolani, 2018).

In addition to a pure focus on animal decline and rights, an opportunity resides in exploring how to rebuild the ecosystem functions provided by large animals. In parts of the world, societal changes have promoted more or less spontaneous megafauna' comebacks: e.g., brown bear (*Ursus arctos)* and wolf (*Canis lupus)* (Chapron et al, 2014; Deinet et al, 2013). Additionally, active restoration of the ecological function of wild megafauna is increasingly being debated and implemented under the concept of rewilding (Svenning et al, 2016, Lorimer et al, 2015; Jepson, 2015). Where and when megafaunal rewilding is applicable or pertinent, and with what species, are the subjects of much discussion (Svenning et al, 2016, Jepson, 2015; Jørgensen, 2015; Reardon, 2014). Recent widespread re-expansions of a range of large carnivores in Europe and North America demonstrate that modern societies and landscapes may provide greater possibilities for human-megafauna coexistence than previously expected (Chapron et al, 2014; Deinet et al, 2013).

Equally important, trophic cascades offer an inestimable theoretical framework for rewilding, and trophic (or megafaunal) rewilding is an ecological restoration approach that uses species introductions to restore top-down trophic interactions to bolster self-regulating biodiverse ecosystems. Likewise, restored megafaunas and associated trophic cascades may encourage a heightened ecological resilience against climate change (Svenning et al, 2016). For example, restored megafauna may increase other species' ability to track climate change by augmenting dispersal distances. Conversely, deficiency or ongoing loss of megafauna may enhance extinction risk of such associated species. In some cases, restored megafauna may also confer greater resistance toward ecosystem variation under climate change (Malhi et al, 2016). Notably, large herbivores may bestow resistance of low-growing vegetation types (grasslands, scrub, tundra) to invasion by taller growing woody invasion: e.g., decelerating shrubification of arctic tundra (Post & Pedersen, 2008; Kaarlejärvi, Hoset & Olofsson, 2015) or woody encroachment of natural savannas (Asner, Vaughn, Smit & Levick, 2016).

As a matter of fact, in an ever-increasing globalized planet, invasive species tend to become a major hazard to biodiversity (Malhi et al, 2016). Hereof, restored megafaunas and associated trophic cascades may contribute to increased ecological resilience against such invasions: e.g., via top-down control of invasive medium-sized carnivores (Pardi & Smith, 2016). Likewise, in a number of cases, restoring native top predators stimulates the suppression of invasive mesopredators or invasive herbivores to the benefit of native species (Wallach, Ripple & Carroll, 2015). More controversially, exotic top predators may provide analogous responses, by replacing lost native species. One example the dingo (*Canis lupus dingo),* which, by subduing invasive mesopredators and herbivores, is described to have positive reactions on a range of native species in Australia (Wallach et al, 2015).

As can be seen, there are circumstances to combine strategies with knowledge of human population dynamics. The nation-by-nation data model from (McKee et al, 2013) in the segment Expropriation shows that of the twelve countries with declining human populations from 2000 to 2010, nine had a concurrent abatement in the number of vulnerable animal and bird species, implying the validity of the human population/biodiversity association and the potential for a novel conservation strategy. In essence, countries and areas with shrinking populations could be targeted for wildland reclamation and proactive establishment and restoration of native species, besides the ones that are making a comeback on their own (McKee, 2012).

Some may oppose that biodiversity safeguarding is not a universal value, and therefore should not be included as a constraining factor of development and population size. Contrary to such an objection, fending off the anthropogenic mass genocide now underway and stewarding natural ecosystems, species, healthy populations of biota, and robust ecological and evolutionary processes becomes a necessary requirement to ensure a better and safer future. Whether people value the natural world for its intrinsic standing or for the ecological services it provides humanity (e.g., food, clean water, climate regulation, crop pollination, recreational spaces), sustaining Earth's biological wealth is a unifying and all-pervading good (Daily et al, 2009; Berry, 2000). Addressing catastrophic biodiversity collapse is, therefore, an inescapable responsibility (Crist et al, 2017).

On the whole, undertaking this responsibility obliges a sufficient amount of land and ocean to be sheltered for the continuity of other species (Noss et al, 2012; Dinerstein et al, 2017; Locke 2013; Wilson 2016). Such division of Earth's sources of livelihood, to facilitate both humanity's and nature's well-being, has led to proposals of a sustainable human population ranging between 1.5 billion and 5 billion people (depending on per-person levels of consumption assumed) (Lowe, 2016). Provided that scenario to be quite unlikely to achieve in the coming decades, diminishing defaunation will ask a strongly and aggressively lessening animal overexploitation and habitat destruction; mitigating climate disruption; and stabilizing the impacts of human population growth and uneven resource consumption (Young et al, 2016).

In effect, by losing populations (and species), the intricate ecological networks involving animals, plants, and microorganisms are being irreparably affected (Ripple et al, 2014; Naeem et al, 2012), with the *Living Planet Index* estimating that an average 60 percent of population sizes of wild vertebrates have declined from 1970 to 2014 (WWF, 2018a) (you have read that right, **60 percent!,** figure 4.26); bleaching has affected 94 percent of corals since 1980 (Hughes et al, 2018); tropical tree cover loss was 6.5 million hectares in 2003 and in 2017 it increased more than 2.5 times (roughly 15.8 million hectares) (Weisse & Goldman, 2018) or that 76 percent of fish populations are fully used, overused, or depleted as a result of the insatiable appetite of humanity and their activities, which are inducing the gradual warming of the water bodies (Worm et al, 2006; FAO, 2011c), just to provide a few clear examples of how overpopulation is killing the natural world. As the *Living Planet Index* (2018) distressingly denotes:

> "Exploding human consumption is the driving force behind the unprecedented planetary change we are witnessing, through the increased demand for energy, land and water […] The products we consume, the supply chains behind them, the materials they use and how these are extracted and manufactured have myriad impacts on the world around us."

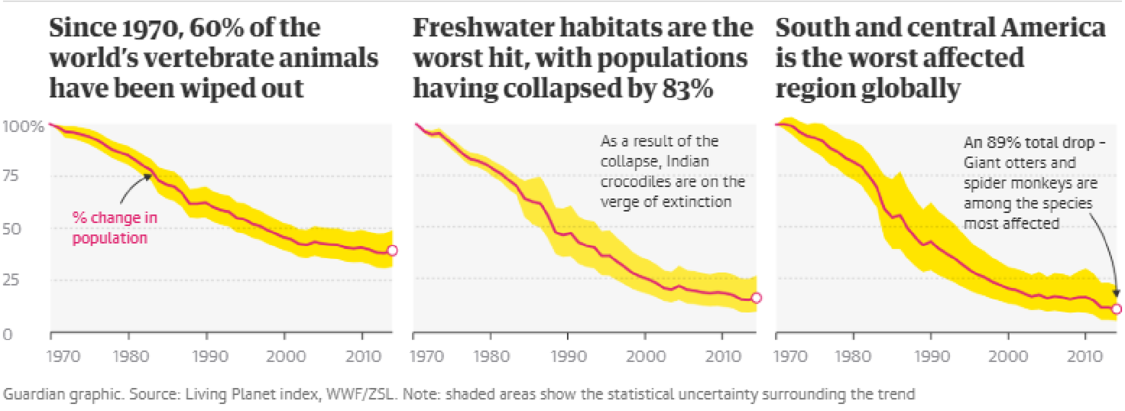


Figure 4.26: The global Living Planet Index (2018) shows an average 60 percent decline between 1970 and 2014 in numbers of vertebrate species; decline of freshwater habitats (83 percent) and South and Central America being the worst hit. The red line shows the index values and the shaded areas represent the 95 percent confidence intervals surrounding the trend. Retrieved from Carrington, 2018f.

Mike Barret, executive director of science and conservation at WWF downright calls out the inertia, fecklessness and double standards of nations and governments, when faced with these results (Carrington, 2018f):

> "If there was a decline in the human population, that would be equivalent to emptying North America, South America, Africa, Europe, China and Oceania. That is the scale of what we have done."

In essence, it certainly becomes hard to deny the connection between the vacuum and emptiness of this world while there is this overwhelming surge in human numbers and their acquired and desired wealth. As Sir David King, science advisor to the British government has acknowledged (Population Matters, 2018f):

> "The massive growth in the human population through the twentieth century has had more impact on biodiversity than any single factor."

And as the environmental writer, Fred Pearce has proclaimed (Population Matters, 2018f):

> "Clearly, other things being equal, fewer people will do less damage to the planet."

Therefore, protecting biodiversity should become an ethical obligation, central to our very survival. The richer the biodiversity the more resilient humans are on the planet (Shragg, 2015). As Tormod V. Burkey describes in his book *Ethics for a Full World or, Can Animal-Lovers Save the World?* (2017):

> "Every instance of dereliction of duty towards a being with inherent value is an injustice. Hence, it is worse to harm a population or an entire species, and even worse to harm an ecological community or ecosystem."

With this intention, it becomes paramount that we include in the agenda a resolution in human population stabilization, as philosophy professor George Sessions wrote:

> "One's position on the human overpopulation issue serves as a litmus test for the extent of one's ecological understanding and commitment to protecting biodiversity and the integrity of the Earth's ecosystems" (quoted in Foreman & Carroll, 2015).

Like Sessions, Professor Eileen Crist at Virginia Tech apprehended the significance of population stabilization and the preservation of species and their ecosystems in her 2003 essay published in *Wild Earth*, *"Limits-to-Growth and the Biodiversity Crisis."* Crist asserted that:

> "The core issue is not the quandary of real-world limits but what kind of real world we desire to live in […] It is critical to focus on what is presently dead certain: that overproduction and overpopulation have been driving the dismantling of complex ecosystems and native life, and leaving in their widening wake constructed environments, simplified ecologies, and lost life forms.

Ultimately, smaller populations decrease the pressures to transfigure forests and wetlands to agriculture or to dam and siphon rivers to provide water for agricultural needs and expanding cities (Götmark et al, 2018). Reducing human population sizes open up the possibility for rewilding lands (Navarro & Pereira, 2015) that cease to be needed for agriculture, forestry, or other intensive human activities (Götmark et al, 2018). It gives nature a fighting chance. In addition, a *Nature* study (Garnett et al, 2018) demonstrated that indigenous groups, regardless of comprising solely five percent of the global population, manage 38 million km^2 of land. Such an extension represents over a quarter of the world's land surfaces, while also converging on 40 percent of all terrestrial PA's and ecologically intact landscapes. By directing more legal power to such groups, environmentalists assert wild places will be in better hands and sheltered from outside influences, like industrial development (Gibbens, 2018).

Altogether, and as Aldo Leopold, conservationist and enormous inspirational figure asserted in *A Sand County Almanac* (1949):

> "[T]here are those who can live without wild things, and there are those who cannot."

If the reader is like me, he or she is among the latter, and a world devoid of wild things and dominated by *Homo sapiens* is an abhorrent vision to contemplate. For this reason, I hope I have been capable and serviceable in demonstrating that without an iron-willed, unyielding and steadfast compromise to cease population growth and eventually reduce our human populace, the conservation battle to shelter, safeguard and secure our non-human Earthling commuters will become futile, since the best efforts of good and dedicated people cannot compete with the devastating and eradicative repercussions of transmogrifying this planet into a factory to suit the needs and desires of a dilating human population.

This marks the end of *Where the Wild Things Were*. I'm aware that this chapter takes a toll on one's morale and disposition, also, in the event that the reader is feeling discouraged and disheartened by the sheer magnitude of complications and aggravations brought about by *Homo sapiens,* I must be honest and confess that this is just the first of what I can conceive to be a long and convoluted list of chapters. With this in mind, as we close this chapter, I can only request that the reader might allow me to escort him or her as we move along to the many intricacies that are begotten by the exigency of feeding a pullulating human population, in *Hunger Games.*

CHAPTER V

HUNGER GAMES

"The hungry world cannot be fed until and unless the growth of its resources and the growth of its population come into balance. Each man and each woman and each nation must make decisions of conscience and policy in the face of this great problem."

- Lyndon B. Johnson

"We are a plague on the Earth. It's not just climate change; it's sheer space, places to grow food for this enormous horde. Either we limit our population growth or the natural world will do it for us."

- Sir David Attenborough

"During the 1980s some of the worst famines in history afflicted large parts of Africa and South Asia, under the very noses of the United Nations and other international agencies. In absolute numbers, more illiterate, impoverished, and chronically malnourished people live in the world at the end of the twentieth century than at the beginning."

- Marvin Harris

Figure 5.1: Greenhouses: As far as the eye can see, greenhouses cover the landscape in Almeria, Spain; © Yann Arthus-Bertrand.

Almost a decade ago, Lewis H. Ziska avouched that, the global population would have surpassed the 7.5 billion mark. At present growth rates, he said, human populations will transcend 9 billion in the next few decades. As population augments, crop production must increase accordingly to cultivate the food security we require for our own survival (Ziska, 2011). Feeding Earth's population is going to be one of our most tremendous challenges, even as the environmental costs identified with intensive agricultural production are already staggering (Wuerthner, 2012). According to the World Bank, which stated, at the beginning of this decade, global food production will have to surge by about 70 percent between now and 2050 to feed nine billion people (The Economist, 2011).

Undoubtedly, the augural prognostication that the human population would inevitably eclipse the amount of available food to (at least in principle) feed everyone did not come to pass, as Thomas Malthus predicted. It was contradicted by converting Earth's most fertile lands for agriculture (after being denuded of their heterogeneity and multiformity of life by ravaging forests, grasslands, and wetlands); by misappropriating extensive swaths of natural areas for domestic animal grazing; by plundering half the world's freshwater—with the biggest share rechanneled for agriculture; by administering enormous quantities of synthetic chemical and fertilizer pollutants; and by ransacking untold numbers of wild fish. In other words, the conjecture of human tribulation in the wake of unsustainable numbers was overthrown by means of the near modification of the biosphere into a human-food factory (Crist, 2016).

In light of this Malthusian prognosis, we must come to realize that the world is in a transition from an era of food abundance to one of paucity and dearth. Over the last decade, world grain reserves have fallen by one third. World food prices have more than doubled, prompting a worldwide land rush and heralding in a new geopolitics of food (Brown, 2012).

As John Scales Avery, renowned intellectual, theoretical chemist and author of countless books and articles, writes in his new book *Population and the Environment* (2018):

> Today we are pressing against the absolute limits of the earth's carrying capacity. There are many indications that the explosively increasing global population of humans, and the growth of pollution-producing and resource-using industries are threatening our earth with an environmental disaster. Among the serious threats that we face are catastrophic anthropogenic climate change, extinction of species, and a severe global famine, perhaps involving billions of people rather than millions. Such a famine may occur by the middle of the present century when the end of the fossil fuel era, combined with the effects of climate change reduce our ability to support a growing population."

Avery is perfectly aware of exactly what needs to be done, as he states in his book *Climate Change, Population Growth and Famine* (2017):

> "Unless efforts are made to stabilize and ultimately reduce global population, there is a serious threat that climate change, population growth, and the end of the fossil fuel era could combine to produce a large-scale famine by the middle of the 21st century."

Food is the new oil. Land is the new gold. We are entering a new era of rising food prices and permeating famine and starvation. On the demand side of the food equation, population growth, rising affluence, and the conversion of food into fuel for cars are joining together to raise consumption to record amounts. On the supply side, acute soil erosion, growing water shortages, and the earth's rising temperatures are making it more difficult to amplify production (Brown, 2012).

It has been known that humanity might reach a point when there are more people than food to nourish them. Malthus (1798) wrote about it in the XVIII century. Food shortages thwarted even earlier civilizations. The Sumerians and Mayans are just two of the many civilizations that apparently faded in time because they moved onto an agricultural path that was environmentally unsustainable (Brown, 2013).

Indeed, the foreboding forecast that the human population would inevitably outstrip the supply of available food to (at least in principle) feed everyone did not come to pass (Crist, 2016). The Green Revolution and globalization ushered in food and jobs to soaring populations. Those events, and the receding of the rate of global population growth, disguise and adumbrate today's situation: the rise in absolute numbers of people, with millions more at risk when things go astray (Marsh, 2017).

But it is not just agriculture, but the entire food supply chain that is concocting a plethora of environmental menaces. As the *World Atlas of Desertification* from the Joint Research Centre at the European Commission (2018) declares:

> "Over the last 20 years the extent of land area harvested for crops has increased by 16 percent, the area under irrigation has doubled, and agricultural production has grown nearly threefold. As the world's economy grows - however unevenly - there is a corresponding acceleration in the demand for animal protein. Intensification of the livestock sector to feedlots means more agriculture land is used to indirectly produce food."

At present, the food supply chain creates roughly 13.7 billion metric tons of carbon dioxide equivalents (CO_2eq) of anthropogenic GHG emissions. An additional 2.8 billion metric tons of CO_2eq (5 percent) are precipitated by non-food agriculture and other drivers of deforestation (Poore & Nemecek, 2018). In like manner, food production expedites around 32 percent of global terrestrial acidification and approximately 78 percent of eutrophication. Ultimately, these emissions can reshape species composition of natural ecosystems, shrinking biodiversity and ecological resilience (Bouwman, Van Vuuren, Derwent & Posch, 2002).

To this end, food security - preserving supply and assuring equitable access to food - is a preeminent concern in terms of the aftermath due to climatic changes on the most basic human rights, and is a driving aspect behind mass migration. Elevated temperatures and unpredictable rainfall patterns will have pervasive, large-scale negative repercussions on food production and food security. Moreover, with an expanding human population and rising global demand for food, guaranteeing that the right food - especially staples such as wheat, maize and rice - can be yielded or supplied in the right places, at the right time and at the right price, becomes an integral challenge (Environmental Justice Foundation, 2017).

Whilst the nexus between climate change and food security is quite Byzantine - the UN Food and Agriculture Organization (FAO) recognizes multiple interdependencies (FAO, 2016a) - by way of the "new normal" of more recurrent weather and climate extremes, which, to a greater extent are being appreciated as a significant hazard to food security and equitable access (EJF, 2017).

The Union for Concerned Scientists (2017) asserts that the following climate-related menaces will have to be considered when examining global food production:

- "**Reduced yields.** The productivity of crops and livestock, including milk yields, may decline because of high temperatures and drought-related stress.
- **Increased irrigation**. Regions of the world that now depend on rain-fed agriculture may require irrigation, bringing higher costs and potential conflict over access to water.
- **Planting and harvesting changes.** Shifting seasonal rainfall patterns and more severe precipitation events - and related flooding - may delay planting and harvesting.

- **Decreased arability.** Prime growing temperatures may shift to higher latitudes, where soil and nutrients may not be as suitable for producing crop, leaving lower-latitude areas less productive.
- **More pests.** Insect and plant pests may survive in greatest numbers or even reproduce more often if cold winters no longer keep them in check. New pests may also invade as temperature and humidity conditions change.
- **Risks to fisheries.** Shifts in the abundance and types of fish and other seafood may hurt fisheries. Extreme ocean temperatures and ocean acidification place coral reefs - the foundation of many of the world's fisheries - at risk.
- **Sudden-onset extreme weather events** and their impacts - storms, floods and wildfires - lead to dramatic loss of crops and livestock."

The IPCC encapsulates the issues in their Fifth Assessment Report (2014):

> "For the essential crops - wheat, rice and maize - in tropical and temperate regions, without adaptation, climate change is forecasted to negatively impact yields for local temperature rises of 2ºC or more above late 20th century levels. Likewise, global temperature intensification of 4ºC or more above late 20th century levels, united with rising food demand, would present large risks to food security globally. Equally important, all elements of food security are potentially disturbed by climate change including food access, utilization and price steadiness. Furthermore, rural areas are anticipated to undergo major impacts on water availability and supply, food security, infrastructure and agricultural incomes, in conjunction with fluctuations in production areas of food and non-food crops across the world."

In like manner, droughts and heatwaves are predicted to have abated the global harvest of cereal - including rice, wheat and maize - by up to 10 percent between 1964 and 2007. Important to realize is that drought is one of the crucial components that lead to agricultural deterioration, similarly, its augmentation in severity, frequency and duration, induced by climate change, will give rise to calamitous forfeitures of crop yields (Lesk, Rowhani & Ramankutty, 2016).

As an illustration, rain-reliant farmers and pastoralists in the rangelands that stretch over a quarter of the earth's land surface are preeminently defenseless to food shortages instigated by drought (Western, Mose, Worden & Maitumo, 2015). Over the last century, extreme famines evoked by droughts have dwindled around the world as subsistence farmers and herders have entered market economies and become less liable to the whims of climate (Devereux, 2009). Although this may be true, Africa is a flagrant irregularity, on the grounds of its large number of subsistence communities and rapidly swelling populations still reliant on rain-fed food production (Western et al, 2015). Intensified exposure to hazards and constrained coping adequacy are engendering abysmal risks to millions of the world's poorest people in countries with low resilience and fragile economies (EJF, 2017).

By the same token, climate change has radically compressed renewable surface water and groundwater - essential for agriculture - in most dry subtropical regions (Misra, 2014), and water availability is, to all appearances going to diminish in the low latitudes, including critical agricultural areas in China, India and Egypt (FAO, 2016). Identically, glacier and snow cover - which play a pivotal role in bestowing river flows during the summer - are also withering (FAO, 2013a).

In the same fashion, the area of dry land on a global perspective has doubled since the 1970s, while mountain water storage has considerably been curtailed (FAO, 2016a). The IPCC's Fifth Assessment Report concluded that alterations in precipitation and temperature could cause global food prices to increase by up to 84 percent by 2050 (Porter et al, 2014).

Food insecurity also stems from price escalations, specifically for staple foods such as grain. In fact, the price of many major crops is foreseen to increase 10-60 percent between 2010 and 2030. This, in turn, could reinforce levels of poverty by 20-50 percent in parts of southern Asia and sub-Saharan Africa (Hertel, Burke & Lobell, 2010).

By 2050, the price of maize could inflate by 87-106 percent; of rice 31-78 percent; and wheat by 44-59 percent, compared to 2010 price levels (Nelson et al, 2010). Such price augmentation inordinately impinges on low-income households forced to spend a larger part of the income on food. In Tanzania, three-quarters of the total workforce revolve around agriculture (IFAD, 2016) and the average wage for agricultural labour is tantamount to just US$1.6 a day (Rapsomanikis, 2015). With this abysmal poverty pervading Tanzania, one would reckon that the country's government are actively promoting strategies to break out of such a state of affairs. On the contrary. President John Magufuli has pressed women to stop using birth control pills, declaring that the country needs more people. One would have to harbour suspicion of these claims, since Tanzania currently stands with a population of 53 million, with 49 percent of them living with less than 2$ a day. Failing to address population growth in this day and age, is a recipe for disaster (BBC News, 2018b).

As an illustration, a World Bank study that collected data from 73 countries gauged that almost 160 million people, 90 million being rural population, were forced into poverty by the impact of the global food crisis in 2008 (De Hoyos & Medvedev, 2009), comparatively, another study assessed that 63 million people were driven into hunger from the 2008 price shocks (Tiwari & Zeman, 2010).

Owing to the poorest households employing much higher proportions of their income on food, in countries such as Bangladesh, Malawi and Vietnam, the poor often spend 35 percent or more of their income on staple food (IFAD, WPF & FAO, 2011). On average in many developing countries, total food purchases epitomize about 70 percent of the expenditures of the poorest 20 percent of families (IFAD et al, 2011). For this reason, an inflation in food prices of almost any magnitude will lead to a negative outcome (HLPE, 2011).

As FAO puts forward, the livelihoods of these mostly rural people have been discombobulated and "many of them have found no option than increasing the statistics of distress migration", said Graziano da Silva, FAO's Director-General (FAO, 2017a).

In light of this reality, we have to realize that the global food system is subject to the paradoxical pressures of delivering the food required by a swelled and increasingly affluent population, while helping to achieve environmental sustainability (Godfray et al, 2010; Tilman & Clark, 2014). Besides the perennial impendence of rising population, higher consumption rates for commodities such as meat and milk, due to more preponderant incomes (Kearney, 2010; Keyzer, Merbis, Pavel & van Wesenbeeck, 2005; Tilman, Balzer, Hill & Befort, 2011) and increasing non-food demands for agricultural commodities, mainly for bioenergy (Müller, Schmidhuber, Hoogeveen & Steduto, 2008), all increase the tension and encumbrance on agriculture (Alexander et al, 2017).

To add insult to injury, climate impacts, precipitate variations and transformations in land suitability and crop and animal yields (Müller & Robertson 2014; Nelson et al, 2014). In view of these changes, attaining the desired food demands will come about either by expanding agricultural areas, causing land use change, or the intensification of production (i.e. seeking higher yields through the use of greater inputs, such as fertilisers, pesticides, or water, or changes in management practices) which bear the potential to cause environmental ruination (Alexander et al, 2017). This is to say, some of the most discernible repercussions are:

greenhouse gas emissions (GHGs), languishing of soil quality, sparsity and uncommonness of water and biodiversity impairment (Cassman, 1999; Johnson, Runge, Senauer, Foley & Polasky, 2014; Smith et al, 2013).

In a report authored by *Dexia Asset Management,* entitled *Food Scarcity - Trends, Challenges, Solutions* (2010) the document states:

> "Next to population growth, the global food situation is being redefined by other driving forces, such as rising incomes, limited land availability, high energy prices, inefficient food distribution systems and climate change, which are all impacting food demand and supply to varying degrees."

This challenge is further aggravated by dynamic dietary patterns. It is, therefore, vital to impede and suppress, as much as possible, the negative environmental consequences of agriculture, while ensuring that the same quantity of food can be delivered (Muller et al, 2017). There are innumerable proposals for accomplishing this goal, such as further augmentation of efficiency in production and resource use, or adopting holistic approaches such as agroecology and organic production, or shrinking consumption of animal products and food wastage (Garnett et al, 2013;, Stehfest et al, 2009, FAO, 2013b; Lichtfouse, Hamelin, Navarrete, Debaeke & Henri, 2011). Likewise, deliberation regarding food waste and expansion of the agricultural frontier typically overlook the phenomenon that not all waste can be obviated, that most productive land worldwide is already in use for agriculture (Tilman, Cassman, Matson, Naylor & Polasky, 2002) and that what remains is natural habitat that serves as cornerstone for essential ecosystem services and sanctuary for what prevails of the world's wildlife (Kuhlemann, 2018).

While these are all worthwhile goals to pursue, a rising global population will only make the challenges harder or impossible to achieve, due to the finite limitations and constraints of the closed system that is our planet. We must come to realize, and ponder deeply on our procreative and consumptive choices and habits, since there is chronic hunger in our present day that hasn't been eradicated, and for that end, it is certainly not morally righteous and virtuous, to persist on contributing to increasing our population when millions go to bed every night, hungry.

The United Nations Food and Agriculture Organization predicted that about 815 million people of the 7.6 billion people in the world in 2016, or 10.7 percent, were languishing from chronic undernourishment in 2016. Almost all the hungry people, 780 million, live in developing countries, representing 13.5 percent, or one in eight, of the population of developing countries (World Hunger.org, 2018).

Countries across Africa and the Middle East, many of which are in conflict situations, with 20 million people across the two regions currently enduring famine from a prolonged drought, are the most impacted. Future trends foresee that by 2030, climate risks could place 43 million Africans below the poverty line (The World Bank, 2017) once abundant land is no longer arable, when there is sand where there used to be trees, when droughts arise more often and last longer, when grass on which to graze cows or goats becomes erratic and sporadic, and when hotter weather and shorter rains means growing food or tending to animals is no longer a viable option (Global Environment Facility, 2017).

As of 3 July 2017, the Food and Agriculture Organization of the United Nations (FAO) singled out 19 countries in a protracted crisis situation, facing extreme climate events such as droughts and floods and by conflict over insufficiency of resources. Thus, FAO declared that the number of hungry people in the world has increased since 2015, revoking years of progress with a risk of famine being most elevated in northeast Nigeria, Somalia, South Sudan and Yemen, with 20 million people severely affected. “This is a time bomb, because all the Sahel is in this situation, and especially with climate change, the food supply will be less abundant than before,” says John May, a visiting scholar at the Population Reference Bureau (Filipovic, 2017).

By the same token, the *Global Report on Food Crises* (Food Security Information Network, 2018) established that 124 million people in 51 countries were affected by acute food insecurity during 2017 - which is 11 million more people than the previous year. The report defines acute hunger as a state so severe that it poses an immediate threat to livelihood.

Even though a strong international pledge into expunging world hunger has been in place, the number of people in a state of hunger has been expanding, after it had been coming down for several years. Nonetheless, the phenomenon seems to be mostly confined to zones affected by severe climate change or/and military conflicts (Coelho & Rodrigues, 2018).

In figure 5.2, Alexandra Prado Coelho and Célia Rodrigues (2018) assemble the data on the food insecurity by region with Northern Africa, Sub-Saharan, Central and South-Western Asia demonstrating, respectively, 12,2; 29,4 and 12,6 percentage of the population in an undernourishment state. Graziano da Silva, Director-General of FAO justifies that the years of 2015 and 2016 saw a rise in the number of people in an undernourishment state primarily due to the conflicts that have multiplied in South Sudan, Congo, Somalia and the impact of droughts that have stricken Ethiopia, Somalia and all of Northeast Africa. Unfortunately, no mention is made of the multiplicative effect of a swelling population in Africa and Asia, where most population growth is taking place.

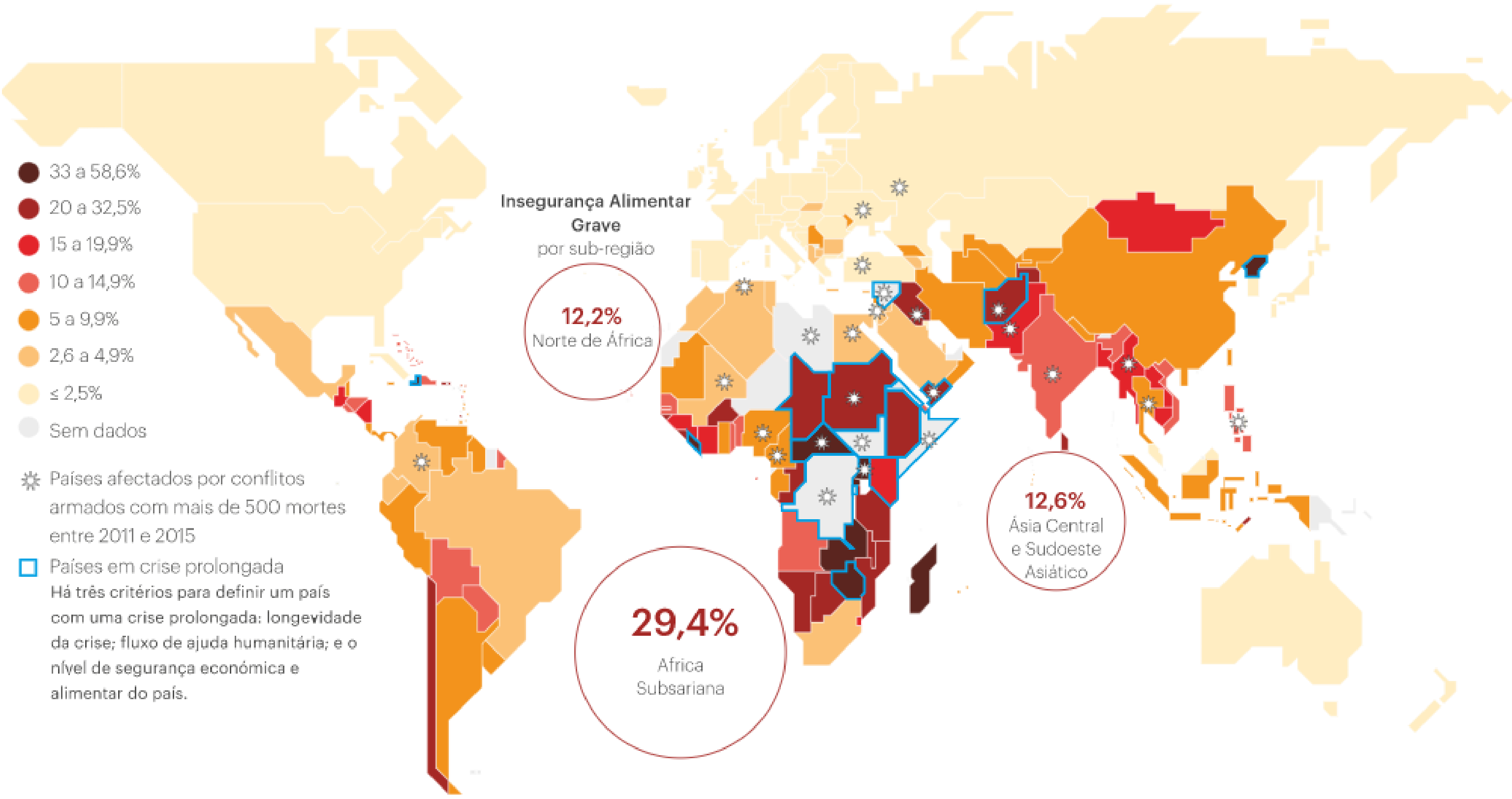


Figure 5.2: Map showing the percentage of people in an undernourishment state with Sub-Saharan Africa, Northern Africa and Central/Southeast Asia displaying percentages of 29,4; 12,2 and 12,6 respectively. Countries with a barbed wheel have been affected by conflicts between 2011 and 2015 that have resulted in at least 500 deaths. Countries with a highlighted border are shown to be in a prolonged crisis. Retrieved from Coelho & Rodrigues, 2018.

With this in mind, Robert Walker of the Population Institute (2010) writes in *Failing, But Still Growing* (2010):

> "There is in fact, an alarming correlation between failing states, countries with rapid population growth, and those with severe hunger. Many failing countries are heavily dependent upon external food aid for their survival. The UN's World Food Programme (WFP) is currently helping to feed one out of four Somalis, but Somalia's population is expected to jump by more than 150 percent in the next four decades. The Global Hunger Index lists the current situation in Niger as "extremely alarming," but Niger's population is expected to triple in the next 40 years."

Failing nations, almost without exception, have high population growth rates. *Foreign Policy* and the Fund for Peace publish an annual ranking of these failed states. In 2009, all of the top ten countries in this Index had a total fertility rate (average number of children born by a woman over her lifetime) extensively more elevated than the global average of 2.4 (The World Bank, 2018b). Six of them had TFR's of 5.0 or higher (Population Institute, 2009).

The 2018 edition list of the top failing states does not bear any fundamental surprise (table 5.1). They include South Sudan, Somalia, Yemen, Syria, Central African Republic, Congo Democratic Republic, Sudan, Chad, Afghanistan and Zimbabwe, only in the top 10. If we look closely at the rank assessed by Fragile States Index (2018) it shows the correlation between the fragility of the state and its demographic influence. Just in the top 25 nations, we can verify how only Myanmar (22nd) and Libya (25th) rank below 8.1 in the scale of 1-10, with 10 being the highest possible value attributable. Additionally, the average of this rank for the top 25 fragile states stands at a startling 8.8, by which we can safely infer that population is exerting a strikingly effect.

Country	Position	Rank	Population (2017)	Population (2050)	TFR (2017)	Expected Population Growth (millions)
South Sudan	1st	10	12,6	27,9	5,1	15,3
Somalia	2nd	10	14,7	35,9	6,4	21,2
Yemen	3rd	9,6	28,3	48,3	4,1	20
Syria	4th	8,2	18,3	34	2,9	15,7
Central African Republic	5th	9,3	4,7	8,9	4,9	4,2
Congo Democratic Republic	6th	9,6	81,5	215,9	6,3	134,4
Sudan	7th	9,3	40,6	88,1	4,7	47,5
Chad	8th	10	14,9	36,8	6,4	21,9

Afghanistan	9th	9,2	35,5	68,9	5,3	33,4
Zimbabwe	10th	8,9	16,6	33,2	4	16,6
Iraq	11th	8,7	39,2	76,5	4,1	37,3
Haity	12th	9	10,6	14,5	2,9	3,9
Guinea	13th	8,8	11,5	24,3	4,9	12,8
Nigeria	14th	9,1	190,9	410,6	5,5	219,7
Ethiopia	15th	9,5	105	190,9	4,6	85,9
Guinea Bissau	16th	8,8	1,9	3,6	4,7	1,7
Kenya	17th	8,9	49,7	95,5	3,9	45,8
Burundi	18th	9,4	10,4	23,5	5,5	13,1
Eritrea	19th	8,7	5,9	8,9	4,2	3
Pakistan	20th	8,1	199,3	310,5	3,6	111,2
Niger	21st	9,1	20,6	65,6	7,3	45
Myanmar	22nd	6,3	53,4	62,4	2,3	9
Cameroon	23rd	8,1	25	51,9	4,8	26,9
Uganda	24th	8,9	42,8	95,6	5,4	52,8
Libya	25th	4,6	6,4	8,1	2,3	1,7
Sum	-	-	1040,3	2040,3		1000
Average	-	8,8	41,6	81,6	4,644	40

Table 5.1: Top 25 fragile states according to various indicators collected and reviewed by the Fragile States Index. The Rank is an indicator of demographic influence from 1-10, with 10 signifying the most elevated correlation possible. Retrieved from Fragile States Index 2018. Population data for 2017, projection for 2050 and TFR were taken from United Nations World Population Prospects 2017 Revision (UNDESA, 2017). Sums and averages were calculated independently by the author.

When we delve into the population of these nations in 2017 and compare it to the projections to 2050, we realize a ghastly reality. In 2017, these 25 countries amounted to a total population of close to 1 billion and in just 30 years time, these 25 fragile nations alone will have added the behemothic aggregate of 1 billion people to the planet.

As previously demonstrated, the countries that occupy the top positions of this table are considered to not only being fragile but failed in their ability to provide food security for its citizens and heavily relying on external help. If with current populations we are witnessing millions of people on an undernourished state and suffering from acute hunger, what can we expect to happen in the coming decades, when just these 25 countries will have supplemented close to a billion more mouths to be fed, without any prospect of achieving any success?

To add fuel to the fire, food production deeply converges the human and ecological worlds.

In *National Geographic's The Future of Food - Where will we find enough food for 9 billion?* Jonathan Foley (2014) presents the case for the corruptive side of agriculture and what the price is for turning this planet into a human factory:

> "Agriculture is among the greatest contributors to global warming, emitting more greenhouse gases than all our cars, trucks, trains, and airplanes combined - largely from methane released by cattle and rice farms, nitrous oxide from fertilized fields, and carbon dioxide from the cutting of rainforest to grow crops or raise livestock. Farming is the thirstiest user of our precious water supplies and major polluter, as runoff from fertilizers and manure disrupts fragile lakes, rivers, and coastal ecosystems across the globe. Agriculture also accelerates the loss of biodiversity. As we've cleared areas of grassland and forest for farms, we've lost crucial habitat, making agriculture a major driver of wildlife extinction."

Foley pulls no punches and supplements his argument by stating:

> "The environmental challenges posed by agriculture are huge, and they'll only become more pressing as we try to meet the growing need for food worldwide. We'll likely have two billion more mouths to feed by mid-century - more than nine billion people. But sheer population growth isn't the only reason we'll need more food. The spread of prosperity across the world, especially in China and India, is driving an increased demand for meat, eggs, and dairy, boosting pressure to grow more corn and soybeans to feed more cattle, pigs, and chickens. If these trends continue, the double whammy of population growth and richer diets will require us to roughly double the amount of crops we grow by 2050."

In any event, Jelle Bruinsma from the FAO asserts in *The Resource Outlook to 2050* (Bruinsma, 2009):

> "Growth in agricultural production will continue to slow down as a consequence of the slowdown in population growth and of the fact than an ever increasing share of world population is reaching medium to high levels of food consumption."

Still and all, the FAO acknowledges:

> "Nevertheless, agricultural production would still need to increase by 70 percent (nearly 100 percent in developing countries) by 2050 to cope with a 40 percent increase in world population and to raise average food consumption to 3130 kcal per person per day by 2050. This translates into an additional billion tonnes of cereals and 200 million tonnes of meat to be produced annually by 2050 (as compared to production in 2005)."

Owing to the ecological backlash of food production being amply documented (Foley et al, 2005) and the need to feed a growing human populace, researchers exhort that production must be expanded without draining on existing biodiversity and squandering additional natural areas to cultivation (Crist et al, 2017).

Such "sustainable intensification" (Clay, 2011; Baulcombe et al, 2009), it is argued, may be achieved through a number of resolutions: by augmenting yields on agricultural lands already in production; by emphasizing efficiency in freshwater use; by applying fertilizers and pesticides through more cautious methodologies; and possibly by genetically modifying crops to produce booming yields or to tailor them to specific challenges (Crist et al, 2017).

Cutback on meat consumption in the developed world is also supported, because meat and other animal products are ecologically costly to produce (Foley, 2011; Waggoner, 1996). Through such agronomic adjustments, efficiency gains, and perhaps consumer shifts, researchers are confident that food supplies can meet the enormous demand without added biodiversity losses (Crist et al, 2017). Notwithstanding the best intentions for the global implementation of biodiversity conservation, mounting human stressors continue to drive extinctions, wild species population declines, and habitat extirpation (Butchart et al, 2010; Tittensor et al, 2014; Pimm et al, 2014; Dirzo et al, 2014; Maxwell et al, 2016; Ehrlich & Pringle, 2008).

A point often overlooked is that land for agriculture and animal grazing has come to overrun about 40 percent of the planet's ice-free land (Foley et al, 2005; Ramankutty & Foley, 1999; Asner, Elmore, Olander, Martin & Harris, 2004). On top of that, unfolding tropical deforestation (Gibbs et al, 2010; Crowther et al, 2015; Mora & Zapata, 2013), anticipated amplification of cultivated areas (Tilman et al, 2001; Deininger & Byerlee, 2011), an envisaged 55 percent surge in demand for water by 2050 (Leflaive, 2012), expected growth in global pesticide use (Tilman et al, 2001) [on top of the ±700 percent increase in fertilizer use in the past 40 years (Matson, Parton, Power & Swift, 1997; Tilman et al, 2001)], the constant increase of greenhouse gases (with agriculture a major contributor), and the expansion of global trade of foods and other products (Lenzen et al, 2012) all forebode a mounting ecological impact of food production. It appears questionable whether sustainable intensification can triumph over biodiversity-encroaching food production trends, for an expanding and ever richer human population (Crist et al, 2017).

In spite of our ecological reality, in 2002, the FAO (Harrison et al, 2002) published a major study delineating world food production prospects until 2030. FAO alleged that although growth rates of agricultural production and crop yields had decelerated in recent years, this had been the result of a response to slower demand, and not a manifestation of land or water scantiness (Harrison et al, 2002). Conversely, the FAO is convinced global food lapses are implausible in the future (at least until 2030), if national and international policies promote efficiency, and that the world population will be increasingly well-fed, although in 2017 and as described above close to 800 million of people were in a state of chronic undernourishment (FAO, IFAD, UNICEF, WPF & WHO, 2017).

According to their surveys, food production growth will come from higher productivity. In developing countries, the FAO considers that about 70 percent of increased crop production will come from higher yields (from additional irrigation and fertilizer use), 10 percent from more concise fallow periods and multiple cropping, and 20 percent from the expansion of arable land (Harrison et al, 2002; FAO, 2002).

On top of that, developing countries will necessitate 14 percent more water for irrigation by 2030 (FAO, 2003). However, by that date, more than 25 developing countries will suffer actual or impending water scarcity, 11 being located in Africa (FAO, 2002).

Developing countries will need a supplementary 120 million hectares (ha) for crops, but most of the "suitable" new lands are in Sub-Saharan Africa (60 million ha) and Latin American (40 million ha). Most of this new land will come from forest clearance, and would equate to a destruction of about 10 percent of the Sub-Saharan African forest and about 4 percent of the Latin American forest (since 2000) (FAO, 2011a).

For this reason, in *The State of the World's Land and Water Resources for Food and Agriculture* (FAO, 2011a)*:*

> "A decline of about 135 Mha (3.3 percent) in forested area between 1990 and 2010 suggests that the expansion in the cultivated area and the replacement of degraded arable land with new cultivated land have been partly achieved through conversion of previously forested areas (FAO, 2010)."

All things considered, the FAO recognizes the "challenges" of meeting production needs while safeguarding the environmental services and biodiversity provided by trees (Harrison et al, 2002). It goes on and declares that nitrogen fertilizers are "a major source of water and air pollution," and the foreseen "60 percent increase in emissions of ammonia and methane from the livestock sector" will demand "comprehensive measures" (Harrison et al, 2002).

A RAND report by the title *Population and Environment: A Complex Relationship* (Hunter, 2000) on population and environment, discussed FAO's land-use projections, and noted:

> "Converting land to agricultural use can lead to soil erosion, and the chemicals often used in fertilizers can also degrade soil. Deforestation is also associated with soil erosion and can lessen the ability of soil to hold water, thereby increasing the frequency and severity of floods."

A report from the United Nations Population Division (2001) cites a 1992 estimate from the World Bank that about 60 percent of tropical forest clearing was caused by agricultural development. As it has been noted, human-induced changes in land often accrue to habitat fragmentation and subversion, the primary cause of species decline. In fact, if current rates of forest clearing are maintained or expand, one-quarter of all species on Earth could be lost within the next 50 years (Hunter, 2000).

A Central Intelligence Agency assessment of long-term demographic trends documented that "tropical forests are vanishing at a rate of 250 acres per minute." Additionally, the report states that nearly half of the world's original forest cover has been obliterated in the last 50 years, and each year about 16 million hectares of virgin forest are "cut, bulldozed, or burned" (CIA, 2001).

Forasmuch as about 60 percent of the world's population growth in the coming decades will materialize in countries with tropical forests, the report contemplates that this population pressure will produce "accelerating destruction of forests." Similarly, a consolidation of demand for cooking and heating, a need for more cropland, and demand for wood in developed countries make certain that "forests will continue to be destroyed at an alarming rate" (CIA, 2001). Already today, the forests that have prevailed are but destitute fragments of their former ecological and evolutionary majesty, splendor and grandeur. Earth's old-growth forest heritage has been sundered and mutilated through logging, drenched and impregnated in nitrogen, expurgated and sterilized of large wildlife, and have become sources rather than sinks of carbon pollution (Barry, 2017).

The commemorated augmentation in food production has given rise to extensive environmental devastation. For example, the booming use of fertilizer has led to the degeneracy of water quality in many regions (Bennett, Carpenter & Caraco, 2001; Pimm & Raven, 2000). Moreover, some irrigated lands have become heavily salinized, originating the worldwide squandering of ±1.5 million hectares of arable land per year, along with a predicted $11 billion in lost production (Wood, Sebastian & Scherr, 2001).

Together with this, up to ±40 percent of global croplands may also be going through some degree of soil desedimentation, reduced prolificity, or overgrazing (Wood et al, 2001). The loss of native habitats also perturbs agricultural production by degrading the services of pollinators, especially bees (Kremen, Williams & Thorp 2002; Ricketts, Daily, Ehrlich & Michener, 2004). Not surprisingly, agriculture is a notable driver of biodiversity ruin. A field of corn is a biological desert from a biodiversity viewpoint. Industrial agriculture involves stripping the land of its native species of animals, plants, fungi, and other organisms and reinstate them with large-scale monocultures (Wuerthner, 2012).

Given these points, a comprehensive analysis of the environmental impacts of our nutritional needs is examined and perfectly delineated in the paper published in the journal *Nature*, *Options for keeping the food system within environmental limits* (Springmann et al, 2018), which describes many drivers intensified by population growth and rise in per capita affluence, discussed in this chapter. The authors declare:

> "The food system is a major driver of climate changes, changes in land use, depletion of freshwater resources, and pollution of aquatic and terrestrial ecosystems throught excessive nitrogen and phosphorus inputs [...] Between 2010 and 2050, as a result of expected changes in population and income levels, the environmental effects of the food system could increase by 50-90% […]."

Although the repercussions of pollution are beyond the scope of this first volume, it is crucial to name the problem. Thereupon, the authors of this study encapsulated their findings in an orderly and proficient figure (Appendix Figure III), and their findings point to:

> "We estimate that, in 2010, the food system emitted roughly the equivalent of 5.2 billion tonnes of carbon dioxide in GHG emissions in the form of methane and nitrous oxide; the food system also occupied 12.6 million km^2 of cropland, used 1,810 km^3 of freshwater resources from surface and groundwater (bluewater), and applied 104 teragrams of nitrogen (TgN) and 18 teragrams of phosphorous (TgP) in the form of fertilizers."

Given the changes in population growth and augmented affluence, food production and consumption are envisaged to profoundly alter the environmental pressures mentioned above. Consequently, and as the authors disclose:

> "Because of these changes, we predict the environmental pressures to increase by 50-92% for each indicator in the absence of technological change and *other* mitigation measures. The greatest increases along the baseline pathway are projected for GHG emissions (87%, range 80-92%), then for the demand for cropland use (67%, range 66-68%), bluewater use (65%, range 64-65%), phosphorous application (54%. Range 51-55%) and nitrogen application (51%, range 50-52%)."

All in all, in the afterword of the book *Overdevelopment, Overpopulation, Overshoot* (2015), Eileen Crist perfectly sums up the end in view of this chapter:

> "Those endeavouring to figure out how to increase food production without more harms to nature may well be sincere; but they appear to be in the throes of wishful thinking. For even if for a moment we ignore the fact that present-day industrial agriculture, industrial aquaculture, and industrial fishing constitute a mounting planet-wide disaster—which goes largely unremarked only because it is nigh equaled by planet-wide unawareness—simply saying that we need to grow more food without further ecological destruction is not going to stop hungry and acquisitive people from taking what they need and think they need: clearing more forests and grasslands, moving up slopes, overgrazing pasture and rangelands, decimating sea creatures, replacing mangrove forests with shrimp operations, or killing wild animals for cash or food."

Given the conflicts surrounding the use of land and ocean for food production while also protecting biodiversity, people question whether feeding the world and safeguarding biodiversity are even consonant aspirations (Musters, de Graff & Keurs, 2000; Mora & Sale, 2011; Newton et al, 2007). This topic is also explored in the previous chapter, in the segment Roosevelt's Legacy.

In light of these events, we can't deny how providing for the needs of an ever-expanding human population, through food production for humans and their domestics aren't responsible for disseminating so much of the carnage and liquidation of the natural world that is currently taking place on the planet. The next segment will examine how surface area is being monopolized by human activities. Let the 'games' begin!

Lebensraum

- Living Space and Land Allocation -

“We abuse land because we regard it as a commodity that belongs to us. When we see land as a community to which we belong, we may begin to use it with love and respect”

- Aldo Leopold

“Human beings are taking over so much of the planet. Our population has increased hugely over the past one hundred years so that wild areas have become more cramped and encroached upon by roads and buildings.”

- Sir David Attenborough

Massimo Livi Bacci opens up his book, *Our Shrinking Planet* (2017) with the following words:

> “The planet has got smaller. A thousand times smaller. In the age of the birth of agriculture, 10,000 years ago, the 10 million human beings who populated the Earth (theoretically) had at their disposal some 13 km^2 of land each - an area equivalent to a quarter of the island of Manhattan per head. By 2050 there will be 10 billion of us, and the area at the disposal of each human being will be 10,000 times smaller - of the dimensions of a football pitch.”

A population requires space to live. Territory for housing, room for food production, for community activities, for nurturing animals, for syphoning fossil fuels or to garner renewable energy, for infrastructure. Just like any animal, humans require living space - *Lebensraum* - which they can occupy and colonize. Population growth moves in tandem with the heightened demand for more expansion - amplitudes that are appropriated from the natural world. On top of that, if the world is finite and land is finite, then demographic growth cannot persist without a frontier (Bacci, 2017).

Land is the critical resource for the agricultural sector and it provisions food and fodder to feed the Earth's population of ±7.6 billion; fibre and fuel for an array of purposes. It provides livelihoods for billions of people worldwide. It is finite and supplies a multitude of goods and ecosystem services that are fundamental to human well-being. Human economies and quality of life are directly dependent on the services and the resources provided by land (Smith et al, 2014).

Land-use activities - whether transmogrifying natural landscapes for human use or altering management practices on lands controlled by human influence - have metamorphosed a large proportion of the planet’s land surface (Foley et al, 2005). Land change is a source and sequel of global environmental change (Turner, Lambin & Reenberg, 2007; Foley et al, 2005). Permutations in land use and land cover substantially alter the Earth’s energy balance and biogeochemical cycles, which are conducive to climate change and – in turn – impinge on land surface properties and the provision of ecosystem services (Turner et al, 2007; Foley et al, 2005; Quéré et al, 2016; Alkama & Cescatti, 2016).

By laying waste to tropical forests, practicing subsistence agriculture, intensifying farmland production, broadening urban centers, human actions are changing the world’s landscapes in extensive ways (DeFries, Asner & Houghton, 2004; DeFries, Foley & Asner, 2004). Although land-use practices vary tremendously across the globe, its ultimate causatum is generally the same: the accretion of the natural world for immediate human needs, often at the expense of environmental degradation (Foley et al, 2005). In fact, of all the land changes, 60 percent are linked with direct human activities and 40 percent with indirect agents such as climate change (Song et al, 2018).

Humanity is currently usurping half of the global habitable area for agricultural production, as it is displayed in figure 5.3 (of the remnant, 37 percent is forested; 11 percent as shrubbery; and one-percent is exploited as urban infrastructure) (Roser & Ritchie, 2018). As it was previously discussed in Where the Wild Things Were chapter and now becomes more elucidative, by hijacking 50 percent of all habitable land for agricultural practises to provide for the needs of a growing human population, we have in fact monopolized the natural world to serve the requirements of one species, above all others.

Equally important is that more than three-quarters of our agricultural land is used for the breeding of livestock through a combination of grazing land and land used for animal feed production. Notwithstanding that agriculture is the dominant factor in land allocation, meat and dairy products cater for only 17 percent of global caloric supply and only 33 percent of global protein supply. In other words, the 11 million square kilometres set aside for crops, provisions more calories and protein for the global population than the almost 4-times larger area used for livestock (Roser & Ritchie, 2017). As Xiao-Peng Song and colleagues incontestably remark in *Global land change from 1982 to 2016* published in the journal *Nature* (2018):

> "As population and per capita consumption continue to grow, so does demand for food, natural resources and consequent stress to ecosystems."

In *National Geographic*'s article *Feeding 9 Billion* Jonathan Foley (2014) illustrates how:

> "We've already cleared an area roughly the size of South America to grow crops. To raise livestock, we've taken over even more, an area roughly the size of Africa. Agriculture's footprint has caused the loss of whole ecosystems around the globe, including the prairies of North America and the Atlantic forests of Brazil, and tropical forests continue to be cleared at alarming rates. [...] Most of the land cleared for agriculture in the tropics does not contribute much to the world's food security but is instead used to produce cattle, soybeans for livestock, timber, and palm oil. Avoiding further deforestation must be a top priority."

Picturing land use areas on a global map is perhaps the most identifiable way to discern the scale of different land uses across the world. In the picture below (figure 5.4) Roser & Ritchie (2018) exhibit the graphic displayed here (figure 5.3) - on the breakdown of global land use and cover - by scale on a global map.

The chart homes in on land allocation for human activity and brings out that:

- global land designated to livestock - either in the form of grazing land or cropland used for animal feed is tantamount to the area of the Americas (North, Central and South America put together);
- cropland (minus land used for the production of animal feed) is proportionate to the area of East Asia-Pacific, spanning as far south as Thailand;
- the forested area is identical to Africa (minus Libya), the Middle East and South Asia;
- global freshwater (inland water bodies) is convertible to the area of Mongolia;
- total build-up of land (villages, towns, cities & infrastructure) is parallel to an area the size of Libya;

- shrubland corresponds to an area the size of East Asia-Pacific, from Malaysia southwards;
- barren land is a duplicate of the size of Europe;
- Glaciers (permanent ice & snow) equal an area of Antarctica and Greenland combined.

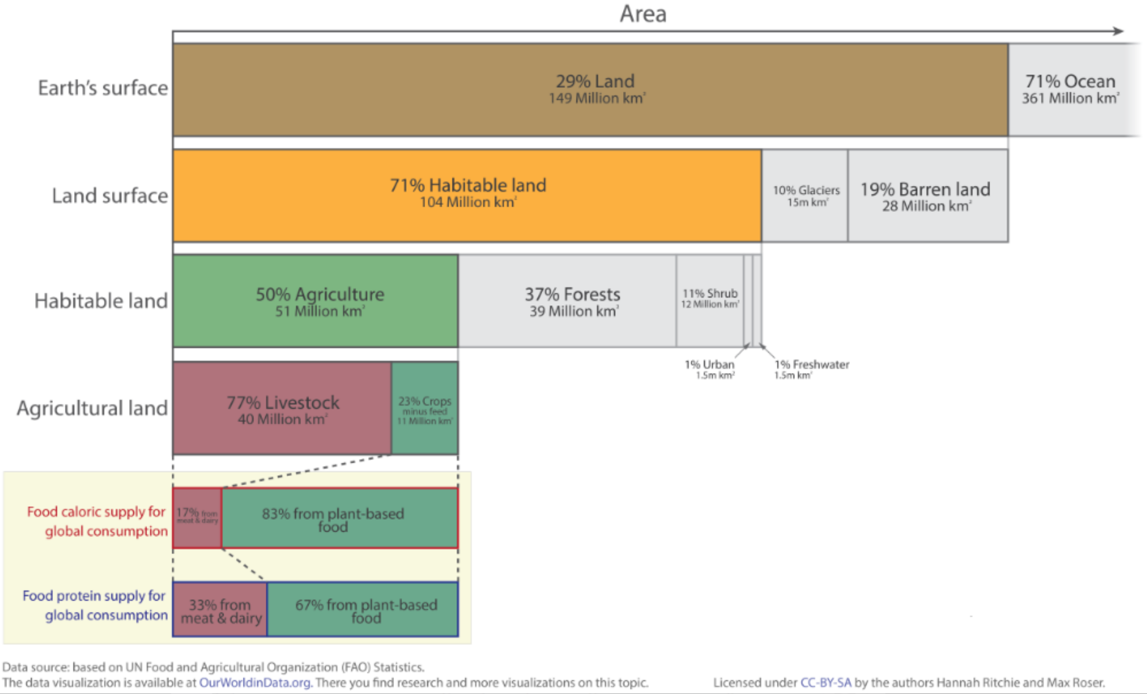


Figure 5.3: Global surface area allocation for food production. The breakdown of Earth surface area by functional and allocated uses, down to agricultural land allocation for livestock and food crop production, measured in millions of square kilometres. Area for livestock farming includes grazing land for animals, and arable land used for animal feed production. The relative production of food calories and protein for final consumption from livestock versus plant-based commodities is also shown. Retrieved from Roser & Ritchie, 2018.

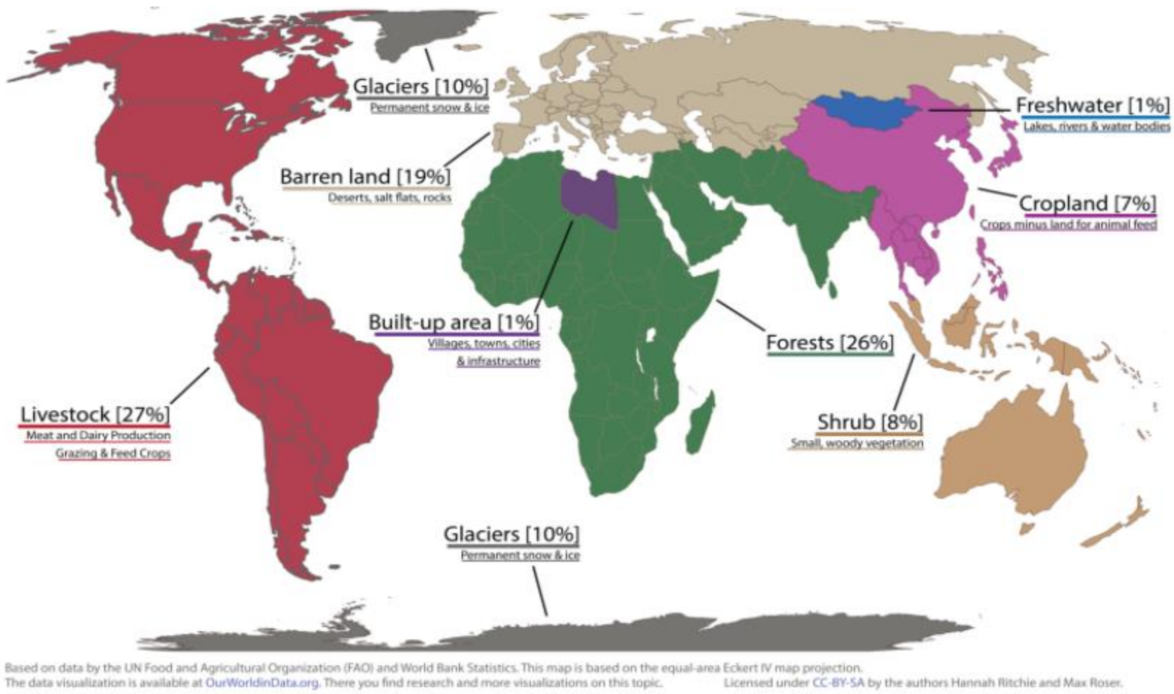


Figure 5.4: How the world's land is used: Total area sizes by type of use & land cover. Global surface area if land was aggregated by usage or terrain cover. Land categories are not shown by their distribution around the world but are representative of the total area that they cover. Land uses as a percentage of global land area are shown in square brackets. Cropland is shown as land area used for crop production minus area used for production of animal feed. Livestock area is inclusive of both grazing land and cropland for animal feed. Barren land refers to land cover in which less than one-third of the area has vegetation or other cover. Retrieved from Roser & Ritchie, 2018.

At this point, it has become apparent how ubiquitous and extensive the agricultural footprint has transformed and engulfed this world. Demonstrably, figure 5.5 portrays how the United States allocates the uses of its land. In a rough sense, 41 percent of the U.S. land revolves around feeding livestock, which in turn is required to supply the rapacious appetite of U.S. citizens and for exports. Moreover, more than one-third of the entire corn crop is devoted to ethanol production, and agricultural land as a whole occupies about a fifth of the country. Equally important, the U.S. is expanding its urban areas - about 1 million additional acres a year. That translates into an additional urban area the size of Los Angeles, Houston and Phoenix combined. Urban areas have quadrupled since 1945. Finally, it can be noted how insubstantial the sum of National parks, Federal wilderness and State parks amounts to (Merrill & Leatherby, 2018). With the population of the United States predicted to expand, one can only venture a guess how this map will change in the coming decades.

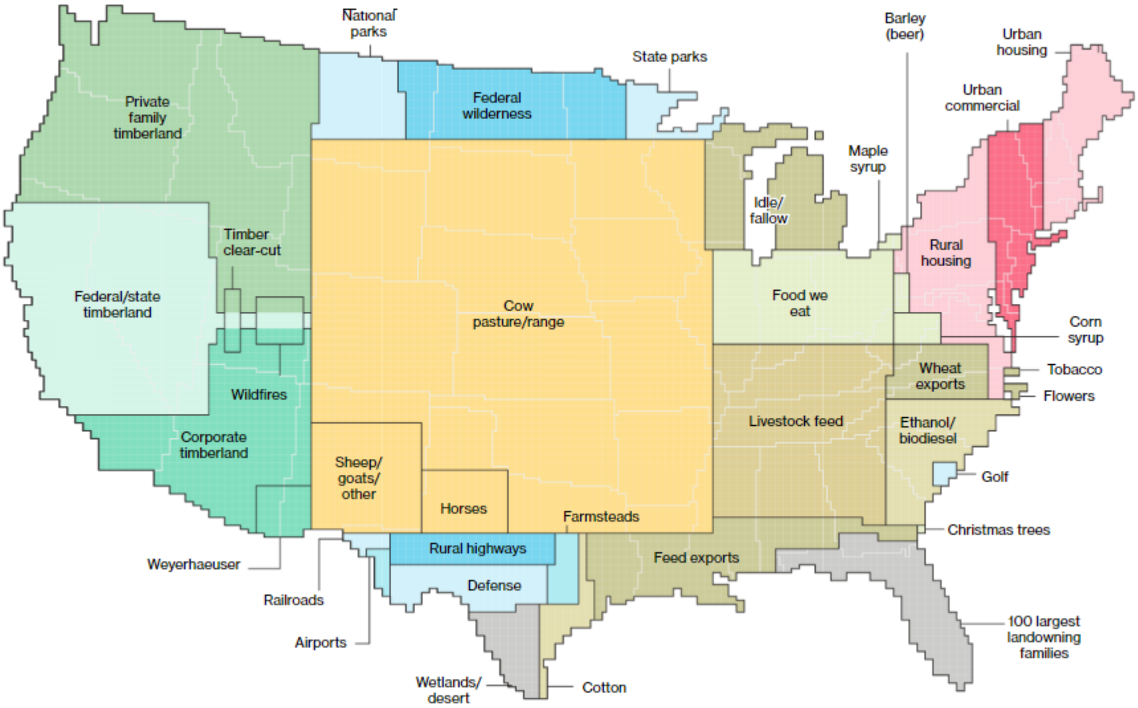
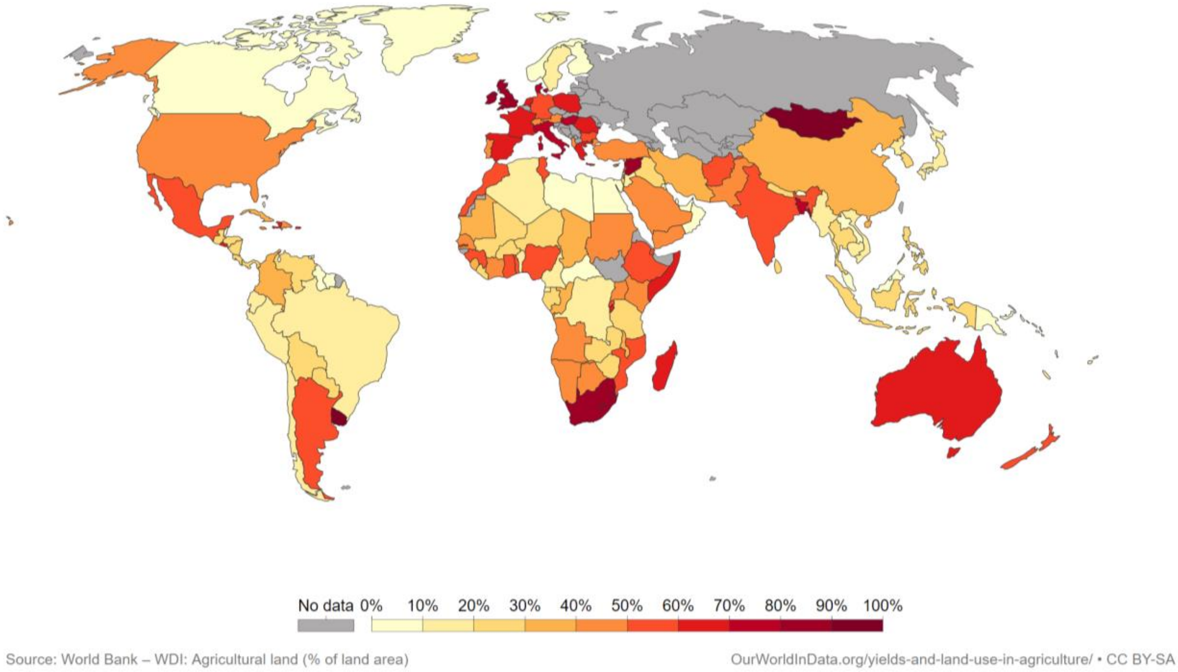


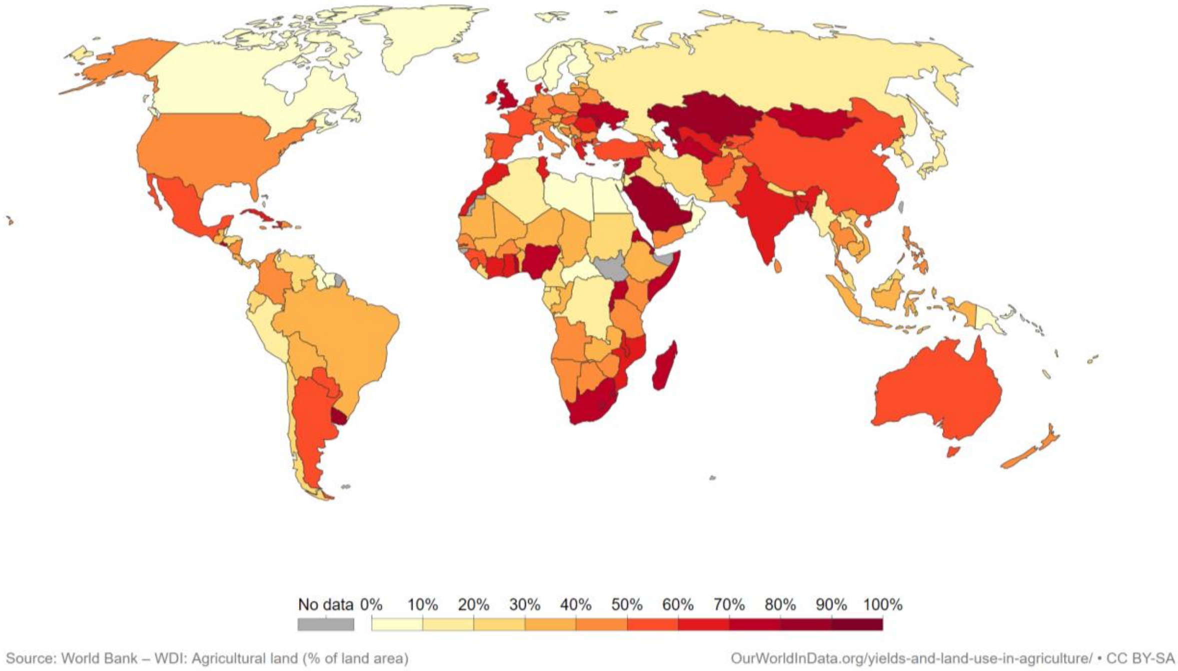
Figure 5.5: How America Uses its Land. **Sources:** U.S. Department of Agriculture, Economic Research Service: Major Uses of Land in the United States, 2012; U.S. Department of the Interior, National Land Cover Database, 2011; U.S. Census Bureau; State governments; stateparks.org; American Farmland Trust; Golf Course Superintendents Association of America; USDA National Agricultural Statistics Service; USDA Census of Agriculture; U.S. Bureau of Land Management; U.S. Forest Service; Weyerhaeuser Co.; The Land Report magazine. Retrieved from Merrill & Leatherby, 2018.

But how much of total land area is employed for agriculture across the world? In the maps below (figures 5.6 and 5.7) a share of total (both habitable and non-habitable) land area used for agriculture in 2014 is portrayed across the span of half a century (Roser & Ritchie, 2018).

There is a discernible asymmetry in the share of land a given country sets aside for agriculture. Allocation fluctuates from less than ten percent, notably across countries in Sub-Saharan Africa and the Scandinavian region, to close to 80 percent across most regions (including the UK, Uruguay, South Africa, Nigeria and Saudi Arabia). It's vital to remark that this metric includes both land used for arable (cropland) production and pasture land for livestock grazing; which signifies that agriculture can appropriate a voluminous share of land area, even in arid and semi-arid regions where extensive arable farming is not possible (Roser & Ritchie, 2018).

When contrasting both images of allocation of land to agriculture and how much it has diverged over time across the global regions, one can recognize how the share of land use for agriculture has been rising across most of the world's regions over the past few decades. However, land use across Europe and Central Asia- particularly in the European Union (EU) zone- and North American has been diminishing (Roser & Ritchie, 2018).





Figures 5.6 and 5.7: Share of land area used for agriculture in 1961 and 2014. The share of land area used for agriculture, measured as a percentage of total land area. Agricultural land refers to the share of land area that is arable, under permanent crops, and under permanent pastures. Retrieved from Roser & Ritchie, 2018.

On a positive note, the continued expansion in cereal yields across the world has been the major driver of total cereal production - there are exceptions, for example in Sub-Saharan Africa. As a matter of fact, the average cereal yield has risen by 175 percent since 1961. Today, the world can generate almost three-times as much cereal from a given area of land as it did in 1961. This has inevitably allowed relieving the land that otherwise would have to be remodelled for cereal production to feed the ever-growing population, and in the process invading the shrinking forested area (Roser & Ritchie, 2018).

In the chart below (figure 5.8) it is possible to see how the global area under cereal production (in blue) has enlarged from 625 to 721 million hectares from 1961-2014. To put that in perspective, this variation is approximately equal to the land area of Mexico. However, if global average cereal yields were to have prevailed at their 1961 levels, the bulk of additional land (in green) would have had to be modified to arable land to achieve the same levels of cereal production. This "spared" land purported to 1.26 billion hectares in 2014 - roughly to the area of Mexico and Europe combined (Roser & Ritchie, 2018).

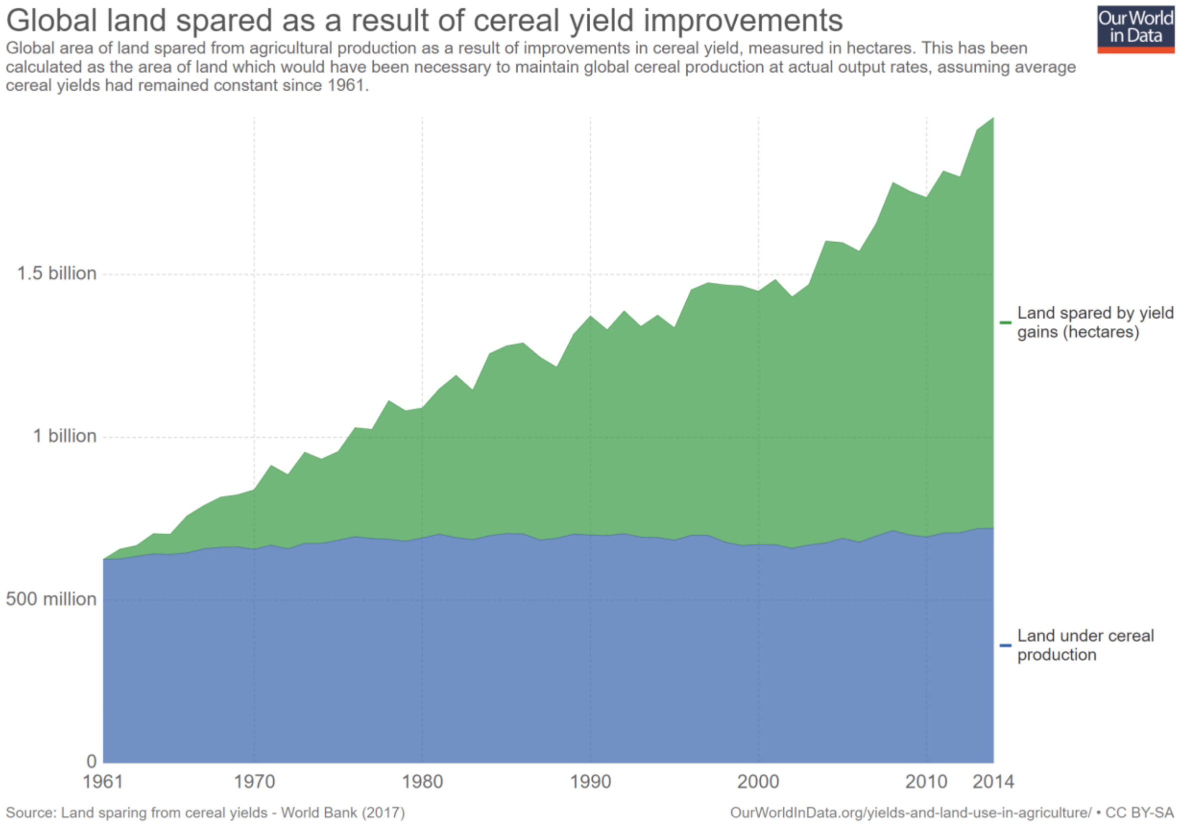


Figure 5.8: Global land spared as a result of cereal yield improvements. This has been calculated as the area of land which would have been necessary to maintain global cereal production at actual output rates, assuming average cereal yields had remained constant since 1961. Retrieved from Roser & Ritchie, 2018).

Contemporaneous agricultural use is approximately 50 percent of the global habitable land, but then again, without cereal yield increases, this may have risen to 62 percent. This agricultural expansion would likely have been into fertile forested land, resulting in a loss of up to one-third of the world's forests (Roser & Ritchie, 2018). The culmination of this reaction is that over the past three centuries the total cultivated territory has increased less than the population has; in the time that it took the former to expand fivefold, the population surged 9.5 times over. Nevertheless, the last few decades have witnessed a swift contraction in the per capita arable land area, which balances out the repercussions of population growth (Bacci, 2017).

Still, while agricultural inputs (fossil fuel based fertilizers), irrigation and technological advances have artificially augmented the bioproductivity of agricultural land, the persistent degradation of ecosystems everywhere induces to a drop in planetary bioproductivity every year. At the same time — the number of humans keeps expanding, and the average — or fair share — of bioproductive global hectares (gha) available per person has descended from 3.2 to 1.7 gha in the early 1960s to today (Wahl, 2018). Correspondingly, the global average ecological footprint per person is 2.7 gha, consequently, roughly 50 percent more than would be sustainable (1.7 gha) (WWF, 2016a; Global Footprint Network, 2018).

There is, therefore, an important affinity between yields enhancement and land use. In order to grow more food, we can increase the output from a given area of land (called 'intensification'), or expand the area over which we cultivate our food (called 'extensification'). In other words, rising yields reduces the pressure of expanding agricultural land (Roser & Ritchie, 2018). To that effect, Andrew Balmford of the University of Cambridge asserts that most species will dwindle as food production *must* inevitably increase to feed a growing human population, that land sparing will support more species than land sharing, and also that high-yield farming is the best strategy to maintain species with small ranges and narrow ecological niches (Bradshaw, 2018).

As an illustration, figure 5.9 demonstrates how most European, American (both North and Latin American), Asian and Pacific countries have seen a much larger augmentation in cereal yields relative to the area used for production. For many, developments in the arable land have been minimal (or have declined). This is a vital contrast to Africa where results are more mixed. Some countries, including Ethiopia, Nigeria and Algeria have followed the rest of the world in yield enhancement. However, a lack of success in boosting agricultural productivity in many Sub-Saharan countries has led to large increases in land used for cereal production (Roser & Ritchie, 2018).

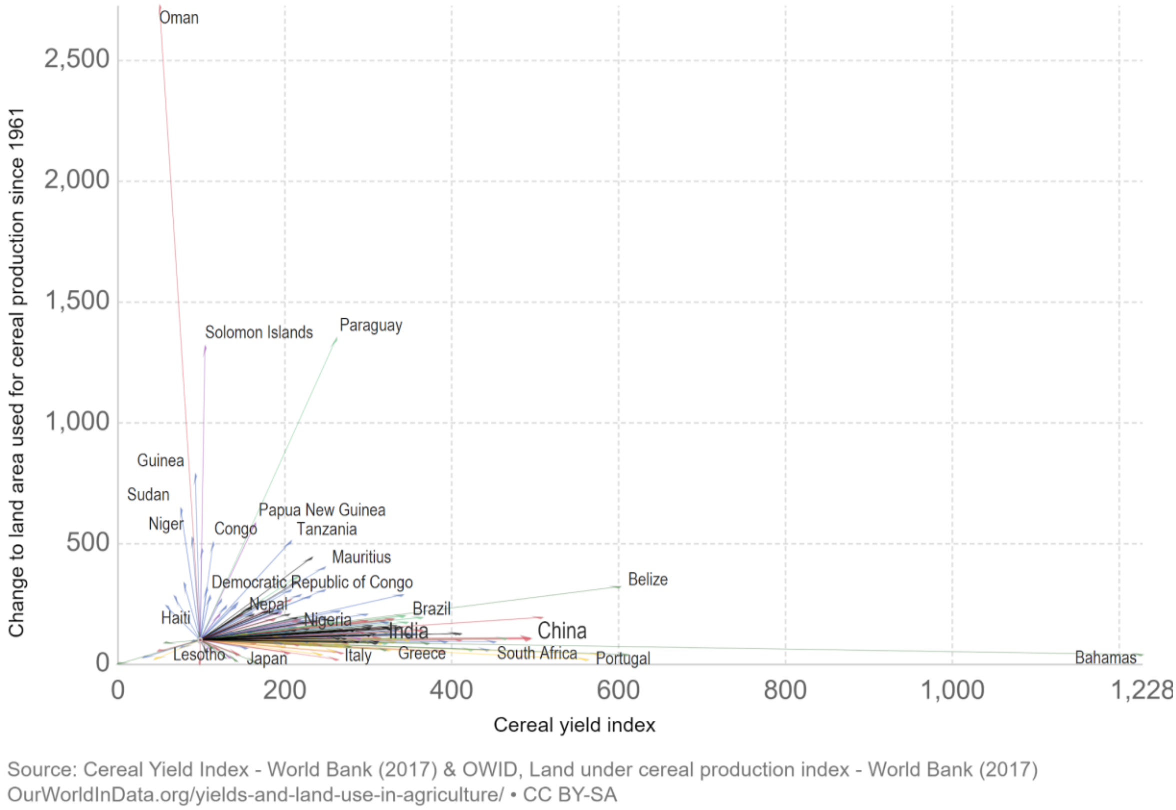


Figure 5.9: Land use vs yield change in cereal production 1961 to 2014. Indexed change measured relative to values in 1961 (i.e. 1961 = 100). Retrieved from Roser & Ritchie, 2018.

Also crucial to this discussion is the volume of land required to generate food, which has wide variations depending on the product - this is especially true when differentiating crops and animal products. In the chart below (figure 5.10) the average land required (also referred to as "land footprint") to produce one gram of protein across a range of food types is presented (Roser & Ritchie, 2018).

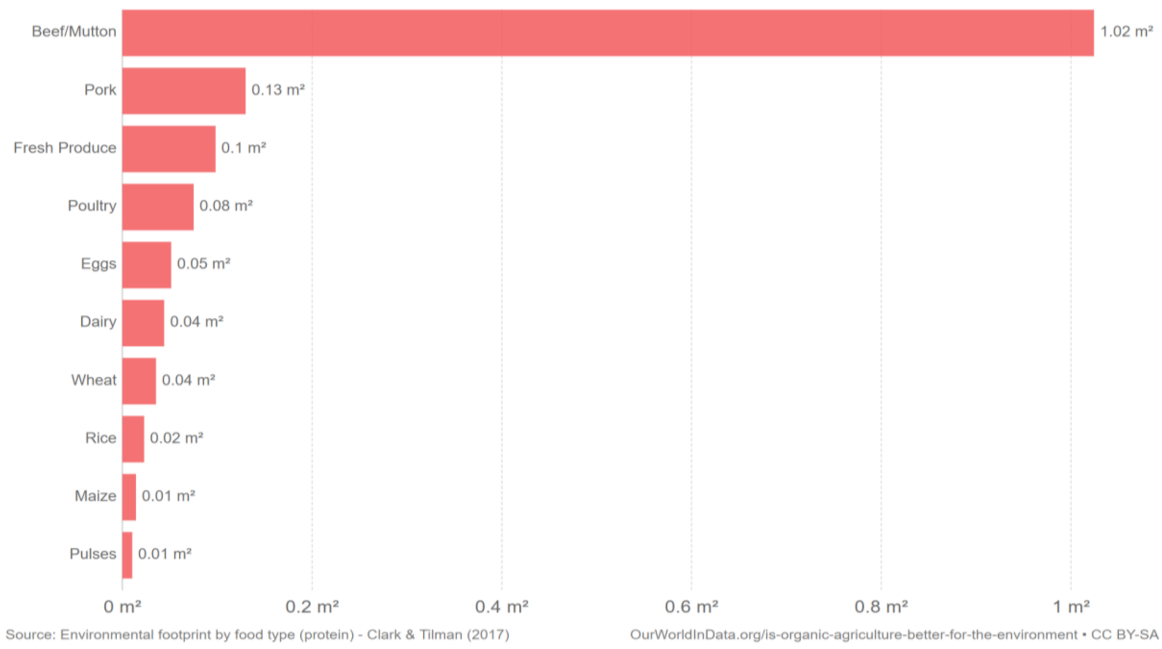


Figure 5.10: Land use per gram of protein, by food type. Average land use area needed to produce one unit of protein by food type, measured in metres squared (m2) per gram of protein over a crop's annual cycle of the average animal's lifetime. Average values are based on a meta-analysis of studies across 743 agricultural systems and over 90 unique foods. Retrieved from Roser & Ritchie, 2018.

At the bottom of the scale, it can be observed that cereal crops, as a rule, have a small land impact per unit of protein (although such protein is often lacking in some essential amino acids). At the upper end of the spectrum, meat products are located, with land required for beef or mutton up to 100 times larger than cereals (Roser & Ritchie, 2018).

Comparatively, ruminants deplete the bulk of feed crops (3,700,000,000 tons compared with 1,000,000,000 tons by pigs and poultry) (Herrero et al, 2013). Coupled with the fact that they require the greatest area per kilogram of meat (or protein) produced of all types of livestock and globally seize more area than any other land use, equally important is the enteric fermentation from ruminant production, that alone is the largest source of anthropogenic methane emissions (Ripple et al, 2014). Beef production also requires 6 times more reactive nitrogen to produce than dairy, poultry, pork, and eggs (Eshel, Shepon, Makov & Milo, 2014).

Nonetheless, it's critical to perceive the differences in land required across the meat products: poultry and pork have a land footprint 8-10 times inferior to that of beef. This means individuals can make notable reductions in the environmental impact of their diets simply by replacing beef or mutton for other lower-impact meat products (Roser & Ritchie, 2018).

In the first part of this segment, it was possible for the reader to perceive how anthropogenic activities, particularly agriculture, have completely altered the surface of the planet in the last century or so. With the knowledge now acquired it will be possible to understand how these trends stretch even further back, and how population growth has been its main catalyst. The following example from Massimo Livi Bacci's book *Our Shrinking Planet* (2017), which opened the segment might be enlightening:

> "Let's take the case of Europe. As almost anywhere across the world, up until the Industrial Revolution its main source of nutrition was cereal products. It has been estimated that feeding a person required around 300 kg of grain per year and that around 1800 it took an average of around half a hectare of land to produce this much, given the low productivity of the era's agricultural system. At the beginning of the nineteenth century, Europe's population of around 150 million

people (not including Russia) thus required around 750,000 km^2 of land (out of a territory of around 5 million km^2) to satisfy its basic food needs. Since Europe did not live on bread alone (or just on grain), it needed still further land for growing complementary foods, for grazing livestock, and for the wood necessary for heating. Add to this the space taken up by urban areas, by manufacturing activities, and by the infrastructure - however modest - of the time, and we will not be far off the truth if we conclude that anthropogenic activities took at least one third of the total space away from the natural environment. If we then take into account that another part of Europe's territory was closed off to human activities for natural reasons (freezing climates, mountainous areas, and bodies and courses of water), we can conclude that Europeans of two centuries ago were beginning to get a clear sense of their continent's physical limits. Certainly the great transoceanic migration that began in the middle of the nineteenth century was by no means unrelated to this perception. Indeed, in many areas of Europe this lack of space was turning into an acute lack of resources, driving an intense flow of people out of the continent."

In a final analysis, it is also important to address the extent of agricultural expansion, and if in all likelihood is it possible that it can continue to increase. The next chart in this segment presents the trends of global land under arable and permanent crops from 1961-2014, together with UN FAO projections of arable land use through to 2050. This projection stems from FAO's World agriculture towards 2030/2050 Report (Alexandratos & Bruinsma, 2012).

The FAO foresees that global arable land use will continue to expand to 2050 (figure 5.11), nonetheless, this is likely to be a rate of expansion (towards a certain decline) at a slower rate than over the past 50 years. Most of the projected growth is the result of developing countries, while arable land in developed countries would likely continue to decrease (Roser & Ritchie, 2018).

Evidently, FAO's projection of continued arable land expansion through 2050 was disputed by Ausubel, Wernick & Waggoner (2013), which conjectured that global peak farm had already been attained in 2009. The authors went on to stress that arable land use would decline 0.2 percent per year from 2010-2060 (Roser & Ritchie, 2018).

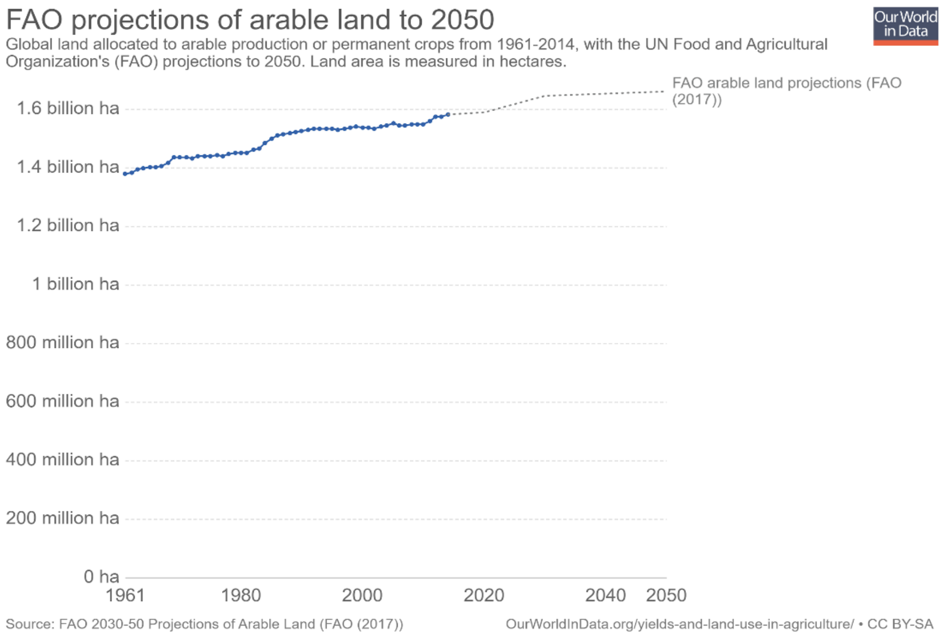


Figure 5.11: FAO projections of arable land to 2050. Global land allocated to arable production or permanent crops from 1961-2014, with the UN Food and Agricultural Organizations (FAO) projections to 2050. Land area is measured by hectares. Retrieved from (Roser & Ritchie, 2018).

Besides the question that dominates the narrative of "can we feed 10 billion people?" there is also the other side of the coin, which is the impact of food production through land appropriation on biodiversity, ecosystems and natural limits.

As it has been noted, land conversion for crop and animal agriculture is the chief driver of habitat loss, that ultimately prompts a contraction of geographical ranges, which, along with direct killing, continues to be the leading hazard to biodiversity, as it is represented in figure 5.12 (Estrada et al, 2017; Maxwell et al, 2016; Mora et al, 2013; Wolf & Ripple, 2017). Of the freshwater resources apportioned for human use, 80 percent is demanded by agriculture (Foley et al, 2005). At least one-fifth of anthropogenic greenhouse gases are connected to the food system (Steinfeld et al, 2006; Schwarzer, Witt & Zommers, 2012). Agriculture is also largely accountable for the world's 400 dead zones, which have been rising in number and extent since the 1960s (Diaz & Rosenberg, 2008) and agricultural pollution, which also disturbs freshwater systems worldwide (Tilman et al, 2001).

Many ecosystems and biomes have been seized for food production (figure 5.12). Temperate grasslands are among the hardest hit, with habitat transmogrification outstripping habitat protection by a ratio of 8:1 (Hoekstra, Boucher, Ricketts & Roberts, 2004). More than half of the world's species-rich wetlands have been depleted over the past century, largely for repurposing into agriculture (Meyer & Turner, 1992; MEA, 2005). Likewise, aquaculture operations are driving a pervasive mangrove downfall (Polidoro et al, 2010).

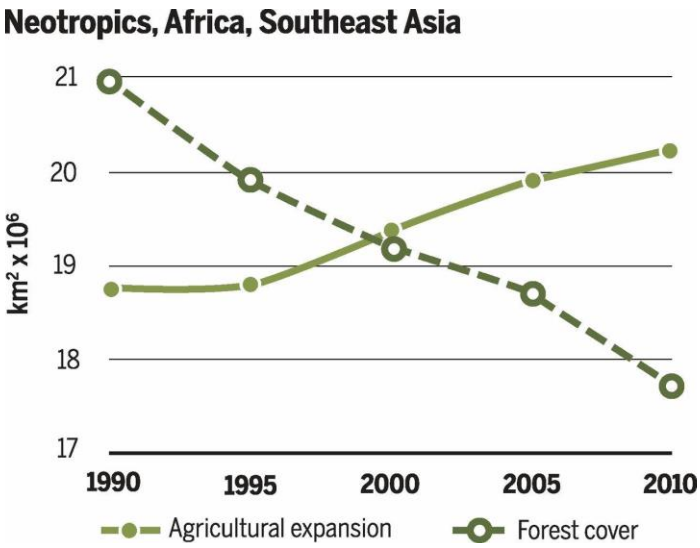
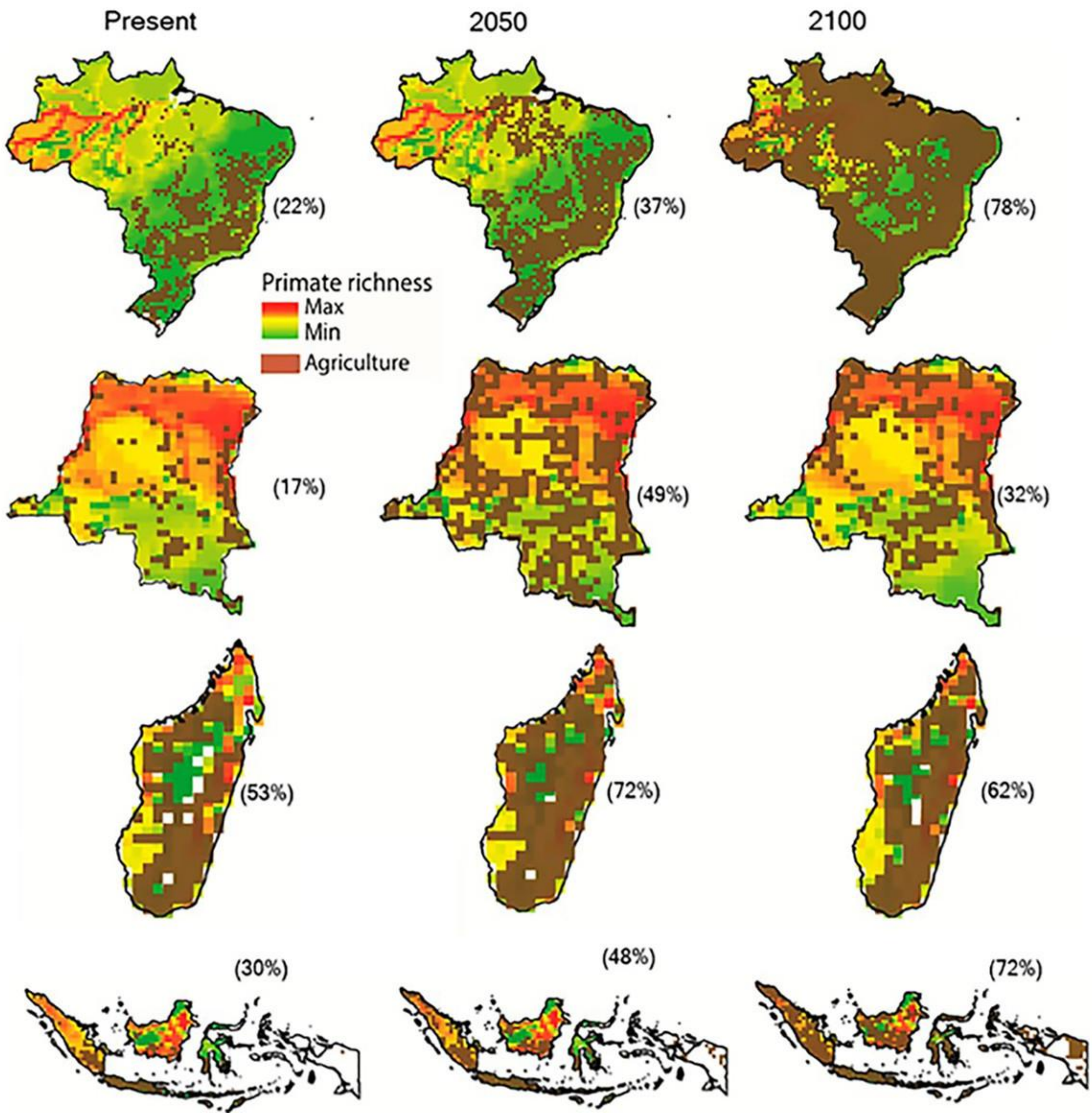


Figure 5.12: Agricultural expansion and declines in forest cover (1990-2010) in primate range regions. Sixty percent of primate species are threatened with extinction and 75 percent have declining populations (Estrada et al, 2017). Source: FAOSTAT. Graphic: Adapted by H. Bishop/Science. Retrieved from (Crist et al, 2017).

Similarly, most tropical deforestation since the 1980s is due to the amplification of plantations and ranches (Gibbs et al, 2010; Geist & Lambin, 2002). Moreover, the precipitous population downturn of big herbivores and carnivores are also associated with crop and animal agriculture (Estes et al, 2011; Ripple et al, 2014; Bauer et al, 2015). Indeed the two least disturbed biomes on Earth - boreal forests and tundra (Hoekstra et al, 2004) - mirror what is exactly going on, for these are the two biomes where large-scale food production does not occur (Crist et al, 2017).

In effect, a global study modeling conflict between agricultural expansion and primate species distributions anticipated that during the 21st century, regions foreseen to be reorganized from forest to agricultural production accounted for 68 percent of the area presently used by primate species (Estrada et al, 2017). Moreover, the modelling regarding a worst-case scenario in this century for this agricultural colonization and the primate range confinement for the four countries of Brazil, Indonesia, Madagascar and Democratic Republic of Congo (DRC) are, respectively, 78; 72; 62 and 32 percent (figure 5.13) (Estrada et al, 2018).

Figure 5.13: The projected expansion of agriculture and pastures in (A) Brazil, (B) the Democratic Republic of the Congo, (C)



Madagascar, and (D) Indonesia for 2050 and 2100, under a worst-case scenario of land **use** from native vegetation to agricultural fields and pasture. Retrieved from Estrada et al, 2018; DOI:10.**7717**/peerj.4869/fig-3. See the original work for a description of methods used.

On top of this agricultural expansion, there is a need to account for the colonization of natural areas by human settlements. Three of the emerging aspects that demand reflection, particularly in the coming half-century - a period in which the speed of population growth will still be rather substantial - are the human intrusion into rainforests, whose integrity is an assurance of the bionatural equilibrium; the upsurge of human settlement in the most delicate habitats, specifically along coasts and along the banks of rivers and lakes, and the overall explosion of urbanisation processes (Bacci, 2017) (the ensuing volume will contain a chapter dedicated to urbanization, Crowded Eden).

Demonstrably, we could think that things are getting better and that international commitments and agreements are safeguarding the small pockets of forested areas that still remain, but that couldn't be farther from the truth. Despite the best efforts by a multitude of uncorrupted individuals to ensure that these ecosystems are maintained, no battle is truly won as long as we continue to expect 3 to 4 billion more people added to this planet until the end of this century, each one pressing for more land to be used for construction and cultivation and the more preeminent consumption of non-renewable energy and resources as well as renewable materials such as timber, that might need to be branded *non-renewable* due to the intense demand and velocity as to which they are sought out and appropriated by humankind.

A prime example of this is that in 2017, *Tropical Forests Suffered Near-Record Tree Losses* (Plumer, 2018) as it is reported in *The New York Times*. Brad Plumer, enucleated how in:

> "Brazil, forest fires set by farmers and ranchers to clear land for agriculture raged out of control last year, wiping out more than 3 million acres of trees [...] undermining Brazil's recent efforts to protect its rain forests."

A study by the Global Forest Watch (2018) is responsible for this newly refreshed clarity, equally so, their satellite data also provided an unhindered picture of Brazil's immense Amazon rain forests. In spite of the pledges by the Brazilian government to reduce illegal logging and agricultural companies to farm *sustainably,* the team's analysis demonstrated that Brazil forfeited a record amount of tree cover in 2016 and 2017, in part due to the fire outbreaks mentioned (Plumer, 2018).

Equally important, research published in *Nature Scientific Reports* by Michelle Kalamandeen and colleagues (2018) details how large forest clearing (>50 ha) has declined substantially in Brazil (46 percent), small clearings (<1 ha) saw a rise of 34 percent (Kalamandeen et al, 2018). Seeing that the smallest size detectable by the Brazilian government deforestation monitoring system is 6.25 ha, this signifies that small-scale logging and deforestation is occurring under the aegis of the Brazilian government. Moreover, in accordance with the research, new hotspots are also emerging in the Amazonian forest that is contained in Bolivia and Peru (Erickson-Davis, 2018b).

In Colombia, a peace deal between the government and the country's largest rebel group (Revolutionary Armed Forces of Colombia, or FARC), with no seemingly objection, has led to a rush in mining, logging and farming in that nation's Amazon region to escalate tremendously, ravaging what was almost considered an unsullied land (Plumer, 2018), and one of the most important hotspots on the planet (Carrington, 2013). The researchers arrived at the conclusion that in one year, 1 million acres of forest were cleared, which amounts to a 46 percent rise from the year 2016 (Plumer, 2018). Mikaela Weisse, a research analyst with the team behind the study disclosed:

> "As FARC has demobilized, large areas are opening up once again, and you're seeing this rush of people grabbing land for different reasons, like planting cocoa or cattle ranching" (Plumer, 2018).

Furthermore, the Democratic Republic of Congo was the country submitted to more forest loss, in addition to Brazil - roughly 3.6 million acres, up 6 percent relative to 2016 - with small-scale logging, charcoal production and farming (all considered subsistence activities, clearly showing that even poor countries have severe impacts on the environment when millions of people contribute on with modest influences) all playing crucial roles (Plumer, 2018).

As a recent exception, Indonesia has seen severe deforestation contraction in 2017, as governmental protection of peat forest took effect, but as Putera Parthama, director general for climate change at Indonesia's Ministry of Environment and Forestry attests:

> "One year's data does not mean a trend that is true. But we believe we are starting one" (Carrington, Kommenda, Guiérrez & Levett, 2018).

All in all, the world lost around 39 million acres (29.4M hectares) of trees in the year 2017 alone, this equates to an area the size of Bangladesh (Plumer, 2018), or one football pitch of forest every second, an area the size of New York per day or one Scotland every 100 days (Carrington et al, 2018) in consonance with the report by Global Forest Watch (2018).

This data only seizes a partial picture of forest integrity around the planet, since it does not encompass trees that are growing back after storms, fires or logging (Plumer, 2018). Nevertheless, separate sources substantiate that tropical forests are recoiling overall, with losses counterbalancing gains (FAO, 2018a). On the other hand, research published in *Nature* (Song et al, 2018) argues that the Earth is gaining tree cover and losing bare ground cover – mainly due to human activity. This stands against the prevailing examination that forest area has diminished globally, when in fact the authors claim it has increased by 2.24 million km^2 (+7.1 percent relative to the 1982 level).

The researchers (Song et al, 2018) write:

> "Expansion of the agricultural frontier is the primary driver of deforestation in the tropics (Gibbs et al, 2010). The three countries with the largest area of net tree cover loss during 1982-2016 are all located in South America: Brazil, Argentina and Paraguay […] Tree canopy in Europe, including European Russia, has increased by 35 percent – the greatest gain among all continents. Natural afforestation on abandoned agricultural land has been a common process in Eastern Europe after the collapse of the Soviet Union (Potapov et al, 2015) [...] an increasing area of plantations in south-eastern China has also led to tree canopy gain (+34 percent) in China. Tree canopy also increased in the United States (+ 15 percent) […] The world's arid and semi-arid drylands exhibited large areas of decrease in short vegetation and large areas of increase in bare ground, indicating long-term land degradation […] Human activities undoubtedly have a dominant role in agricultural and urban landscapes, where lands have been continually modified throughout human history. India and China had the largest bare ground loss among all countries [...] the results of this study reflect a human-dominated Earth system. Direct human action on landscapes is found over large areas on every continent, from intensification and extensification of agriculture to increases in forestry and urban land uses, with implications for the maintenance of ecosystem services (Foley et al, 2005)"

At the same time, Song and colleagues assert that:

> While Earth may presently have more trees than 35 years ago, the study confirms that some of its most productive and biodiverse biomes — especially tropical forests and savannas — are significantly more damaged and degraded, reducing their resilience and capacity to afford ecosystem services.

Even though I claim no expertise in land use and tree cover dynamics, but instead a full-fledged curiosity, one conspicuous point jumps to mind when examining the deliberations made by the researchers in this study. The matter that "an increasing area of plantations in south-eastern China has also led to tree canopy gain (+34 percent)" (Song et al, 2018) casts doubt on the ecologically prowess and suitability of human-made plantations, as worthy substitutes for ancient, structured and rich in biodiverse life-forms that previous biomes originated and granted. That is exactly what Hua et al. (2018) examine in their paper published in the journal *Biological Conservation.*

At a glance, China's ardent reforestation policies, that prompted farmers to plant more than 69.2 million acres of trees on what was once cropland and scrubland, led to an increase in tree cover of 32 percent by 2015 (Erickson-Davis, 2018c). But on closer examination, Hua et al. (2018) assert that all this new cover isn't actually forest, since most reforestation endeavours simply planted one tree species, transforming a plot of reforested land ecologically analogous to a monoculture plantation. In view of this, the researchers point the finger at governments that can't differentiate between monoculture tree cover from real forests. Fangyuan Hua, co-lead author of the study alleged in an interview with *Mongabay* (Erickson-Davis, 2018c):

> "This creates a perverse incentive to establish tree plantations and displace native forests, which is precisely what we see here."

That is exactly what has been occurring in the Portuguese territory. With more than 800,000 hectares dedicated to monocultures of trees from the genus *Eucalyptus* (an invasive tree, originally from Australia), the country stands with a quarter of its forested area invaded by the tree; as the one with the largest area planted in Europe and ranking 5th worldwide. Just like in China, the *eucalyptus* monocultures are the result of a combination of forest policies and market interests, which end up, to all effects, contributing to tree canopy cover increase worldwide (Serra, Barca & Meira, 2018).

This isn't to say that reforestation efforts such as the one employed in China are completely devoid of importance. Hua et al. (2018) argue that if the country's initiative could strengthen compensation incentives to landholders, their research indicates that these households tend to reconcile to government policy and community standards, and so a "social marketing to encourage land-use decisions that will result in more biodiversity and other ecological benefits," could be implemented. Hua reveals (Erickson-Davis, 2018c) that:

> "Profitability plays a significant role in all of this. It is clear from our interviews that how much money a household stands to make determines what they'll do with their land. This really highlights the role that proper incentives can play in encouraging more environmentally friendly uses of land, like protecting and restoring native forests."

Given these points, the contracted ecological integrity of increased tree canopy might just be the tip of the iceberg when scrutinizing these "positive news." Although some progress is being attained, it seems to be at a very high cost.

As leaders around the world assembled in Oslo (Norad, 2018) to discuss how to intensify efforts to protect the world's tropical forests, Andreas Dahl-Jorgensen, deputy director of the Norwegian government's International Climate and Forest Initiative confessed:

> "These new numbers show an alarming situation for the world's rainforests. We simply won't meet the climate targets that we agreed to in Paris without a drastic reduction in tropical deforestation and restoration of forests around the world" (Plumer, 2018).

Frances Seymour at the World Resources Institute, which is responsible for the Global Forest Watch with its partners affirms:

> "The main reason tropical forests are disappearing is not a mystery - vast areas continue to be cleared for soy, beef, palm oil, timber, and other globally traded commodities. Much of this clearing is illegal and linked to corruption."

All things considered, a century ago, roughly 15 percent of Earth's surface was employed to grow crops and raise livestock (Goldewijk, Beusen, van Drecht & de Vos, 2011). In our day and age, the share of the planet's territory under the jurisdiction of *H. sapiens* has climbed to more than 77 percent of land (excluding Antarctica) and 87 percent of oceans (Jones et al, 2018; Allan, Venter & Watson, 2017) (figure V in the Appendix section gives a detailed vision of how extensive is the reach of the human footprint (Watson et al, 2018)). Moreover, between the years 1993 and 2009, an area of terrestrial wilderness larger than India – an overwhelming 3.3 million km^2 – was subjugated and consumed in exchange of human settlement, farming, mining and several other pressures (Watson et al, 2016). In the ocean, areas that have so far escaped this tyrannical exploitation have been confined mostly to the polar regions (Halpern et al, 2016).

The conclusion is apparent: Modern land-use practices, while increasing the short-term necessities of material goods, may undermine the biological integrity and ecosystem services, processes and functions in the remote future, even on regional global scales (Foley et al, 2005). As Tristram Stuart (2014) asserts:

> "The purpose of farming is to deprive other species of the land and sequester it for our own use. But by perfecting the art of monoculture, it has become too easy for us to exterminate everything else, leaving no wild plants, no food for insects, and a barren land for birds."

The same can be said for other exertions on the natural world that converge on fulfilling luxurious predilections, or simply the most basic desideratum for the maintenance of life. By all means, we cannot afford to ignore human numbers, when essentially every new passenger on this planet will create ripples (regardless of how negligible its significance is, when multiplied by billions it becomes rather substantial) that will echo throughout the natural world. These worries are not just directed from the assault on the health and integrity of the natural world, but at the continuation of our own human civilization. In the final analysis, Bradford Hatcher (2017) conveys some much-needed wisdom:

> "Most of us know by now that civilizations come and go. One of the things that sends them packing is the […] exploitation of one-hundred percent of their occupied niche, with nothing lying fallow or given time to recover. Raiding adjacent niches isn't always an option, or when it is, this leads to war and then to accelerated collapse. In other words, it's unwise to occupy an entire niche, and wiser in the long term to underdevelop. Wisdom will allow much of our forested, arable and grazeable lands, in any normal year, to lie fallow, or managed by natural processes, with a change to recover. Lebensraum, room for living, can use some recycling as well. An as-yet unnamed horseman of our apocalypse is overextension, hypertrophy, our crowding into the flood and tidal zones, onto the slopes of Vesuvius, on top of the earthquake faults, and into our armed neighbor's yard. Ecological spacing was the last good excuse we had for war, but we lost it when we outgrew our tribes."

Facing global environmental challenges of land use will require assessing and managing deep-rooted trade-offs between meeting human needs and cultivating the capacity of ecosystems to provide goods and services in the future (Foley et al, 2005). Although improvements in conservation, agronomic, and harvesting practices are evidently needed, the above trends suggest that the demand side must also be prioritized. Enacting a sustainable world—providing a high quality of life for all people while safeguarding Earth's biodiversity—calls for bringing population growth to the forefront of international concerns (Crist et al, 2017).

Watermark

"Whiskey's for drinking, water's for fighting about."

- Mark Twain

- **"Water, water everywhere, / Nor any drop to drink."**
  - Samuel Taylor Coleridge

Figure 5.14 Sign rendered pointless by the 2007/2008 Australian drought. Rawnsley park station, South Australia. CC-BY-SA-2.5 Source: Peripitus

Water is extensively contemplated as the most fundamental natural resource, yet freshwater systems are directly affected by human activities (Meybeck, 2003; UNESCO, 2009; Vörösmarty et al, 2005), as well as anticipated to be further modified by anthropogenic climate change (U.S. Global Change Research Program, 2009). The phenomenon that ensues usually goes by the name of water scarcity, and it can crystallize in physical shortages or scarcity in access due to the missteps by institutions to assure a regular supply or due to an absence of adequate infrastructure (UN Water, 2018). This segment will obviously focus on the first reason, physical shortages due to tremendous increases in demand, surpassing local and regional carrying-capacities that eventually seep into the socio-economic realm, preventing human and non-human prosperity and thriving.

It is important to realize that water scarcity already touches every continent. Water usage has been expanding globally at more than twice the rate of population growth in the last century, and a swelling number of regions are entering a limit at which water services cannot be sustainably delivered, particularly in arid regions (UN Water, 2018).

It is foreseen that a combination of soaring global population, economic growth and climatic activity will translate into five billion (52 percent) of the expected 9.9 billion to live in areas where fresh water supply will be under heavy distress. Moreover, an additional one billion people will be living in areas where water demand will surpass surface-water supply (Schlosser et al, 2014).

As a matter of fact, approximately half the global population are already inhabiting potential water scarce areas at least one month per year and this could escalate to roughly 4.8 - 5.7 billion in 2050. Specifically, about 73 percent of the distressed live in Asia (69 percent by 2050, due to the tremendous population growth expected in Africa) (Burek et al, 2016). Demonstrably, water scarcity will be aggravated as rapidly growing urban areas place heavy pressure on adjacent water resources (UN Water, 2018).

These water systems are being thoroughly transfigured through pandemic land cover changes, urbanization, industrialization, engineering schemes like reservoirs, interbasin transfers that maximize human access to water (Meybeck, 2003; Vörösmarty et al, 2004), and for the maintenance of the agricultural system that needs to provide for the requirements of an enlarged and rapacious human population (Vörösmarty et al, 2010).

Humans secure their lion's share of nutrients from crops and livestock, and these nutrient sources require water, land, and energy for production (Pimentel et al, 2004). World agriculture expends approximately 70 percent of the freshwater withdrawal per year [(industrial sector about 19 percent and household and municipal use, 12 percent (Aquastat, 2014)], and this amount has risen by three times as much in the last 50 years. By 2050, the global demand for agriculture is foreseen to increase by approximately 19 percent due to irrigation requirements (Global Agriculture, 2015).

At the present moment, close to 20 percent of the world's cropland is irrigated, but this irrigated land produces 40 percent of the world's food (Renner, 2012). Worldwide, the extent of irrigated land is slowly broadening, even though salinization, waterlogging, and siltation continues to contract its productivity (Gleick, 2002).

In defiance of a narrow annual increase in total irrigated area, the irrigated area per capita has been declining since 1990 by virtue of rapid population growth (Postel, 1999, Gleick, 2002), which, in many regions, could only be sustained on massive scales by unendurable rates of groundwater monopolization (Wada, van Beek & Bierkens, 2012; Famiglietti, 2014; Gleeson, Wade, Bierkens & van Beek, 2012; Richey et al, 2015; Jaramillo & Destouni, 2015). Notwithstanding, future global agricultural water consumption (including both rainfed and irrigated agriculture) is predicted to rise by about 19 percent to 8,515 km^3 per year by 2050 (WWAP, 2012).

Rising population and their food demands are in all probability going to augment the amount of nonrenewable groundwater suction for irrigation, specifically in emerging countries such as India, Pakistan, China, Iran and Mexico. This will result in falling groundwater levels which may in the course of time become unreachable for local farmers with limited technology (Wada et al, 2012).

The map (figure 5.15) shows the average exposure of water users in each country to baseline water stress, the ratio of total withdrawals to total renewable supply in a given area. A higher percentage means more water users are competing for limited water supplies (Gassert, Reig, Luo & Maddocks, 2013).

Their analysis concluded that 37 countries currently face "extremely high" levels of water stress, meaning that more than 80 percent of the water available to agricultural, domestic, and industrial users is withdrawn annually. Additionally, the authors reflect on the fact that Brazil, Russia, and Canada, for example, are often considered exempt to water risk because of their vast resource base, but the reality is that in these countries most of the water use is condensed in a few regions with relatively limited supplies, while their resources are secluded and unreachable (Gassert et al, 2013).

Couple with this, Singapore is among the countries with the highest water stress ranking, sharing that position with other arid countries such as the United Arab Emirates, although it is regarded worldwide as a phenomenal water manager. As a matter of fact, Singapore is a densely populated island nation with no freshwater lakes or aquifers; its demand far outpaces its naturally occurring supply, resulting in an extremely high level of baseline water stress (Gassert et al, 2013).

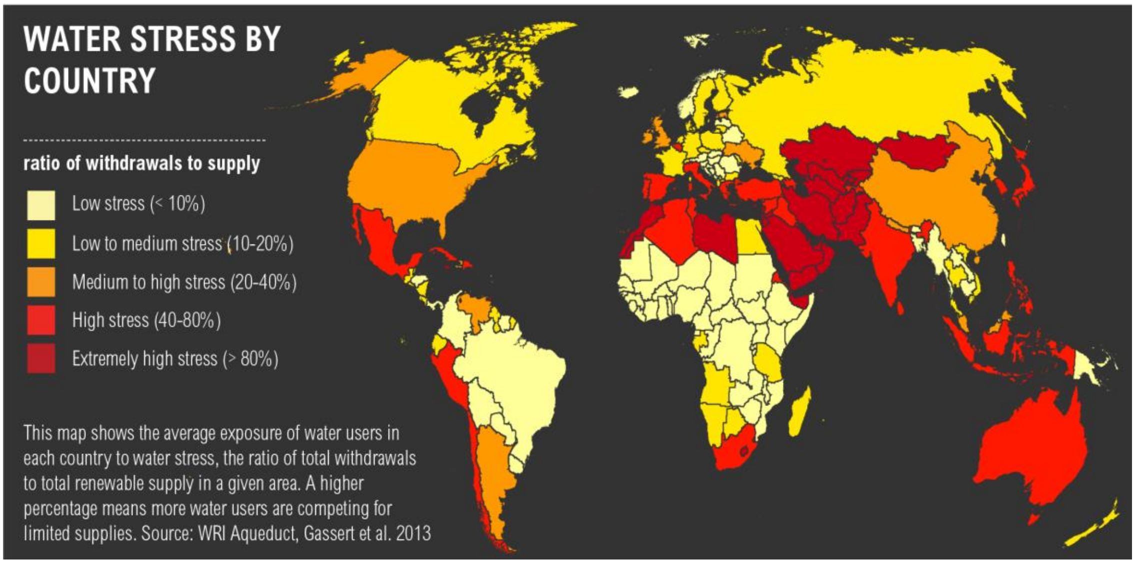


Figure 5.15. Water Stress by country. Source: World Resources Institute. Retrieved from Gassert et al, 2013

In like manner, the Colorado is the 14th most afflicted among the world's most populated river basins, and the 6th most strained by area. This translates into more than 30 million Americans relying on the river, which is overdrawn by the time it touches the Pacific Ocean (Gassert et al, 2013).

In another work titled *Global threats to human water security and river biodiversity*, published in the journal *Nature*, Vörösmarty et al, 2010 articulate their findings, which are illustrated in figure 5.16:

> "We find that nearly 80 percent (4.8 billion) of the world's population (for 2000) lives in areas where either incident human water security or biodiversity threat exceeds the 75th percentile. Regions of intensive agriculture and dense settlement show high incident threat, as exemplified by much of the United States, virtually all of Europe (excluding Scandinavia and northern Russia), and large portions of central Asia, the Middle East, the Indian subcontinent and eastern China. Smaller contiguous areas of high incident threat appear in central Mexico, Cuba, North Africa, Nigeria, South Africa, Korea and Japan."

Surface water and groundwater, replenished by rainfall, each provide half of freshwater supply in the world. Groundwater resources are renewed very slowly, usually at about 1 percent per year (Pimentel et al, 1994). However, people's demand for water has increased gradually with world population and acceleration of the industrialization process (Cheng, Fang & Wu, 2017).

We must realize that both human population and water resources are scattered unevenly across the globe. In many areas, densely populated regions do not overlap with those that are water-rich (Kummu, Ward, Moel & Olli, 2010). Due to the rapid augmentation of the human populace and water use per capita in many areas of the world, around one-third of the world's population currently lives under physical water scarcity (e.g. Vörösmarty, Green, Salisbury & Lammers, 2000; Alcamo et al, 2003, Oki & Kanae 2006).

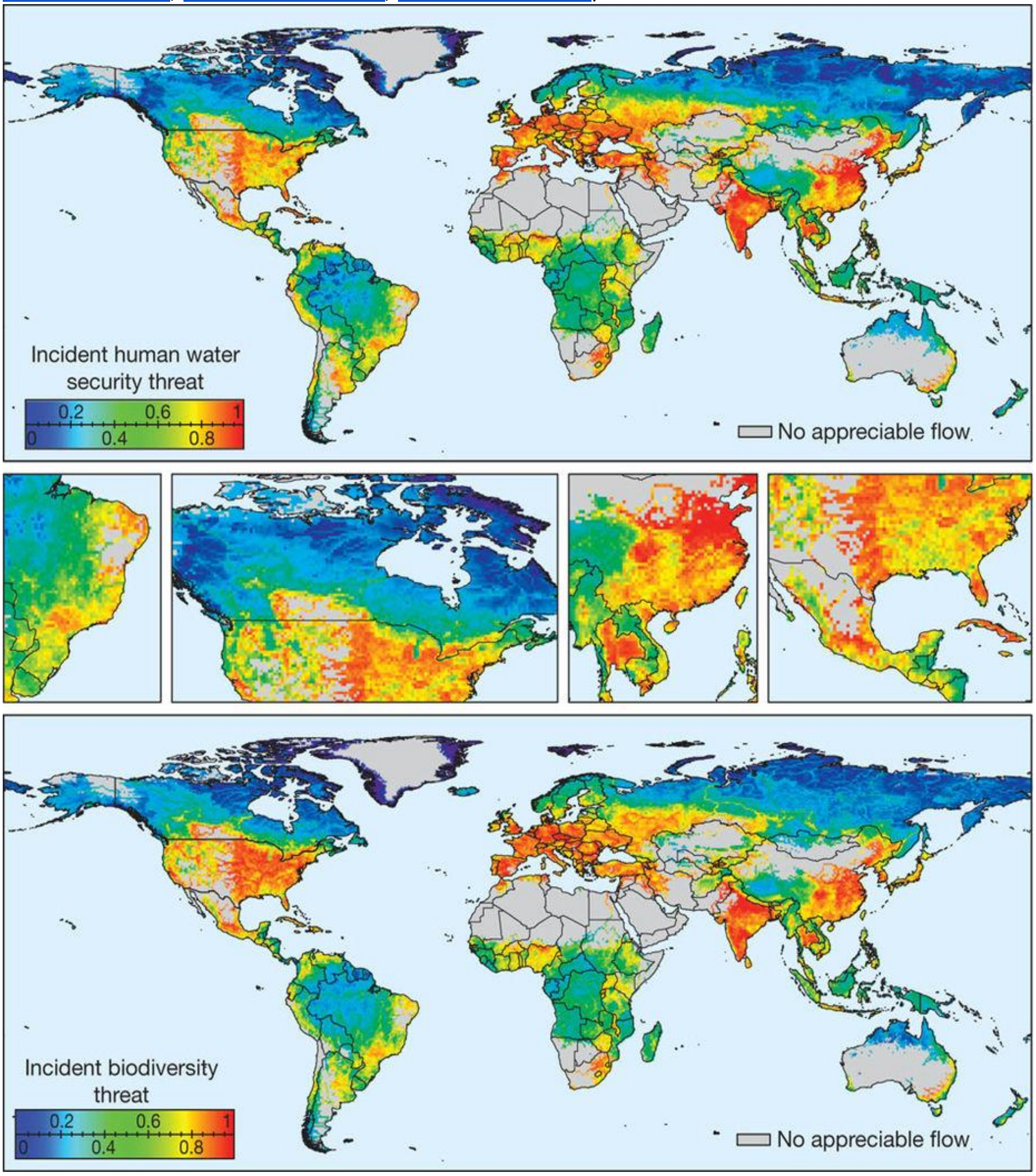


Figure 5.16: Global geography of incident threat to human water security and biodiversity. The maps demonstrate pandemic impacts on both human water security and biodiversity and are highly coherent, although not identical (biodiversity threat = 0.964 × human water security threat + 0.018; r = 0.97, P < 0.001). Spatial correlations among input drivers (stressors) varied, but were generally moderate (mean $|r|$ = 0.34; n = 253 comparisons). Regional maps exemplify main classes of human water security threat. Spatial patterns proved robust in a variety of sensitivity tests. Threat indices are relative and normalized over discharging landmass. Retrieved from Vörösmarty et al, 2010

With the UN's projections that almost half the world's population will be living in areas of high water stress by 2030, which will result in the potential displacement of as many as 700 million people (United Nations Convention to Combat Desertification, 2014). In like manner, some of the most water-stressed countries are also undergoing very high population growth rates (United Nations Development Programme, 2006), while the UN estimates that nearly 80 percent of the jobs that make up the global workforce rely on access to a sufficient water supply (United Nations World Water Assessment Programme, 2016).

By the same token, about 40 percent of people in the world live in regions that compete for freshwater supplies (Pimentel & Giampietro, 1994), and in all likelihood, that situation is set to escalate due to climatic changes that provoke and aggravate armed conflict, particularly in Africa, over the sparse resource (Kuhlemann, 2018).

A CIA (2001) report conjectures that by 2025, 48 countries containing 3 billion people, will face freshwater deficiency, and 20 countries of the Near East and North Africa have the worst forecasts:

> "In those areas, water supplies could run out by 2100 if per capita consumption and excessive use in agriculture are not controlled […] water availability is likely to become one of the most pressing and contentious resource issues of this century […] This situation will only be exacerbated by population growth."

It might be particularly elucidative to provide several examples of water dearth scenarios, in different regions of the world, and how human overpopulation is catalyzing and propelling this privation of an essential resource for life to be able to prosper and thrive.

India, for example, is undergoing its worst water crisis, with roughly 200,000 Indians dying each year due to lack of access to water sources, and the demand is anticipated to be double the supply (EcoWatch, 2018) by 2030, outstripping millions of their livelihoods, and provoking scarcity of hundreds of millions of people, and that shortage is foreseen to shave around 6 percent of the gross domestic product of the country, a report from a think tank chaired by Prime Minister Narendra Modi, attested (Menon, 2018).

The report states that:

> "Critical groundwater resources that account for 40 percent of India's water supply are being depleted at unsustainable rates."

In consonance with government data (Balyan, 2017), the average annual per capita water availability dwindled 15 percent between 2001 and 2011. It is foreseen to decrease another 13 percent by 2025 and 15 percent again by 2050, which means that, in another 30 years each Indian household will have roughly 1.1 million liters of water per year, down from 1.8 million liters in 2011. (A country is branded as water scarce when its water availability drops below 1 million liters per capita per year) (Ayyar, 2018).

While supplementing the information that there are currently seven major ongoing disputes over water resources, engendered by increasing droughts, disputes between states are increasing, as well as with neighbours China, Pakistan and Bangladesh (Saberin, 2018). Furthermore, and according to the reporting from the global advocacy group WaterAid, there isn't a single city in India that can accommodate its citizens. As a matter of fact, the report puts India at the top of its list of countries with the worst access to clean water close to home - 163 million people in the country living in this situation (Ayyar, 2018).

Additionally, another culprit pointed out is the country's dependence on agriculture, which structures a substantial part of its economy and employs around 800 million people. That is to say, that agricultural practices are crippling water management over and above (Ayyar, 2018). Similarly, rampant pollution has converted thousands of water sources into bodies of filth and disease (caused by the millions of individuals who do not have sanitation, since the government can't keep up with the demand required. The theme of pollution will be examined in the upcoming Volume II).

Moreover, the report fills out its recommendations with a push for immediate sustainable management of water resources (Menon, 2018), unfortunately media sources reporting on this, or the report itself (Niti Aayog, 2018) make no mention of India's extensive human overpopulation, or include in the solutions a need to immediately focus on contracting the size of India's immense human population, to avoid human misery and suffering in the coming years. Instead the focus is shifted to, as it is certainly partly to blame, unwise behaviors towards water consumption, management and climate change.

To illustrate this, Mridula Ramesh, founder of the Sundaram Climate Institute, told *Al-Jazeera* (Saberin, 2018):

> "Part of [the crisis] is because of the rising temperature, and the changing rainfall patterns that come with the changing climate. Part of it is because of unwise choices we have made in managing our waste and water."

Surprisingly, *TIME* magazine (2018) mentions the ghastly forecast of India's growing population:

> "The news doesn't get better when you consider that India's burgeoning population could grow to 1.8 billion, if current fertility rates continue (Chamie & Mirkin, 2017)..."

But then again, in the piece's section "What's the solution?" there is absolutely no mention whatsoever of the need for India to focus on decreasing its population. Focusing on suggesting the implementation of desalination plants, centralized water management systems, or changing ways of cultivating crops (Ayyar, 2017) becomes a huge distraction if the population keeps on increasing by the hundreds of millions. Either *this* (the near nonexistence of the incorporation of the population factor by the media in its 'solutions') is intellectual dishonesty or passive admission of the human suffering that it will perpetuate. I would exhort the media to revamp their stance on this.

If only India's government would follow the suggestions by Joseph Chamie and Barry Mirkin of Yale University (2017):

> "The government must emphasize family planning while improving public health and the status of girls and women - or be hard pressed to sustain high rates of economic growth and meet mounting aspiration of its billion-plus inhabitants."

By the same token, and even though humans are and will be severely affected by lack of water, they aren't the only lifeforms to be impaired by the depletion of water reserves. In India, for example, wild animals are straying into villages in search of water and cattle. The *Hindu* (Kuttor, 2018) reports:

> "Experts say the changes in the forest ecosystem, triggered by climate change and excessive human intervention, have led to the straying of wild animals into human habitations where they could easily pick cattle and dog. Rapid increase in wildlife population and pressure on forest fringes due to cultivation have also contributed to the situation."

At the root of this wandering is:

> "[A growing number of]... quarries along the forest borders has been leading to drastic changes in the forest ecosystem, pushing wild animals out of their habitats. Unscrupulous granite quarrying has depleted the groundwater table, drying up waterbodies in the forests."

In either case, it is crucial and vital to stop for a second and analise the particular case of India before moving forward to other examples of water scarcity propelled by population expansion.

It must be remembered that India will overthrow China as the most populous country around 2024, and as Joseph Chamie and Barry Mirkin from Yale University (2017) denote:

> "India will likely hold that rank throughout the 21st century. Its population is 1.34 billion (2017) nearly a fourfold increase since independence 70 years ago. China's population, at 1.41 billion, roughly doubled over the same period. The pace of India's population growth, now at 15 million per year, is the world's largest."

The real conundrum of India, as with many other countries that are still maintaining elevated rates of population growth is that the long-term growth of the nation is largely dependent on its fertility rates, which casts an immeasurable doubt upon the reliability of its forecasts. As an illustration, the UN's population projections denote a range of possible scenarios for India. For example, under a constant fertility rate of 2.3 births per woman, its population will expand to 1.8 billion by 2050 and 2.5 billion by 2100. Moreover, even under an instant-replacement fertility rate of 2.1, India's population would still reach 1.9 billion by the end of the century. It must remembered that the frequently cited UN medium projection presupposes that Indian fertility will contract to below replacement rate by 2035 (that is the general belief that was promulgated by the late Hans Rosling, that the demographic transition revolution would take place all over the world, unfortunately that may not materialize, leaving Rosling's idealist optimism unfounded (Population Matters, 2018a) and remain at 1.8 per woman in the coming decades (Chamie & Mirkin, 2017). More on the demographic transition revolution and Hans Rosling in the segment Demographic Transition Theory.

In reality, while India's fertility has declined to about half the level of the late 1980s, that course, may have run its course, since, in the past eight years, contraceptive use decreased by roughly 35 percent, as voluntary termination of pregnancies and use of emergency pills doubled (Paul, 2017). Significantly, confidence in oral birth control pills, condoms and vasectomies contracted by 30, 52 and 73 percent, respectively (Chamie & Mirkin, 2017). These and other reasons (Chamie and Mirkin, 2017 do an excellent job explaining the economics, health, demographics and other conditions affecting India) might lead to India's population increasing even more than expected, creating almost surely, conditions for human misery and hardship. With attention to such a reality, Dave Foreman and Laura Carroll (2015) ask with austere and unadorned honesty and fear:

> "What will those millions do when the water and grain run out? What will they do to the land and to wildlife living nearby? Where will they go? How much weight will there be on the Indian government to "open" land now in national parks and tiger havens?
>
> When deadly hunger hits that land, there will be twice as many empty bellies as before, making more wretchedness and hunger down the trails, unless that aid comes with hard-nosed, unyielding birth-control goals. Without an end to population growth in India, the homes of what wild animals are left will also be ransacked."

To prevent that from happening, and an aggravation of not just water scarcity but all of the problems that become increasingly difficult with human overpopulation, India and the international community must come to terms with a stabilization and eventual reduction of their nation's populace.

Now, let us examine other events of water dearth impelled by overpopulated countries.

Sana, capital of Yemen and a fast-growing city of more than two million people, is literally running out of water with wells that are thirteen hundred feet deep presenting hard-to-ignore signs of depletion (Brown, 2012).

In this "race to the bottom" in the Sana's valley, oil-drilling equipment is being wielded to dig ever deeper wells and as a result some are now over half a mile deep (UNPD, 2011; Laessing, 2010; AQUASTAT, 2009a). The situation is austere due to the deadlock of importing water into the mountain valley from other provinces that would generate tribal warfare. Desalting sea water on the coast would be expensive on the grounds of the cost of the process itself, the distance the water would have to be pumped, and the city's altitude of seven thousand feet. Given these points, and Yemen's population of 28.3 million (UNDESA, 2017) with prospects of increasing to close to 50 million by 2050, multiplying an already strenuous scenario of paucity and misery, the end result may be Sana soon becoming a ghost city (Lyon, 2009).

Similarly, Quetta, in Pakistan, which was originally outlined for fifty thousand people, now has a population exceeding one million (Brown, 2012). According to the 6th Population Census from Pakistan's Bureau of Statistics, Quetta's district has increased in population by 143 percent during the past 19 years in 1998, Quetta's Division population was 1.72 or 26 percent. Within the Quetta Division, the Quetta District population has risen by 194 percent to 2.275 million - an annual growth rate of 5.83 percent, which is also the highest recorded in any district of Pakistan (Rana, 2017).

On balance, all those people of whom rely on two thousand wells pumping water from what is considered to be a fossil aquifer will soon be met with privation and quite possibly widespread human despair, due 'carrying capacity' restrictions, that will take the form of water checks (Brown, 2012). In the others of one study appraising its water prospect, Quetta might become "a dead city" (Integrated Regional Information Networks, 2002).

Two other semiarid Middle Eastern countries that are undergoing hardship from water shortfall are Syria and Iraq. Both are beginning to reap the sequela of overpumping their aquifers, namely irrigation wells being drained completely (AQUASTAT, 2009b; 2009c). A UN report deduces that more than a hundred thousand people in northern Iraq have been uprooted by virtue of water shortages. Likewise, in Syria, these trends have forced the abandonment of 160 villages. Hundreds of thousands of farmers and herders have left the land and pitched tents on the outskirts of cities, hoping to find work (Brown & Crawford, 2009; De Schutter, 2010; Lightfoot, 2009). As it is discussed further in this chapter, these were all precursors to the war that has torn Syria in the last few years.

Lester Brown writes in his book *World on the Edge: How to Prevent Environmental and Economic Collapse* (2012) how a growing human population, in water-stressed countries, is bounded to lead to the massive Diasporas:

> "People who will be forced to leave their homes are those in places where water tables are falling. With the vast majority of the three billion people projected to be added to the world by 2050 being born in such countries, water refugees are likely to become commonplace. They will be most common in arid and semiarid regions where populations are outgrowing the water supply and sinking into hydrological poverty. Villages in north western India are being abandoned as aquifers are depleted and people can no longer find water. Millions of villagers in northern and western China and in northern Mexico may have to move because of a lack of water (Shah, Molden, Sakthivadivel & Seckler, 2000."

Cape Town, South Africa's second-largest city, is facing its worst drought in a century, and now its citizens are forced to ration every use of water possible. After three years of drought, towns across eastern and southern Africa have faced hindrances, and some already have had to import water. None, though, are as large as Cape Town. In this city of 4 million, people will have to line up in the streets at just 200 water stations. The police and army enforced a limit of 6.6 gallons per person and adopted procedures to control crowds. Some experts believe evacuations will be necessary in the future (Dixon, 2018).

To be clear, this predicament boils down to an acute population growth - Cape Town had 618,000 inhabitants in 1950 and close to 3.8 billion in 2018, with an average growth per year between 2 and 3 percent (World Population Review, 2018) as well as a failure to plan alternative water sources to enlarge the reservoirs, with some rapidly dwindling to arid sandy stretches (Dixon, 2018).

In *Cape Town's drought: don't blame climate change* Mike Muller (2018) argues in the journal *Nature* that people, politics and poor planning are behind most urban water shortages. Although Muller doesn't specifically mention human population growth, he does euphemistically state:

> "Urban growth means that many more places will face similar challenges as they compete with surrounding regions for water."

Turton, of the Center for Environmental Management said that, "politicians have been trying to deflect the blame from themselves. None of that energy has been focused on what we going to do about it." He adjoined that city authorities did not perceive the repercussion of rapid population growth on water demand. "The city didn't understand the depth of the crisis," he affirmed. "They incorrectly assumed that this is a short-term drought and the problem will go away when the drought is over," Turton concluded (Dixon, 2018).

While Cape Town is the first major city to face such a water crisis, it is highly unlikely that it will be the last. Jasper Knight, a geographer and climate expert at the University of Witwatersrand in Johannesburg had this to say (McKenzie & Swails, 2018):

> "The situation in Cape Town is almost a foretaste of what is likely to come in cities worldwide."

Madagascar is another case example. This island nation off the southeastern coast of Africa has seen a horrid and gruesome cycle set in. Rains arrive late and leave early, in this African nation that is considered to be the most susceptible to climate change, according to FAO (2016b). The United Nations Organization reveals that droughts, earthquakes, epidemics, floods, cyclones and extreme temperatures have engendered severe damage on agriculture in recent decades (Dixon, 2017).

Robyn Dixon writes for the *Los Angeles Times* (2017) exposing that the worst drought in 35 years lowered harvests by 95 percent less than in 2015 and that:

> "Nearly 850,000 people in Madagascar desperately need food aid. But the U.N.'s humanitarian appeal for the country is only 29 percent funded because of emergencies elsewhere."

As a result of lack of water, that have led to repeated crop failures, people begin to sell firewood to survive, grabbing axes and hacking the trees that are the lungs of their moribund nation - aggravating the crisis (Dixon, 2017).

But once again, is there any connection to population in this feebled country? According to the Fragile States Index (2018), Madagascar is in the 56th position of 178 countries. Although, when evaluating the demographic pressure indicator, Madagascar reaches a 9.0 in the scale of 1-10. As reported by the United Nations Department of Economic and Social Affairs Population Division (2017), Madagascar's population was 25.5 million in 2017, and is set to almost double in 30 years, to 48 million by 2050.

The most remarkable thing in all of this is that even journalists on the field reporting on this torturous plight do not identify the link between the population factor and the ecological reality. Even though in Madagascar's case, climate change is substantially responsible, and it should go without saying that the country is not among the greatest polluters in the world, the population explosion is not helping to fend off this adversity.

Even in his piece on Madagascar's crisis, Dixon cites a few examples of mothers telling their stories:

> "Tonelie, 42, has six of her eight children still living at home and no husband [...] she took her children out of school because there was no money, so they must help in the grinding job of survival."

> "Jocelyn Rasoanakambana, 29, puts her six children to sleep without water on the days she has no money."

He asserts that:

> "Humanitarian agencies such as the World Food Program, UNICEF, Catholic Relief Services and USAID have tried to help, providing cash grants, food, seeds, as well as water and health projects. But their efforts haven't been enough."

And concludes that the problem:

> "Underlying the crisis is entrenched, grinding poverty, corruption and bad governance."

But of course, no mention whatsoever of the total fertility rate that has averaged 5 in the last 2 decades, and is now at 4.03 (Index Mundi, 2018). All in all, around 90 percent of Madagascar's 25.5 million people subsist on less than $2 a day and 80 percent survive on less than a dollar, according to UNICEF. Due to this enlarged and foreseen to expand population, chronic malnutrition is pervasive with nearly half of the children being stunted, which is the fourth highest rate in the world (Dixon, 2017).

Finally, and not to get under the impression that water shortages are a problem of the developing world, or for that matter, that the developed world doesn't have a population problem, the next example comes from one of the epitomes of civilizational maturation, California.

After thousands of dams had been built through the 1960s, people began to realize the colossal inimical repercussions on rivers, fish and whole landscapes, and a movement grew to protect the best rivers that remained. The demand for water was still massive and dilating with no end in sight, a strategy was pursued to make improved use of the water already had. These efficiency exercises paid off, and per capita use of water diminished by 20 percent in the United States between 1980 and 1995 (Palmer, 2004).

In California, per capita use was halved during a forty-year period. But there's a catch: population growth has demonstrated that the savings were almost inconsequential (Palmer, 2012). In the same 1980-1995 period, the national population rose by 16 percent, and in the previous forty years the population almost doubled (State of California Department of Finance, 2011).

California is the most populous state in the country. In 1900 it had 2 million residents. In 2050 the foreseen population of this state is 50 million. Satellite measurements show that aquifers of the Sacramento and San Joaquin River basins are being overdrafted (pumping higher than the rate of recharge) by 12,000,000 acre-feet of water per year between the years 2011 and 2014 (Shragg, 2015). Ultimately, these water shortages have raised in number and length, while requiring unpopular adjustments by farmers and consumers, albeit still inducing ecosystem insolvency from the Sacramento Delta to Florida's Apalachicola Bay (Palmer, 2012).

Then again, much of the current use could likely be cut in half again (Gleick, Cooley & Groves, 2005), nevertheless, by the time that is brought about, the population will in all probability, have doubled again. With the numbers of people overtaking the volumes of water amassed, it will all end up where it started, except with less capacity for further conservation and with a lot more people waiting in line for water. The point here is that many people desired to do something virtuous and noble in conserving water, something of lasting value. But nothing can truly be protected if the source of the threat continues to grow (Palmer, 2012).

Given these points, asserting that the U.S. is exempt from overpopulation on the grounds that it is a modern country, with below replacement fertility rates is a statement of denial and ignorance (Shragg, 2015). In reality, while world population has its fair share of recognition, growth in the United States is often overlooked and given the cold-shoulder, under the parable that population is solely a problem of developing countries, even though America's population growth rate is one of the highest among industrialized nations as well as many developing countries, including Jamaica, El Salvador, Sri Lanka, and Thailand (CIA, 2018). And most important, in a planetary perspective, growth in the United States is far more important than in other countries, due to the sheer asymmetry in the expenditure of Earth's resources, and that includes water (Palmer, 2012).

It is indisputable that saline lakes across the globe are shrinking (Messager, Lehner, Grill, Nedeva & Schmitt, 2016; Millennium Ecosystem Assessment, 2005). The upsurge in water use by humans especially for agricultural irrigation (Williams, 1996), is a substantial factor in lake insufficiency. For example, agricultural water development in the Aral Sea watershed (Millennium Ecosystem Assessment, 2005) has pauperized lake area by 74 percent and volume by 90 percent (Micklin, 2007). Lake Urmia in Iran has gone through a coinciding fate (Stone, 2015) as have many saline lakes on all continents except Antarctica (figure 5.17).

The evanescence of saline lakes is not a new phenomenon - the oldest known direct human action that resulted in devitalizing a saline lakes was, presumptively, in the Tarim Basin, in China, causing the collapse of the Loulon Kingdom in 645 CE (Mischke et al, 2017) - and researchers have recognized the alarming rate of deterioration of many of these vital ecosystems (Williams, 1993; Gross, 2017; Jellison, Williams, Timms, Alocer & Aladin, 2008). To demonstrate, Owens Lake was completely desiccated by 1940 after the city of Los Angeles redirected streams for agricultural and urban use (Wurtsbaugh et al, 2017).

Due to an ever-expanding requirement of water, California's Salton Sea has withstood a recent and precipitous recession of over 7 m since 2000 (Case et al, 2013). Similarly, water deflections from the Aral Sea heightened salinity above levels tolerated by fish, prompting a cataclysm of the commercial fishery that had once harvested 40,000 metric tons annually and sustained 60,000 jobs (Micklin & Aladin, 2008). Of course, Soviet Union water developers acknowledged that this fishery would be forfeited, but contended that this loss would be more than offset by an economic gain in agricultural production. Obviously, they did not recognize the considerable environmental costs that ensued (Micklin, 1991).

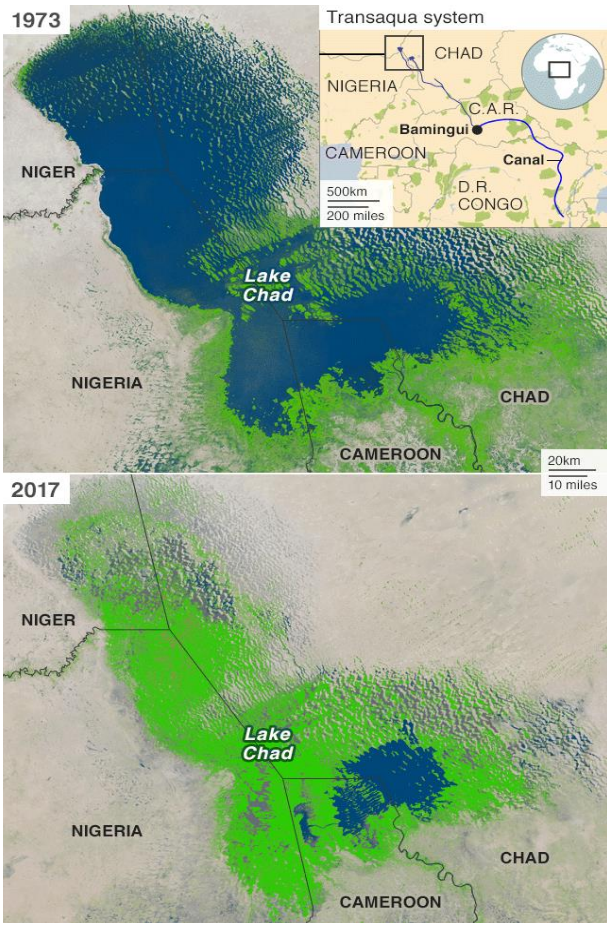
Figure 5.17: Some of the world's salt lakes that have been impaired by water diversions and/or climate change. Larger/blue symbols indicate lakes formerly larger than 250 km 2. Retrieved from Wurtsbaugh et al, 2017.

Since 1847, the Great Salt Lake, in the state of Utah in the United States (figure 5.17), has regularly been diminishing, reaching its lowest recorded level in 2016. In 2017, the lake was 3.6 meters below its 1847 level and just half its original volume. Heretofore, many researchers claimed the decline - here and in other saltwater lakes - was evoked by wet and dry cycles associated to climate change, Wayne Wurtsbaugh, a limnologist at Utah State University in Logan recounts (Derouin, 2017).

In consonance with more than 170 years of water records and a testing of how much water flows in and out of Utah's Great Salt Lake, consumption of freshwater has been found guilty of the contraction of the lake - and of similar lakes around the world (Derouin, 2017).

To investigate that assumption, Wurtsbaugh and his colleagues recreated the climate around the Great Salt Lake for 170 years, based on historical precipitation, stream level records, and tree ring data. The records demonstrated that precipitation and temperature patterns had barely oscillated during the period, meaning that the volume of water flowing into the lake from nearby streams was, to all appearances, the same in 2017 as it was in 1847. Afterwards, the team did hydrological accounting, creating what's known as a water balance. They examined, in contrast, the amount of water flowing into the lake from rivers, precipitation, and groundwater to the amount evaporating out of the lake; if the lake remained the same size, the water in and out should balance. It didn't (Derouin, 2017).

Every year, people that have taken up residence in the region (which includes rapidly growing Salt Lake City) redirect 3.3 trillion liters of water, not from the lake itself, but from the handful of streams sustaining it. With climate staying somewhat invariable and reliable, the team settled that humans are setting off the decline by exhausting stream water before it restores the lake, they reported in *Nature Geoscience* (Wurtsbaugh et al, 2017).



In spite of some of the water rebounding to the lake (for example, by soaking into the ground for irrigation), Wurtsbaugh proclaims the new prognosis indicates that the overall amount diminished 39 percent from 2003 to 2012. This, in addition to long-term stream records, implies that climate change isn't instrumental in the observed shrinkage (Derouin, 2017). Coupled with these examples, Lake Chad (figure 5.18/5.19) - a source of water to millions of people in West Africa - has withered by nine-tenths due to a combination of climatic change, population growth and intensive demand for irrigation, a *BBC News* reports (Ross, 2018).

With the desert encroaching further every year, it is becoming progressively laborious and arduous for people to acquire subsistence through agriculture, fishing and livestock farming, with the UN affirming that 10.7 million people in the Lake Chad basin need humanitarian relief to survive (Ross, 2018).

Figures 5.18 and 5.19: Lake Chad comparison between 1973 and 2017. Source NASA and Transaqua project. Retrieved from Ross, 2018

The decline of the lake has also been linked to the rise of violent extremism - a number of factors including poor governance also played their part - as it became a perfect recruiting ground for the Islamist militants. The offer of a little cash and the promise of some training and a gun, sways many to join (Ross, 2018).

To overcome the diminution of Lake Chad, and instead of dealing with the root cause, an uncontrolled population growth by some of the countries with the highest fertility rates and annual growth in the world (Nigeria with a population of over 195 million and an annual growth of 2.61 percent; Niger, population 22 million, annual growth 3.88 percent; Chad, 15 million and yearly change of 3.04 percent and Cameroon with close to 25 million and a yearly change of 2.60 percent (Worldometers, 2018)], the government of Nigeria plans to divert the Congo river, 2,400 km away, to restore some of Lake Chad's former glory (Ross, 2018).

Nigeria's population alone is expected to surpass the United States and become the 3rd most populous country in the world in 2050 with 400 million citizens. That number is projected to double by 2100. No matter how many rivers one diverts, there can be no solid sustainability forecast if the population is not stabilized and begins to diminish.

All things considered, as dry lakebeds are exposed, salts and sediments can go airborne, causing respiratory and cardiovascular problems, says Maura Hahnenberger, an atmospheric scientist at Salt Lake Community College. She argues that as the Great Salt Lake - and its counterparts - degenerate, "the [pollution] source is very close to the population centers" (Derouin, 2017).

But humans aren't the only creatures impaired by the contraction of these water systems. Saltwater lakes, which account for roughly a quarter of such water bodies around the world (Derouin, 2017), are crucial natural assets with substantial aesthetic, cultural, economic, recreational, scientific, conservation and ecological values (Williams, 2002).

There is a plethora of ecological, sociological and economic benefits of saline lakes, since these can accumulate and recycle nutrients (Blomqvist, Gunnars & Elmgren, 2004) more efficiently than freshwater systems, which translates in a higher amount of quantities of food production for fish, as in the case example of the hyposaline Aral Sea (Wurtsbaugh et al, 2017). These unique lakes also produce unparalleled ecosystems for plants and animals such as the imperiled peregrine falcon. Moreover, they give shelter to migratory shorebirds and waterfowl, many of which bulk up on brine shrimp (*Artemia* spp.) and brine flies (*Ephedra* spp.) (Herbst, 1988; Roberts, 2013) before and during their extended journeys (Wurtsbaugh et al, 2017).

When saline lakes are desiccated, the measure of habitat contracts and salinities can climb beyond the tolerance of the invertebrates that bank on their stability to thrive and survive, limiting both food and habitat for birds (Wurtsbaugh et al, 2017).

The world is facing difficult water management confrontations with an inflating human population and a changing climate. Thereupon, natural variability and climate change - when inaccurately cited as justifications for water stress - produce no basis for a solution and can result in inaction (Wurtsbaugh et al, 2017).

There is a propensity to appeal to 'climate change' as the offender for the decrepitude of saline lakes - warmer temperatures, increased evaporation and altered precipitation do indeed represent a widespread long-term complication for saline lake continuity, with runoff in Great Salt Lake estimated to decline by approximately 11-20 percent by mid-twenty-first century (Bardsley, 2012) and elevated temperatures increasing lake evaporation (Wurtsbaugh et al, 2017). Other saline lakes may end up collecting more water from upsurging precipitation and glacial melting, with the huge Issyk-Kul Lake in Kyrgyzstan and Mar Chiquita in Argentina to sustain these effects (Salamat, Abuduwaili & Shaidyldaeva, 2015; Troin et al, 2016).

On the whole, Wurtsbaugh declares that the key to preserving saltwater lakes is to strike a balance between human consumption and conservation. The team concludes that inflows to the Great Salt Lake will need to grow by 24 to 29 percent to perpetuate its health and stability. Wurtsbaugh adjoins that with the population of Utah set to double by 2050, long-term conservation and planning is crucial (Derouin, 2017).

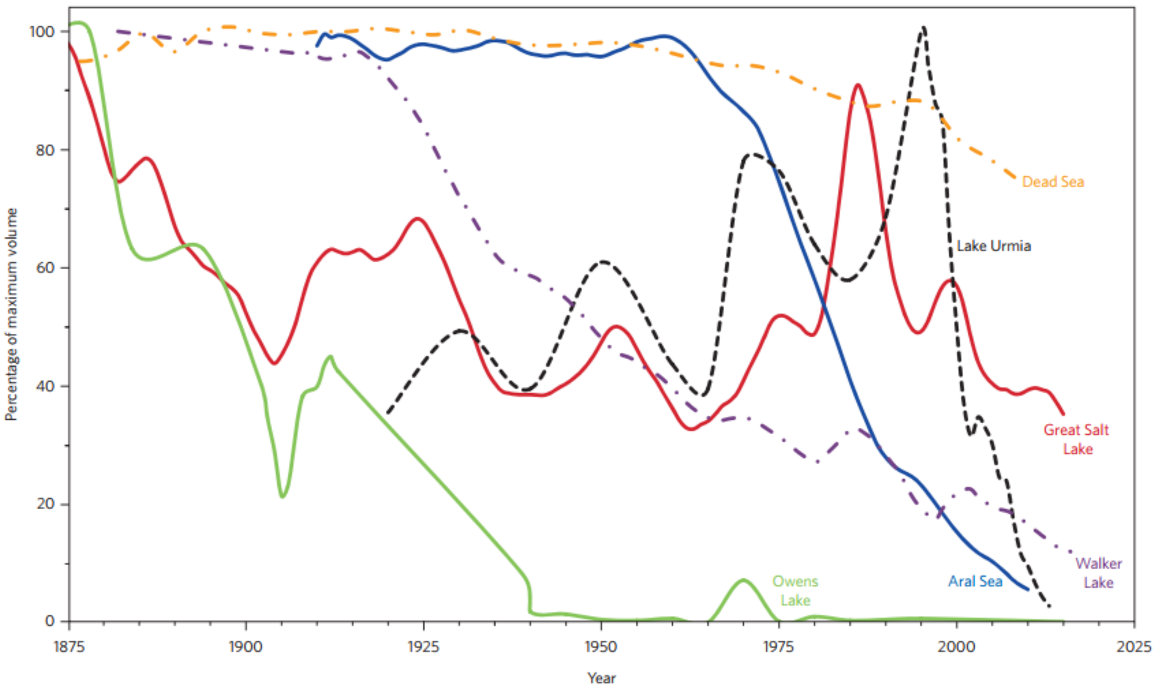


Figure 5.20: Major decreases in the water volumes of important salines lakes over the past 140 years (five-year running averages). Note: The relatively small fractional decline in the volume of the Dead Sea can be explained by its great depth; the elevation of the Dead Sea has been reduced by over 28m during this time period and impacts have been pervasive (Deatrick, 2016). Recently, Lake Urmia has declined most precipitously from a combination of agricultural water and development and drought. Retrieved from Wurtsbaugh et al, 2017.

In contrast, Iran's Lake Urmia will need to renew current lake inflows by approximately 83 percent to attain the lake elevation and salinity required to recover brine shrimp and birds and to attenuate dust impacts to agriculture and the human population. Regardless of the relative influence of climate change and water consumption, the primary conservation response to sustain lake levels is to nurture and repair lake inflows, which must be accomplished through reductions in consumption (Wurtsbaugh et al, 2017).

Given heightened trends in species elimination, human population, climate change, water use and development constraints (Steffen, Crutzen & McNeill, 2007), freshwater systems will continue to be assaulted well into the future.

Without major policy and financial assurances, palpable contrasts in human water security will continue to divorce rich from poor (Vörösmarty et al, 2010). But in reality, the commitments made in the Millennium Development Goals are severely off-pace, [(e.g. basic sanitation services (World Health Organization & UNICEF, 2010)] maybe it has something to do with the supplementing of roughly 83 million humans to the planet every year, that makes the objective so herculean to attain?

Be that as it may, the compromise to safeguard the biological diversity that depends on the freshwater systems that humanity is progressively monopolizing is even more appalling. International goals for its protection lag well behind what was anticipated and global investments are crudely enumerated and in all likelihood to be orders of magnitude lower than those for human water security (Brooks et al, 2006; Butchart et al, 2010; Vörösmarty et al, 2010). One just needs to ponder for a second on what were the more austere findings of the *Living Planet Index* (WWF, 2018a), where the report defends that the habitats undergoing the greatest hardship and transformation are rivers and lakes, where wildlife populations have collapsed by 83 percent, due to the immense thirst of agriculture and substantial number of dams (all side effects of mounting human populations that demand more from their environments) (Carrington, 2018f).

In the face of aquifer depletion, changes in precipitation patterns, desertification advancement, population growth and climate change, water and food security will rely upon water-saving technologies and improved management and governance (Rodell et al, 2018). But as it was previously stated in this segment, diverting the responsibility to climate-change and neglecting human answerability is irresponsible and may lead to inaction. The same is true if we rely too much on the 'techno-fix' narrative and ignore the most important solution, which is the minimization and stability of fertility rates, mostly in developing countries.

In essence, water insufficiency is driven first and foremost by population growth and economic growth and is set to be aggravated by climate change. The expansion of the human populace reinforces and exacerbates every one of the risks described throughout this chapter while swelling the number of people exposed to them (Kuhlemann, 2018). This leaves us in a dire condition and in an article published in *Quartz* titled *Dams and reservoirs can't save us. This is the new future of water infrastructure* (2018), author Zoë Schlanger describes in a nutshell, our current and future predicament:

> "In the recent past, humans thought of freshwater as a constant. Sometimes there was drought, and sometimes there was flood, but water levels always returned to normal. So we built dams and reservoirs […] on the assumption that the dry times would end and the basins would refill. But these gigantic objects are becoming dinossaurs in a new climate age, characterized by growing human demand for freshwater and worsening, lengthening droughts.
>
> […] That's because water, especially in dry places, is finite. Rivers and stream and lakes usually originate as snowmelt or rainfall, and in dry parts of the world, those sources are in decline as droughts strike harder and more regularly. Meanwhile, **human populations are growing, and using freshwater faster than it can be replenished. Potable water is a rare commodity and growing more precious by the decade (**bold added)."

On Dangerous Grounds

- Land Degradation, an Unpredictable Climate and Food Security -

"A nation that destroys its soils destroys itself."

- Franklin D. Roosevelt

"We know that if we don't confront climate change, there will be no hope of ending poverty or boosting shared prosperity. Furthermore, the longer we delay, the higher the cost will be to do the right thing for our planet and our children."

- Jim Yong Kim, World Bank Group President, 2014

-

- **"Man begets, but land does not beget."**

- Cecil Rhodes (1853-1902)

If at this point the reader is still on the fence, with a modest amount of skepticism, regarding the magnitude of the ecological crisis this world is experiencing, this segment will be dedicated to the reduced productivity and ecological decadence of the soils, concocted by the synergies of population growth and climate change that is sure to leave a mark even in the most agnostic of readers, since, first of all, more than 3.2 billion people are touched by land degradation and up to 143 million could be forced to relinquish their homes and lands to circumvent water scarcity and falling crop productivity, propelled by climatic changes (Malek, 2018).

In *Soil Degradation, Land Scarcity and Food Security: Reviewing a Complex Challenge*, Tiziano Gomiero (2016) writes:

> "Soil health, along with water supply, is the valuable resource for humans, as human life depends on the soil's generosity. Soil degradation, therefore, poses a threat to food security, as it reduces yield, forces farmers to use more inputs, and may eventually lead to soil abandonment."

In a report by the United Nations Convention to Combat Desertification (UNCCD), titled *Land Degradation Neutrality Country Profiles* (2018), Managing Director Juan Carlos Mendoza had the following to say:

> "Healthy land is the primary asset that supports livelihoods around the globe - from food to jobs and decent incomes. Today we face a crisis of unseen proportions: 1.5 billion people - mainly in the world's most impoverished countries - are trapped on degrading agricultural land. This reality is fuelling extreme poverty, particularly in areas such as the Sahel and South Asia, where extreme and erratic weather events are on the rise due to the impacts of climate change."

These claims appear to be corroborated by research such as the one from Barbier and Hochard (2016), who, rhetorically ask in their title *Does Land Degradation Increase Poverty in Developing Countries?* Their conclusion clearly speaks to the symbiosis of population growth, land degradation and poverty, as they declare:

> "Our results suggest that the concentration of rural populations on degrading agricultural land (DAL) is a major obstacle to the poverty-reducing effect of overall income growth in developing countries [...] other influences on poverty may arise from increasing population density."

More recent still, a report entitled *World Atlas of Desertification* (WAD) by the Joint Research Centre at the European Commission (2018) established that every year an area half the size of the European Union is degraded by farming, city expansion and deforestation. As Robert Scholes, ecologist and co-chair of IPBES assessment asserted in an interview with *Inter Press Service* (IPS) (Yakupitiyage, 2018):

> "Land degradation is kind of at the overlap of many contemporary concerns [...] about one-third of current climate change relates to processes of land degradation - either deforestation or decrease in soil carbon for agriculture and other processes. Climate change has a reverse effect on land degradation - as the climate changes, the ecosystems that were in a particular place can no longer exist there [...] The current major driver of biodiversity loss is the loss of habitat, and loss of habitat is directly related to land degradation. **From the human side, these direct impacts come through the supply of food.**"

The Intergovernmental Panel for Climate Change (IPCC) has acknowledged population growth as a primary driver of climate change (Pachauri et al, 2015), along with economic growth. The IPCC alerts that climate change may have relentless repercussions on food security via elevated temperatures, precipitation changes, a heightened frequency of extreme weather events, the dissemination of new pests and ocean acidification (Kuhlemann, 2018). In light of this revelation, it is no wonder that FAO diagnoses population and economic expansion as the primary drivers of the continuous loss and degeneration of agricultural soils, which in turn is a major threat to food security (Montanarella et al, 2015).

Land degradation is a term that encapsulates such issues as wind and water erosion, soil pollution by urban waste or pesticide and the accumulation of mineral salts precipitated by improper irrigation (Encyclopedia of World Problems & Human Potential, 2018). As a result, land degradation can take many forms, but always encompasses a severe disruption of a healthy balance between five ecosystem functions, which are food production; fibre provision; microclimate regulation; water retention; and carbon storage (der Esch et al, 2017). The impacts of losing these functions might range from loss of soil fertility, destruction of species and biodiversity, soil erosion and the overboard nutrient runoff into lakes. Land degradation also has a menacing ripple effect on humans, such as malnutrition, disease, forced migration, cultural damage and rise in conflict and eventually war (El-Zein, 2018).

In consonance with the Encyclopedia of World Problems & Human Potential (2018) there are eleven principal menaces to land, which perfectly epitomize the pervasive impacts of an ever-expanding human population, which are:

> "Agriculture, vegetation clearing, feral animals, fire, forestry, grazing, mining, salinization, tourism, urbanization and weeds. The two most significant direct causes of land degradation are the conversion of native vegetation into crop and grazing lands and unsustainable land-management practices: deforestation; poor management of arable and pasture land, including over-use of fertilizers and pesticides, the clearance of steep slopes and marginal land for cultivation, inadequate soil conservation and overgrazing; poor management of watersheds and water resources; uncontrolled dumping of wastes; deposition of pollutants from the air; and poor-land-use planning. Other factors include the effects of climate change and loss of land to rapid urbanisation, infrastructure and mining."

The Encyclopedia is supplemented with:

> "The underlying driver of all these changes is rising per-capita demand from growing human populations for protein, fibre and bioenergy. This in turn leads to more demand for land and further encroachment into areas with marginal soils."

At present, more than 570 million farms are already occupying almost all the world's climates and soils (FAO, 2014) each utilizing vastly different agronomic methods that have distinctive repercussions on soil integrity (Poore & Nemecek, 2018). For example, the average farm size can range from 0.5 ha in Bangladesh to 3000 ha in Australia (FAO, 2014) or the average mineral fertilizer use can be 1 kg of nitrogen per ha in Uganda and 300 kg in China (FAOSTAT, 2018).

According to the IPBES report that has been cited throughout this work, worsening land degradation induced by human activities is sabotaging the wellbeing of two-fifths of humanity, engendering the extinction of populations and species and escalating the effects of anthropogenic climate change (IPBES, 2018). Reporting on this major assessment *The Hindu* (2018) writes:

> "Worsening land degradation caused by human activity is undermining the well-being of two fifths of humanity, driving species to extinction and intensifying climate change, as well as being a major contributor to mass human migration and increased conflict."

Coupled with this, the assessment estimates that 43 percent of world populations live in regions affected by land degradation. By 2050, the assessment projects, 4 billion people will be inhabiting drylands. These are defined by the United Nations as land with an "aridity ratio" of less than 0.65, which translates to a bigger loss of water than the amount it receives through precipitation. Such areas are highly vulnerable to food and water insecurity, especially in sub-Saharan Africa and the Middle East (El-Zein, 2018).

Biodiversity is also essential to a fertile and vigorous agriculture, and humans have no technology to supplant for most of the services catered by diverse species (wild biota) (Pimentel et al, 1994; Pimentel et al, 1997). Thus, there are ecological caps on the feasibility of transforming natural habitats into agricultural fields, and some experts have proposed protecting environmental quality by safeguarding about one-third of the terrestrial ecosystem as natural vegetation (Pimentel & Giampietro, 1994; Pimentel et al, 1994).

The Hindu adds that:

> "The dangers of land degradation, cost the equivalent of about 10 percent of the world's annual gross product in 2010 through the loss of biodiversity and ecosystem services. Rapid expansion and unsustainable management of croplands and grazing lands is the most extensive global direct driver of land degradation, causing significant loss of biodiversity and ecosystem services. By 2014, more than 1.5 billion hectares of natural ecosystems had been converted into croplands."

It would be misleading to ascertain that that land degradation is solely a problem for the developing world. Overall, land is broadly more degenerated in the developed countries - as evidenced, for example, by increased declines in soil organic carbon content (Lal, 2016), a measure of soil fertility.

Furthermore, a report from the European Environment Agency (EEA, 2017) highlights that urban development and intensive agricultural practices are partly responsible for the land degradation - exacerbated by elevated fragmentation on 30 percent of land area in Europe (Green News.ie, 2018).

Likewise, it is in sub-Saharan Africa, Asia and South and Central America that the quandary is amplifying most rapidly. But climate change, expressly where droughts and forest fires are becoming more frequent, can lead to grave land degradation, even in affluent places such as California, Australia and the Iberian Peninsula (El-Zein, 2018). As an illustration, according to the most recent data acquired by ISRO's Space Applications Centre (2016) in Ahmedabad, India, the document reveals that during the period of 2011-2013, 29.3 percent of the country was withstanding land degradation. Commenting on these results, S. Dharumarajan, a scientist at the Indian Council of Agricultural Research-National Bureau of Soil Survey and Land Use Planning points at the heart of the matter (Jain, 2018):

> “Overexploitation of natural resources is the main reason for increasing land degradation in India.”

The IPBES assessment also lays emphasis on the decline of availability of agricultural land, which is certain to affect food prices on a global scale. By 2050, the report states, humans will have transfigured almost every part of the planet, apart from uninhabitable stretches such as deserts, mountains, tundra and Polar Regions (El-Zein, 2018).

Owing to consumption of the earth’s natural reserves having doubled in the last 30 years, with a third of the planet’s land now severely degraded, the United Nations Convention to Combat Desertification (UNCCD) summarises in their *Global Land Outlook* (UNCCD, 2017) that, “Each year, we lose 15 billion trees and 24 billion tonnes of fertile soil,” while divulging that a substantial fraction of managed and natural ecosystems are degrading and at further risk from climate change and biodiversity depletion (Kamal, 2017). Together with this, the report postulates some key facts: from 1998 to 2013, roughly 20 percent of the Earth’s vegetated land surface demonstrated enduring languishing trends in productivity, discernible in 20 percent of cropland, 16 percent of forest land, 19 percent of grassland, and 27 per cent of rangeland (UNCCD, 2017).

Even though global cereal production has seen substantial improvements in crop yields (described in the segment *Lebensraum*), these climate change side-effects - temperature increases specifically - are predicted to develop into production recessions in certain areas. Moreover, many crops rely on limited and exact temperature ranges to generate good yields. In effect, an array of crops may go through reduced yields if temperatures go beyond 32ºC during the flowering stage (Hatfield & Prueger, 2015).

Under those circumstances, rice yields (one of the staple foods, alongside wheat and maize) for example can dwindle as those temperatures can make its flowers unproductive, meaning that no grain is originated, with higher respiration losses also making it less prolific (IRRI, 2017). Consequently, if temperatures reach the range of 27ºC to 32ºC, rice yields could decline by 90 percent, and dropping to zero if temperatures surpass 35ºC (Krishnamurthy, Lewis & Choularton, 2014).

The contraction in average rice yields in rain-fed, drought-prone areas has ranged from 17-40 percent in drastic drought years with their magnitude and prevalence envisioned to surge. As a result, water scarcity already affects more than 23 million hectares of rain-fed rice production areas in South and Southeast Asia (IRRI, 2017).

In Africa, persistent drought perturbs nearly 80 percent of the potential 20 million hectares of rain-fed lowland rice (IRRI, 2017). The International Food Policy Research Institute (IFPRI) 2009 report, *Climate Change: Impact on Agriculture and Costs of Adaptation,* adumbrates that rice yields could decay by 10-15 percent globally and rice prices soar between 32-37 percent by 2050 (Nelson et al, 2009).

With world harvest projected at 734 million tonnes in 2017/18 (FAO, 2018b), wheat is by far the most crucial single crop in terms of human consumption, which means, a sinking production could have widespread repercussions in countries where it is both a staple underpinning food security, and where opportunities to import are restricted (EJF, 2017). Unfortunately, the swelling in temperature between 1980 and 2008 already culminated in an average minimization of global wheat yields by 5.5 percent (Lobell, Schlenker & Costa-Roberts, 2011).

In the same way, a 2016 study comprising scientists from the US, China and the EU, and based on a extensive range of modelling techniques and statistical analyses, appraised the potential impact of temperature variations on wheat production. The results all point in the direction of a global temperature increase of 1ºC generating a planetary abatement in wheat yields by between 4.1-6.4 percent (Liu et al, 2016).

The study generated analogous findings on a country level for the world's largest wheat producers, including in the U.S., China, India and France. For instance, China will see yield declines of about 3 percent per 1ºC rises in global temperature, while India is contemplated to undergo a much more acute recession of around 8 percent. Although it is uncertain what losses smaller producers will be subjected to, all the studies arrived at the conclusion that warmer regions will withstand the greatest temperature-related losses (Liu et al, 2016).

A point often overlooked is that, on a global scale, many of the areas where crop yields are prognosticated to decline are already undergoing food insecurity (FAO, 2016a). With climate change predicted to expose the number of people at risk of hunger by 10 to 20 percent by 2050, one needs to ponder on the enormity of the challenge for Africa, since 65 percent of those will be located there. In like manner, the number of malnourished children could also swell by more than 20 percent globally (Parry, Evans, Rosegrant & Wheeler, 2009).

In the Philippines for example, climate change scenarios (2030-2050) depict a reduction in average per capita consumption of cereals by 24 percent and fruits and vegetables by 13 percent - intensifying the number of people imperiled by hunger by 1.4 million in 2030 and 2.5 million by 2050, if preventive and corrective measures to curb rising global temperatures fail. The projected economic costs are contemplated to border an annual average of US$4.3 billion (IFPRI, 2015).

Equally important are the ramifications of climate change on the dissemination of pests, as they arrive earlier in the season, expand to new geographic areas and persevere longer into the winter. Pests are presently abbreviating global harvests by between 10 and 16 percent and evoke losses of at least US$220 billion per year (Chakraborty & Newton, 2011), with these numbers being anticipated to further escalate as the backlash of climate change intensifies (EJF, 2017).

To point out, presently in the US the potato leafhopper emerges around ten days prematurely than in 1950s resulting in damages totalling several million dollars (FAO, 2016a). Additionally, the desert locust in Africa is counted upon propagating much further and wider due to climatic changes (Cressman, 2013) with floods, cyclones and warmer circumstances engendering a rise in the number of locust generations in a year, making the liability of devastating plagues more likely. A very small locust swarm can consume as much as 35,000 people eat in a day (FAO, 2015a).

During the locust infestation in 2004, 10 countries in Africa were disturbed. Notably, in Mauritania, a roughly 80 percent of crops were wrecked (FAO, 2004). In 2015, Argentina went through the worst locust infestation in over 60 years, with 700,000 hectares of land affected. Provided there were numerous factors at play, the winter was the third warmest on record and the wettest since 1932. As one FAO expert, Keith Cressman attested: "Extreme weather events, including torrential downpours, have the potential to trigger a massive surge in locust numbers" (Taub, 2016).

Given these points, The UN World Food Programme (WFP, 2017) writes that:

> "For millions of people across Africa, Asia and Latin America, climate change means more frequent and intense floods, droughts and storms, accounting each year for up to 90 percent of all natural disasters. In the last decade, almost half of the World Food Programme's emergency and recovery operations have been in response to climate-related disasters, at a cost of US$23 billion. In the absence of improvements to people's ability to prepare, respond and recover, it has been estimated that the risk of hunger and malnutrition could increase by up to 20 percent by 2050."

Overall, climate risks, including desertification and drought, jeopardize hard-won development gains by hindering growth in strategic sectors such as agriculture, water resource management, and urban development. These hazards, magnified further by fragility and conflict situations, are on the rise in many parts of the world (The World Bank, 2017).

And nowhere are these risks more flagrant than in the countries most dependent on farming, with sub-Saharan Africa at the greatest risk. In consonance with the Food and Agriculture Organization of the United Nations (FAO, 2013), roughly 2.5 billion people in poor countries inhabit rural areas and most are remarkably subservient to agriculture for their livelihoods. To that effect, a likely 500 million smallholder farms are shouldering approximately two billion people and producing around 80 percent of the food consumed in Asia and sub-Saharan Africa. With low capacity for adjustment, these farms are exceptionally accessible to environmental shocks.

According to the FAO, 25 percent of the total economic losses caused by climate-induced hazards in developing countries overwhelmed the agricultural sector and resulted in US$80 billion in losses to crops and livestock between 2003 and 2013 (FAO, 2015b).

The report from the Central Intelligence Agency of the United States (CIA, 2001) clearly states:

> "Population growth in developing countries will increase stress on soils from erosion and poor fertilization and irrigation practices. Lower classes are farming barren tracts to survive, which increases environmental damage, leading to a vicious downward cycle of productivity and opportunity"

As a matter of fact, the developing world, which a few decades ago was a net agricultural exporter, is at present a net agricultural importer, and the FAO prognosticates the agricultural trade deficit of developing countries to increase "dramatically" by 2030 (FAO, 2009).

In the same way, land degradation reinforces climate change while exaggerating the vulnerability of millions of people, especially the poor, women and children, the UNCCD vindicates while adding that contemporary management practices in the land-use sector are answerable for about 25 percent of the world's greenhouse gases, whereas land degradation is both a cause and a result of poverty (Kamal, 2017).

The Global Land Outlook report (UNCCD, 2017) contends that:

> "Over 1.3 billion people, mostly in developing countries, are trapped on degrading agricultural land, exposed to climate stress, and therefore excluded from wider infrastructure and economic development."

The report reminds that land degradation also triggers competition for scarce resources, which can prompt migration and insecurity while exacerbating access and income inequalities and says:

> "Soil erosion, desertification, and water scarcity all contribute to societal stress and breakdown. In this regard, land degradation can be considered a "threat amplifier", especially when it slowly reduces people's ability to use the land for food production and water storage or undermines other vital ecosystem services."

Therefore, it is crucial to emphasize how *soil* is much more than just an accumulation of tiny fragments of earth. Soil is pullulating with mycelia and other microorganisms, worms, bugs, and roots, all cycling the nutrients and water. As a matter of fact, soil has prodigious biodiversity within, breaks up waste into its component parts and adjusts atmospheric nitrogen into usable forms. By and large, these processes are crucial to the lives of species growing in and above the ground as well as for growing crops (McKee, 2003).

According to the UN Food and Agriculture Organisation, at current rates of soil loss, driven in a grand manner by poor farming practices, we have just 60 years of harvests left (Monbiot, 2015a), and this was before the Global Land Outlook report, published in September 2017, established that productivity is already deteriorating on 20 percent of the world's cropland (Watts, 2017).

Despite the fact that climate change has a Brobdingnagian role to play in the desertification of the landscapes, over-grazing has impoverished the land, as populations took to cutting down trees to feed their herds, making it arduous to grow anything at all (Filipovic, 2017). Overgrazing not only strips and lays the land bare, but remodels its vegetative cover that in turn rebounds in local weather patterns by lowering transpiration and allowing unguarded soil to heat up (McKee, 2003).

To put it another way, the sheer number of people and their activities exert an effect on their surroundings. The civil war in Syria is one such example. When the Syrian steppe was opened to unrestricted grazing in 1958, which led to an ecological, hydrological and agricultural collapse, the Syrian government determined it would be unsuspicious to attribute responsibility to protracted droughts or climate change, on the grounds that they are extraneous and peripheral causes and a way to escape accountability – while justifying inaction (Serra, 2015).

In a study entitled *Climate change in the Fertile Crescent and implications of the recent Syrian drought* published in the *Proceedings of the National Academy of Sciences* (PNAS), Colin Kelley and colleagues (2015) describe how human-driven climatic changes ravaged the agricultural breadbasket in northern Syria.

Richard Seager, one of the co-authors asserts in an interview with *The Ecologist* (Kirby, 2015):

> "We're not saying the drought caused the war. We're saying that, added to all the other stressors, it helped kick things over the threshold into open conflict. And a drought of that severity was made much more likely by the ongoing human-driven drying of that region."

What figure 5.21 shows is a fence compartmentalizing the steppe terrain in two parts: the area on the left was serviceable to sheep grazing; the area on the right has been safeguarded for at least 10 years. It is important to realize that the image (on the right) demonstrates how the Syrian steppe ecosystem is perfectly adapted to cope with droughts – even those aggravated by climate change phenomena. Nonetheless, the landscape can easily capitulate to human unreasonableness and callousness (left side) (Serra, 2015).

Figure 5.21: The edge of an experimental sheep grazing exclusion zone (to the right) within Al Talila Reserve, Palmyra, photographed in March 2008 in the midst of an intense drought period. Sheep quasi uncontrolled grazing was allowed to the left of the fence. Grazing of reintroduced native antelopes at low densities had been allowed within the exclusion zone for a period of 10 years. Photo: Gianluca Serra. Retrieved from Serra, 2015

In consonance with Francesca de Châtel's work *The Role of Drought and Climate Change in the Syrian Uprising: Untangling the Triggers of the Revolution* (2014) the 50 years of sustained dereliction and malpractice and the inability of the Syrian government to come to grips with the uncontrolled steppe ecological crisis, steadily unfolded into the social unrest and then in a brutal civil war in the country, among other reasons (Serra, 2015).

The beginning of the ecological degradation was inaugurated with the nationalization of the steppe in 1958 when it started to be over-grazed by free-ranging pastoralists and urban investors who threw thousands of livestock. As the FAO states (Steinfeld et al, 2006):

> "Prolonged heavy grazing undoubtedly contributes to the disappearance of palatable species and the subsequent dominance by other, less palatable, herbaceous plants or bushes. Such loss of plant and, in consequence, animal biodiversity can require a long regenerative cycle (30 years in savannas, 100 years in rainforests). Excessive livestock grazing also causes soil compaction and erosion, decreases soil fertility and water infiltration, and a loss in organic matter content and water storage capacity."

On the other hand - and this is why megaherbivores are needed to perform ecological functions and processes (segment Key Impacts of Megafaunal and Predators Loss) and why replacing them with domesticated cattle (next segment) to feed the human population is so corruptive to ecosystem continuity – FAO (Haan, Steinfeld & Blackburn, 2002) attests that:

> "Total absence of grazing also reduces biodiversity because a thick canopy of shrubs and trees develops which intercepts light and moisture and results in overprotected plant communities which are susceptible to natural disasters."

A kindred scenario developed in the eastern part of the Syrian steppe, east to the Euphrates, where intensive agriculture via irrigation through underground water, with uninhibited control and unchecked appropriateness signified that wells had to be dug every year deeper with snowballing consumption of fuel (Serra, 2015). Every day for more than 20 years, an average of 2,000 hectares of irrigated land in arid and semi-arid areas across 75 countries have been degraded by salt, due to irrigation practices without drainage management that lead to accumulation of salts, causing extensive soil damage and reduced productivity. Today about 62 million hectares are affected – 20 percent of the world's irrigated lands (an area roughly the size of France). This is up from 45 million hectares in the early 1990s. (Hamilton, 2014).

By the same token, a huge increase in population from four million in the 1950s to 18.5 million in recent years (UNPD, 2015) as well as the 1.5 million people who fled from the countryside to cities already distressed by waves of refugees from the war in neighbouring Iraq (Kirby, 2015) has generated ripples of environmental and societal chaos. Colin Kelley and his fellow authors from the *PNAS* study mentioned above had the following to say relative to population pressures (Kirby, 2015):

> “Rapid demographic change encourages instability. Whether it was a primary or substantial factor is impossible to know, but drought can lead to devastating consequences when coupled with pre-existing acute vulnerability.”

While in the past the steppe was able to recuperate and convalesce even following acute periods of droughts, the indisputable desertification process caused by ecological pressures represented a gradual and incessant decrease of the resilience of this kind of ecosystem. Following the recent cycle of intense drought from 2006 to 2010, the agriculture system ultimately succumbed in eastern Syria expedited by a precipitous halt of government subsidies and ensuing soaring prices of fuel for wells. This ecological collapse inflamed a humanitarian crisis in the rural areas of the country, followed by massive internal displacements (Serra, 2015).

In view of these events, Syria, recognized to be a dignified and autonomous nation in terms of food production (and actually even exporting food), had to depend on a massive international emergency food aid in 2008. Therefrom, it should not be a coincidence that the insurrection in 2011 started in provincial towns rather than in the major urban centers of Damascus and Aleppo, Francesca de Chatêl argues (2014).

The same sort of ratiocination was achieved in examining the triggers of the Darfur war that materialized from 2003 to 2010 not far from Syria (Borger, 2007). Darfur encountered precisely the same sort of over-exploited semi-arid ecosystem, while once again rural and indigenous people were the casualties, including nomadic pastoralists (Serra, 2015). For others, the repercussions are collateral and oblique. Smaller plots of arable land translate into more violent conflicts over it; terrorists amass and annex food, water and land in areas of paucity to centralize power and influence; young men who are unable to raise a family because the land is no longer fertile find purpose and manhood in the extremist groups that create chaos and displace millions across the continent (Filipovic, 2017).

Overgrazing that denudes the land was at the heart of a classic 1968 paper by Garrett Hardin of the University of California, Santa Barbara. He called it “*The Tragedy of the Commons*.” What he meant by that title is best portrayed in Hardin’s own words, though shortened here:

> “Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point the inherent logic of the commons remorselessly generates tragedy.
>
> As a rational being, each herder seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, “What is the utility to me of adding one more animal to my herd?” … The positive component is a function of the …. Proceeds from the sale of one more animal. The negative component is a function of the additional overgrazing created by one more animal … shared by all the herdsmen.
>
> Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd… but this is the conclusion reached by each and every rational herdsman sharing the commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit - in a world that is limited … Freedom in the commons brings ruin to all.”

Notwithstanding the CIA demographic report that connotes that the U.S. and other rich countries can ward off, to a certain extent the repercussions of global environmental problems, there are studies that admonish of a Malthusian trap within several decades if populations are not reduced (Kates, 2004).

If one takes the U.S. as an example and postulates there will be no supplementary forfeiture of arable land and/or crop yield, Pimentel and other agricultural ecologists reckon the maximum population size that could be fed a justly, diverse and nutritious diet of plant and animal products is 350 million. Nonetheless, an optimal population size for the U.S., which not only met nutritional requirements but also allowed an ecologically sustainable form of agriculture, is about 210 million (Pimentel & Giampietro, 1994). U.S. population, (328 million in 2018), is expected to reach 354.7 million (mid-2030’s) and 389.6 million (mid-2050’s) (Population Reference Bureau, 2018). If Pimentel’s calculations are errorless and factual, the U.S. has already lost the aptness to be self-sufficient in ecologically sustainable food production (Kates, 2004).

Ultimately, this segment is about the degradation of land and soil health, and how it stands as the backbone of our entire human civilization. We should not forget, as Monique Barbut, UNCCD’s executive secretary says (Malek, 2018):

> “Land is worth so much more than the economic value we attach to it. It defines our way of life and our culture – whether we live in the city or villages. It purifies the water we drink. It feeds us. It surrounds us with beauty. **But we cannot meet the needs and wants of a growing population if the amount of healthy and productive land continues to decline so dramatically.”** (Bold added by author).

The confluence of population growth, expanding agriculture, climate change and an overabundance of other human activities, all assemble to aggravate land degradation and all have a *prima-facie* probability of exacerbating the biodiversity crisis as well as to create immense challenges for humanity. One of its worse manifestations is a rise in conflict and warfare, as prognosticated by Malthus a few centuries ago.

Malthusian Trap

"Europe is overpopulated, the world will soon be in the same condition, and if the self-reproduction of man is not rationalized… we shall have war."

- Henri Bergson, *The Two Sources of Morality and Religion* (original 1932, link 1977)

"Human population growth is probably the single most serious long-term threat to survival. We're in for a major disaster if it isn't curbed… We have no option. If it isn't controlled voluntarily, it will be controlled involuntarily by an increase in disease, starvation and war."

- Prince Philip

In an era of unstable and wavering climate and submerging economies, Malthusian limits to growth are more palpable than ever. Whereas *more people* once signified more ingenuity, more talent and more innovation, for the time being, it just seems to mean *less for each*. Contracted amounts of water for every cattle herder in the Horn of Africa (The United Nations foresees there will be more than four billion people living in nations defined as water-stressed by 2050, up from half a billion in 1995) are one such repercussions. Identically, there will be less land for every farmer, which is already pushed into tilling slopes so steep they risk injury or death as well as less capacity for the atmosphere to secure the heat-trapping gases that could elevate the temperature of the planet to levels never before experienced by humanity (Engelman, 2009).

Many of the theoretical expostulations that connect population pressures to scarcity of resources and ensuing conflict derive from the original work of Thomas Malthus (1798) in which he predicated food production grew linearly, while population increases tended to be exponential. At some point, the population would engage in conflict over the scarce resources (Tir & Diehl, 1998). Correspondingly, an all-encompassing breakdown of civil wars over the past 70 years reveals that at least 40 percent are associated to the contested monopolization or use of natural resources such as land, water, minerals or oil (UNEP, 2009).

Therefore, it is paramount that in the coming decades, we aim attention on the interactive circuit that connects the availability of food to nutrition, to the proliferation of avertible diseases, to survival and reproductive practices and, ergo, demographic growth. This has been appropriately designated as the Malthusian 'trap': the trap that entangles societies with high demographic growth. Experiencing food dearth, diseases, and high mortality, they retain high reproduction rates, which in turn provokes a further increment in the population and a doomed cycle of poverty (figure 5.22) (Bacci, 2017).

Massimo Livi Bacci, Emeritus Professor of Demography at the University of Florence and author of the book *Our Shrinking Planet* (Bacci, 2017) gives us an overview of what this Malthusian trap entails in the food production sphere:

> "In future decades the predicted growth of the world's population and an increase in the economic means of famished or undernourished populations will cause a strong rise in food demand and considerable stress on the productive capacity of the world's agricultural system. Experts seem confident that this demand can be met through a moderate increase in the amount of land used for crops and a wise policy on water; but they also rely on a strong increase in productivity that should derive from new technologies and, most importantly on the dissemination of the technology that already exists.

The predictions of the Food and Agriculture Organization (FAO) indicate a rise in the world production of cereals from 2.3 billion tonnes in 2015 to 3 billion in 2050 (a 30 percent rise) and a rise in meat production from 305 to 463 million tonnes (a 52 percent rise) between those same two dates (Conforti, 2011). The production system will also have to provide for an improvement in nutrition levels in the countries where they are insufficient. Naturally this will place considerable stress on production, which will be thick with uncertainties about its environmental effects, also as a result of the possible further growth of demand of biofuels. Risks could also emerge from the climate change that results from global warming. The imperfect or distorted functioning of the markets, the persistence of major inequalities of income distribution, mistaken public policy interventions, and political instability are other potential factors that could have a serious influence on future prospects. However, **the slowing of demographic growth should make it easier to satisfy the demand from poor populations than it was in the past** (bold added)."

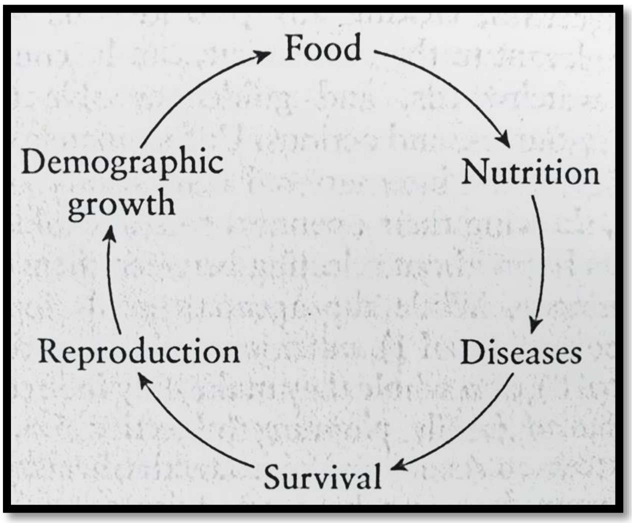


Figure 5.22: Malthusian Trap. Retrieved from Bacci, 2017

As it has been stated repeatedly throughout this work, this planet and its resources are finite, and that is to say, land area is circumscribed to natural limits, and technological adjustments questionable and conjectural. Provided that we can envisage population pressures to augment, especially in Africa and parts of Asia, an unavoidable outcome is conflict intensification (Tir & Diehl, 1998). For this reason, population growth puts forward supplementary confrontations by disrupting the maintenance or continuity of stable food supplies, which in turn sparks struggle and strife over the land required for biodiversity conservation (Mora, 2014). Harte (2007) designates this circumstance as the "low-hanging fruit gets picked first," to intimate that it is very likely that humanity has already exploited or is already capitalizing on the most fertile soils and cleanest water; thus, as we expand our population and broaden its distribution, less suitable areas will be available for agriculture.

Meeting these food demands through an unavoidable agricultural expansion could also engender conflicts between the use of the land for agriculture and the land needed for biodiversity safeguard. Demonstrably, by 2050 about 26 percent of the world's land could witness clashing uses between what is essential to supply humanity's dietary requirements and what is vital for sheltering all the non-human life on this planet from human hazards (Musters, de Graff & ter Keurs, 1999; Mora & Sale, 2011).

In his best-selling book *Collapse,* Jared Diamond (2005) asserts that some societies "choose to fail or succeed." Diamond maintains that when populations swell, some societies overuse resources which, to put it differently, instigates environmental degradation and, eventually social collapse. For instance, when populations expand, people embrace more intensive agricultural techniques in order to feed themselves. By way of irrigation, fertilizers, terracing and other technologies individuals are able to increase crop yields. However, a rising population also places pressure on the availability of fertile land, and has this land becomes increasingly sparse, people bring marginal land under cultivation. They also abbreviate the fallow period, which depletes the soil of nutrients, and for this reason, the result can be environmental havoc: valuable ecosystems are ravaged, soils are drained, and resources overused. People and the environment languish and societal collapse often follows environmental collapse (Boudreaux, 2009).

As anthropologists Dwight W. Read from University of California and Steven A. Leblanc from Harvard University assert in *Population Growth, Carrying Capacity and Conflict* (2003):

> "Human population growth and the effect of population stress on human systems have long been the topics of concern for anthropologists. Most arguments about human societal development favour slow to almost non-existent growth and populations well below carrying capacity for most of human history since at least the Middle Palaeolithic, and the archaeological record supports this view [...] Hunter-gatherer groups living in low-resource-density areas are more likely to display long-term demographic stability, and the higher the resource density, the more likely is the occurrence either of intergroup conflict or of Malthusian growth constraints such as disease and starvation [...] Chronic intersocietal conflict arises as populations in a region approach or exceed their equilibrium population sizes..."

A particular set of convincing case studies by Homer-Dixon (1994, 1999) linking population enlargement in the presence of resource paucity to civil strife in the Eastern Islands, the Senegal river valley, southern parts of the Philippines and the Assam region in India. The most noteworthy of these examples is the 1994 Rwandan genocide where over half a million Tutsi were slaughtered by Hutu militias. Diamond explored the Rwandan genocide in his book *Collapse*, in which he described as a modern day Malthusian trap, which can be understood, in part, as a society-wide response to elevated fertility rates conjugated with land scarcity. Diamond postulated that too many people and insufficient land were key variables in decoding the Rwandan carnage (Boudreaux, 2009).

Even supposing that an accepted vindication of the civil war has been ethnic hatred between two very polarised groups, Homer-Dixon calls attention to the fact that, Rwanda was at the time of the conflict, one of the most densely populated countries in the world. Moreover, fertile land was in exceedingly short supply due to a persistent degradation of the environment, making food a remarkably deficient good (Brückner, 2010). Uniquely so, interviews of Rwandan war casualties assembled by Andre and Platteau (1998) echo the pronouncement that overpopulation and stringency of resources played a major role in kindling the Rwandan genocide.

Andre and Platteau are quoted in Diamond's *Collapse* (2005) demonstrating that:

> "The 1994 events provided a unique opportunity to settle scores, or to reshuffle land properties, even among Hutu villagers....It is not rare, even today, to hear Rwandans argue that a war is necessary to wipe out an excess of population and to bring numbers into line with the available land resources."

Whereas these case studies divulge crucial and intricate observations of the workings of population-pressure-induced conflict, they were heavily castigated for harboring selectivity bias and lack of generality (Gleditsch & Urdal, 2002; Urdal, 2005, Boudreaux, 2009).

As a result, Collier and Hoeffler (2004) and Fearon and Laitin (2003) used panel data to knuckle down these shortcomings. With this intention, they found vigorous evidence pointing towards countries with larger population size to be prone to a higher risk of intra-state war. Together with this, other empirical panel-data studies ensued, finding similarly detrimental repercussions of population size on civil conflict (Hegre & Sambanis, 2006).

Notably, the authors substantiate:

> "We confirm that a large population and low per capita income increase the risk of civil war, and this is consistent with many studies of civil war."

By and large, population growth tensions had a momentous reverberation on the likelihood that a state would become involved in military conflict. It must be remembered that the Nazi concept of *Lebensraum*, founded on the ideas of Friedrich Ratzel, asserted that Germany required space to accommodate its growing population. Japan used similar arguments in legitimizing its invasion of Korea and Manchuria (Tir & Diehl, 1998).

Equally important to this discussion is the distinction between static and dynamic population pressures. On one hand, static pressure is characterized by a high population density that may instigate states to take possession of new territories in order to deal with the concomitant spatial and environmental problems related to overcrowding. On the other hand, dynamic pressure refers to substantial population growth, which may augment the strain on states as they seek to accommodate the necessities of the swelling population. With this in mind, international conflictual actions may be the product of state attempts to cope with resource shortages and other demographically-induced constrictions (Tir & Diehl, 1998).

For instance, President Buhari from Nigeria has declared that the country's growing population is a major determinant of the crisis between herders and farmers. There have been several deadly skirmishes recently between Muslim cattle herders and Christian farmers with the latest leading to the death of 83 people in Benue. According to *Reuters* (2018), the Presidency said the limited availability of land elicited both parties to adopt all means to meet their need.

Business Insider (Taiwo, 2018) also reported on the situation as the Presidency issued the following email statement:

> "President Buhari holds the view, as do many experts, that these conflicts are more often than not, as a result of major demographic changes in Nigeria. Nigeria's population was around 63 million when the West African country gained independence in 1960, compared with a population now "estimated at close to 200 million". While the land size has not changed and will not change, urban sprawl and development have simply reduced land area both for peasant farming and cattle grazing."

Now we need to add climate change to this already unstable situation.

A Climate Change Exposure Index (CCEI), produced by the UK risk analytics firm Verisk Maplecroft (2016) proclaims that the physical risks posed by climate change are 'high' or 'extreme' in 85 percent of the world's most agriculturally-dependent countries. Sub-Saharan Africa experiences the highest risk of changing weather patterns with the region being home to 17 of the 20 countries most economically sustained by agriculture and among the worst-placed countries to combat repeated disruption to harvests (EJF, 2017).

With agriculture representing over 30 percent of national GDP in countries such as Sierra Leone, Liberia, Central African Republic, Guinea-Bissau, Burundi and Rwanda, all of which are rated 'extreme risk' in the CCEI. Not to mention, all of these countries demonstrate low resilience to ride out climate change, and recent conflicts within each reinforce the risk to their populations (Verisk Maplecroft, 2016).

As well as reducing food security, contracted yields in key export crops such as tea, coffee, cashew nuts and cotton will harshly impact national incomes as well as the smallholder farmers depending on these crops. This susceptibility is upheaved by poor governance and closely associated with recent violent conflict and unrest. Chiefly, of the worst performing countries in the CCEI - Central African Republic, DR Congo, Haiti, Liberia, South Sudan (Verisk Maplecroft, 2016) - all but Haiti have experienced or are continuing to suffer from civil war in the past decade; Haiti's food riots and violent protests in 2008 reinforced the overthrow of the government that year. Civil war and protests can themselves generate thwarting in food production and a downward spiral in food security, access and availability to vulnerable people (EJF, 2017).

Laikipia in Kenya is also in the midst of bloodshed due to the arrival of hundreds of poor tribesmen from drought-hit regions ransacking for grazing lands for their cattle. Private properties are being appropriated with thousands of head of cattle, overgrazing and provoking "lots of damage to property and the wildlife", said Josh Perrett, a manager on Mugie ranch in the Laikipia County in Kenya (Burke, 2017).

At the same time, across the region, dozens of elephants have been killed and their tusks removed, as well as thousands of buffaloes, antelopes and other game. Centuries-old trees have been cut down for firewood or fodder (Burke, 2017) (this phenomenon of poaching and bushmeat hunting as humans move around, for subsistence and merchandising has been previously described in No Sanctuary).

Jamie Manual, who looks after the wildlife, told the *BBC* (Leithead, 2017) that:

> "The damage occurring with the large number of stock at the moment is catastrophic. The land will be overgrazed and degraded and this will turn to a situation where we have a disaster on our hands. A lot of wildlife will die through starvation through a lack of grass in the conservancy. Other times we've had a lot of incidents where wildlife has come into conflict with herders and it results in a gunshot, a spear or a poison arrow."

In reality wildlife habitats are being menaced across the continent, in great part due to new farms and new fences in wildlife reserves, in which potential farmland or grazing land is taken off the table (some wildlife refuges tolerate grazing, but it often gets quickly out of control) (Gettleman, 2017).

At this point, it shouldn't come as a surprise that a precipitous population swelling in Kenya has been in the making, which has led to massive pressure on land, but that isn't the only factor in play since human-overpopulation multiplies the reach of other threats.

Markedly, politicians were "promising 10,000 pastoralists with 500,000 head of cattle that if they come and drove people out they would keep the land", a rancher tells *The Guardian* (Burke, 2017). Economic growth, the materialization of a new class of "cattle barons," as well as years of plentiful rainfall have boosted cattle numbers, furthermore, poor management has resulted in overgrazing in the north that is now unsatisfactory for the humongous herds.

"The reality is that there are too many people and too much livestock and it's a global thing" Anne Powys, who manages a tourist facility that was invaded, overwhelmed and burned down, tells *The Guardian* (Burke, 2017).

Generally speaking, humans have always quarrelled over territory, and Laikipia is no oddity, but many residents say the years of 2016-17 have been the bloodiest ever with at least 80 people being killed, and the violence does not seem to stop (Gettleman, 2017).

Jeffrey Gettleman writes in *The New York Times* (2017*)* that:

> "Kenya has a land problem and Africa itself has a land problem. Population swells, climate change, soil degradation, erosion, poaching, global food prices and the benefits of affluence are exerting incredible pressure on African land."

In *East Africa in the Malthusian Trap?* Andrey Korotayev and Julia Zinkina (2015) reach the following conclusion:

> "The main countries of East Africa (Uganda, Kenya and Tanzania) have not yet escaped the Malthusian Trap and won't avoid it unless they first achieve serious successes in lowering their fertility rate."

Gettleman again:

> "The World Bank points out that, more than in other region of the world people live of the land with seventy percent of Africa's population making a living through agriculture. As the population rises, with more siblings competing for their share of the family farm, the slices are getting thinner. In many parts of Africa, average farm size is just an acre or two, and after divisions people are left to subsist on a sliver that is not much bigger than a tennis court. With this comes overuse. Fast-growing populations mean that many African families can't afford to let land sit fallow and replenish. This lowers the levels of organic matter in the soil, reducing crop yields."

All things considered, data from NASA satellites exposes an overwhelming decadence of agricultural land throughout Africa, while at the same time, high birth rates and amplified life spans means that, at the end of the century, there could be as much as four billion people in the continent, **10 times more as 40 years ago**, with the quality of farmland deteriorating concomitantly (Gettleman, 2017*)*. A world populated with ever more humans and less of everything else is a world brimming with rivalry and strife. In order to avoid unleashing upon it a titanic clash resembling that of the Greek mythology, over insufficiency of resources and living space, our numbers and personal aspirations will have to be curtailed.

The 'Other' Population Crisis

"By eating meat we share the responsibility of climate change, the destruction of our forests, and the poisoning of our air and water. The simple act of becoming a vegetarian will make a difference in the health of our planet."

- *Thich Nhat Hanh, The World We Have: A Buddhist Approach to Peace and Ecology* (2008)

"It is critical to focus on what is presently dead certain: that overproduction and overpopulation have been driving the dismantling of complex ecosystems and native life, and leaving in their widening wake constructed environments, simplified ecologies, and lost life forms."

- Eileen Crist

As it has been stated repeatedly throughout this work, livestock production has one of the most deleterious environmental tolls among the multitude of human activities. In fact, we may think that we inhabit a planet, but in reality, we have transmogrified the surface of the Earth in such a profound way, that it should be more adequate to consider it one gargantuan farm that is sporadically broken up by cities, forests, and the oceans (Walsh, 2013).

It is important to realize that livestock production - which encompasses meat, milk, and eggs - is responsible for 40 percent of the global agricultural gross domestic product and provides income for more than 1.3 billion people (Walsh, 2013). The list of positive benefits from the sector is, to all likelihood, not much longer, in contrast, the list of its negative repercussions is surely far-reaching and voluminous.

Distinct schemes of livestock production have particular side-effects on natural resources (FAO, 2017b) and the nourishing of tens of billions of domestics has exacted the extermination or deracination of wild animals from their erstwhile habitats, the banishment, torture and slaughter of carnivores regarded as menaces to farm animals, and the erosion and degeneration of lands from overgrazing (Crist, 2016). On top of that, even though grazing has its fair share of responsibility, the alternative - *The Economist's* (2011) so-called livestock revolution - embodies a pollution nightmare and an atrocious and deplorable violation of basic decency in the treatment of animals as well as breaching several ethical and moral conducts of action (Crist, 2016).

Industrial food production, specifically the meat and animal products sector, are conducive to at least 30 percent of anthropogenic greenhouse gases – more than any other economic activity (the literature puts the number between 14.5 percent and 51 percent, either way, those are values that should rightly concern us) (Goodland & Anhang, 2009; Gilbert, 2012; Gerber et al, 2013; Ripple et al, 2014), and if the ongoing course of growth continues, the sector will eat up 80 percent of the world's greenhouse gas budget for a 1.5ºC scenario, the upper-temperature goal agreed by nations under the Paris Agreement (Holder, 2018) (More on this subject in the chapter Category: Chaos). Given the potential boundless and abysmal backlashes of climate change, addressing the contribution of livestock-produced greenhouse gases is a serviceable constituent of biodiversity conservation (Machovina, Feeley & Ripple, 2015).

These greenhouse gases are begetting a climate change episode that could warm up the planet to an average temperature increase analogous to the Paleocene-Eocene Thermal Maximum

(PETM), when in less than 20,000 years the temperature of the planet increased by 5-8ºC, due to a massive carbon injection into the atmosphere (Mcinerney & Wing, 2011). This climatic event at around 55.5 million years ago had no human influence and during that time studies suggest that a modest 0.2 gigatonnes of carbon were being released per year (with peaks of 0.58 gigatonnes). The bad news is that, contemporaneously, humans are responsible for about 10 gigatonnes per year (Timmer, 2017; Davis, 2017; Crist, 2016).

Land-use change (deforestation & feedcrop expansion) dominates CO_2 production from livestock with an estimated 2,400,000,000 tons of CO_2 released annually (Steinfeld et al, 2006). Releases of methane from enteric fermentation amounts to 2,200,000,000 tons of CO_2. The use of nitrogen fertilizers in feed and manure production reinforces with 75-80 percent of annual agricultural emissions of N_20, equivalent to 2,200,000,000 tons of $C0_2$. Moreover, some data implies that N_20 is the largest livestock-driven climate change menace, primarily resulting from the generation of manure and the intensive over-use of fertilizers for the preparation of animal feed (Idel, 2013, pp. 157). Indeed the amount of nitrogen released by livestock via manure is predicted to surpass the global use of nitrogen fertilizers (Bouwman, Beusen & Billen, 2009).

Land-use change presupposes not only the discharge of carbon with the conversion of forests and other habitats into grazing pastures but also the metamorphosis of natural grasslands into intensive feedcrop agriculture, which is an ongoing trend in developing countries (Bruinsma, 2003; Thornton, 2010). Correspondingly, grasslands are one of the most far-reaching vegetation types, covering 15,000,000 km^2 in the tropics (as much as tropical forests) and another 9,000,000 km^2 in temperate regions (Scurlock & Hall, 1998) for a total of nearly 40 percent of the world's land surface excluding Greenland and Antarctica (White, Murray & Rohweder, 2000). Grasslands are a pivotal organic carbon store, with tropical woodland and savannahs alone possessing roughly 10 percent of the world's soil carbon (Post, Emanuel, Zinke & Stangenberger, 1982; Cao & Woodward, 1998). When grasslands are tilted for agriculture, large amounts of CO_2 are released (Scurlock & Hall 1998).

In a meta-analysis of carbon fluxes (Guo & Gifford, 2002), it was established that shifts from pasture to crops always diminish soil carbon stocks by 50 percent or more, and in high rainfall environments, the sequent soil carbon decreases can outpace 75 percent. On the western hemisphere, over 70 percent of all grasslands have already been converted to croplands (Machovina et al, 2015). As a matter of fact, in Asia and Africa over 19 percent of grasslands have been transformed into crops and in Oceania over 37 percent of grasslands have been converted to crops (White et al, 2000). On balance, this conversion of the world's remaining grasslands to agroindustrial croplands is likely to persevere and potentially accelerate under ongoing international land grabbing and intensification of livestock production (Rulli, Saviori & D'Odorico, 2013).

Adding insult to injury, livestock production is also the prime driver of natural habitat loss worldwide. Livestock numbers are swelling at around 2.4 percent a year (Alexandratos & Bruinsma, 2012). Over the 300 years ending in 1990, the extent of global cropland area expanded more than five-fold and pasture areas increased more than six-fold, the latter enveloping an area 3.5 times larger than the United States (Goldewijk, 2001).

In light of this terrestrial colonization, a direct cost of land being transformed to food production was the subjugation of nearly one-half of all natural forests worldwide. Besides much of habitat dissipated to agriculture in the 1800s being temperate forests and grasslands, the second half of the 1900s saw rapid agricultural expansion in tropical countries, chiefly at the expense of biodiverse tropical forests (Gibbs et al, 2010).

In an early segment of this chapter, *Lebensraum* a review of the state of the surface area of the planet was presented. I suppose, to the amazement of many it came as a surprise to discover that some 40 percent of the world's land surface is exploited with the objective to keeping all 7.6 (soon to be an archaic figure) billion of us fed - admittingly, some more than others, as this chapter has unveiled so far. And the vast majority of that land - about 27 percent of the world's total ice-free surface (Roser & Ritchie, 2018) - is used not to raise grains, fruits and vegetables that are directly consumed by humans, but to nourish the chickens, pigs, poultry and cattle that humanity has been growing more dependant on (Walsh, 2013).

For this reason, agricultural magnification is, by far, the leading cause of tropical deforestation (Geist & Lambin, 2002) and while some agricultural development is driven by farmers growing crops for direct human consumption, livestock production, in conjunction with feed production, is responsible for the biggest share of destruction.

The yearly quota of 13 billion hectares of forest area being appropriated for human use - for agriculture, pastures or cropland, for both food and livestock feed crop production - has pernicious repercussions on regional water availability, soil fertility, biodiversity and climate change. Equally important, 20 percent of the world's grasslands are degraded and the trend is broadening, mainly due to accentuated animal density per area (FAO, 2012). By the same disquieting token, livestock incorporates one-fifth of the total terrestrial biomass and consumes over half of directly-used human-appropriated biomass (Krausmann et al, 2008) and one-third of global cereal production (Foley et al, 2011; Alexandratos & Bruinsma, 2012).

As an illustration, the Amazon is the planet's largest continuous tropical forest and is an elementary archetype of biodiversity bereavement being driven by livestock production. Never before has so much old-growth and primary forest been transmogrified to human land uses so quickly as in the Amazon region (Walker et al, 2009). Over three-quarters of all deforested lands in the region have been converted to livestock pasture and feed crop production for domestic and international markets (Nepstad, Stickler & Almeida, 2006; Nepstad, Stickler, Soares-Filho & Merry, 2008; Walker et al, 2009).

In like manner, the grain that farm animals consume is being enriched by oil crops, particularly soya, for which the forests and savannas of South America are being cleared at shocking rates (WWF, 2017b). Moreover, feedcrop production, as well as pasture, is envisioned to remain widening in the Amazon (Masuda & Goldsmith, 2009). Eventually, cleared land that is suitable for feedstock soy production will become scarce and remaining forests outside of protected areas in the Brazilian Amazon will be at risk of conversion to soy (Nepstad et al, 2014). Comparatively, the woodland-savannah ecosystem of the Cerrado adjoining the south-southeastern region of the Amazon is another expansive and diverse tropical habitat. More than half of the Cerrado's original territory has already been metamorphosed to agriculture (Bianchi & Haig, 2013), especially for the production of beef and soy. At the current rate of loss, the entire 2,000,000 km^2 of the Cerrado's ecosystem (21 percent of Brazil's territory) could be modified in less than two decades (Steinfeld et al, 2006). Not to mention one of the main findings from the *Living Planet Index* (WWF, 2018a), which asserts that the Cerrado is losing an area the size of Greater London every two months, which caused a decline of 89 percent of vertebrate populations (Carrington, 2018f).

Another neotropical example, nearly half of Costa Rica's anciently highly-diverse tropical forests have now been cleared of any signs of life and dedicated to livestock production (Morales-Hidalgo, 2006). In fact, livestock grazing in pastures is the top land use in Costa Rica, covering four times more land than is under protected status - this is a country often considered quintessential for biodiversity protection (Boza, 1993). Likewise, the transformation of forests to pasture in other Central American and Latin American nations has been, in like manner, considerable and indiscriminate (Szott, Ibrahim & Beer, 2000).

In Africa, timber harvesting and fire come into view as the two principal processes causing deforestation, with instances of farms superseding forests predominantly due to small-scale cropping (Steinfeld et al, 2006). However, a rise in feedstock production is foreseen for Africa as international agricultural companies are latching or leasing land in Africa to grow feedstocks for export markets (Rulli et al, 2013), modeled after the industrial development of the Brazilian Cerrado region (Clements & Fernandes, 2013). Under rising insistence by urbanizing populations, livestock production is rapidly altering in Asia, with both an increase of production and a shift away from mixed farming systems to intensive production systems directly located near urban markets (Machovina et al, 2015). This originates negative environmental ramifications of increased monoculture feedstock demands at local and international scales as well as heightened pollution of surface water, groundwater and soils by nutrients, organic matter, and heavy metals (Rae & Hertel, 2000).

The rapid expansion of livestock production in developing countries has been credited as the "livestock revolution" (Delgado, 2003). Half of the global meat production now manifests in developing countries (Green, Cornell, Scharlemann & Balmford, 2005), where annual per capita expenditure of meat more than doubled from 11kg to 25 kg from 1973 to 1997 (Delgado, 2003; Steinfeld et al, 2006). In like manner, researchers from the International Livestock Research Institute in Kenya, the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia and the International Institute for Applied Systems Analysis (IIASA) in Austria produced an encyclopedic assessment of the livestock industry around the globe (Walsh, 2013), and the striking results are in:

- Each year the livestock sector produces on global scale 586 million tons of milk, 124 million tons of poultry, 91 million tons of pork, 59 million tons of cattle and buffalo meat, and 11 million tons of meat from sheep and goats. That amounts to 285 million tons of meat altogether - or about 41.90 kg per person if it were all divided evenly - which it isn't. Americans eat 122 kg (270 lb.) of meat a year on average, while Bangladeshis eat 1.8 kg (4 lb) (ChartsBin, 2013).
- Of the 95 million tons of beef produced in the world in 2000, its preponderance came from cattle in Latin America, Europe and North America. All of sub-Saharan Africa - a region with three times as many people as the entire U.S. - produced 3 million tons of beef.
- 1.3 billion tons of grain is given to farm animals each year - and almost all of it is fed to livestock, mostly pork and poultry, in the developed world and in China and Latin America.
- The poor quality feed given to livestock in impoverished regions like sub-Saharan Africa translates into a cow there consuming as much as 10 times more feed - mostly grasses - to produce a kilogram of protein than a cow nurtured in richer regions. This lack of efficiency also means that cattle in countries like Ethiopia and Somalia accounts for as much as 1,000 kg of carbon for every kg of protein produced - in the form of methane from manure as well as from the reduced carbon absorption that accrues from forests being converted to pastureland. That is about 10 times more carbon release per kg of

protein than in many parts of the U.S. and Europe, where livestock production is already much more intensive.

- To illustrate the previous point in more detail: in North America or Europe, a cow consumes about 75 kg to 300 kg of dry matter - grass or grain - to create a kg of protein. On the grounds of the poor quality feed in arid countries and by virtue of high mortality rates in herds of often undernourished and sick animals, this becomes quite the problem.

Given these points, it should be stated that while factory farming in the U.S. and the rest of the developed world gets its fair share of criticism for its cruelty, the danger it poses to public health through the overuse of antibiotics and the pollution it creates to air and water, it is still much more efficient. And that needs to enter the equation since the human population does not seem to stagnate any time soon, as well as the voracious global appetite for more meat (Walsh, 2013).

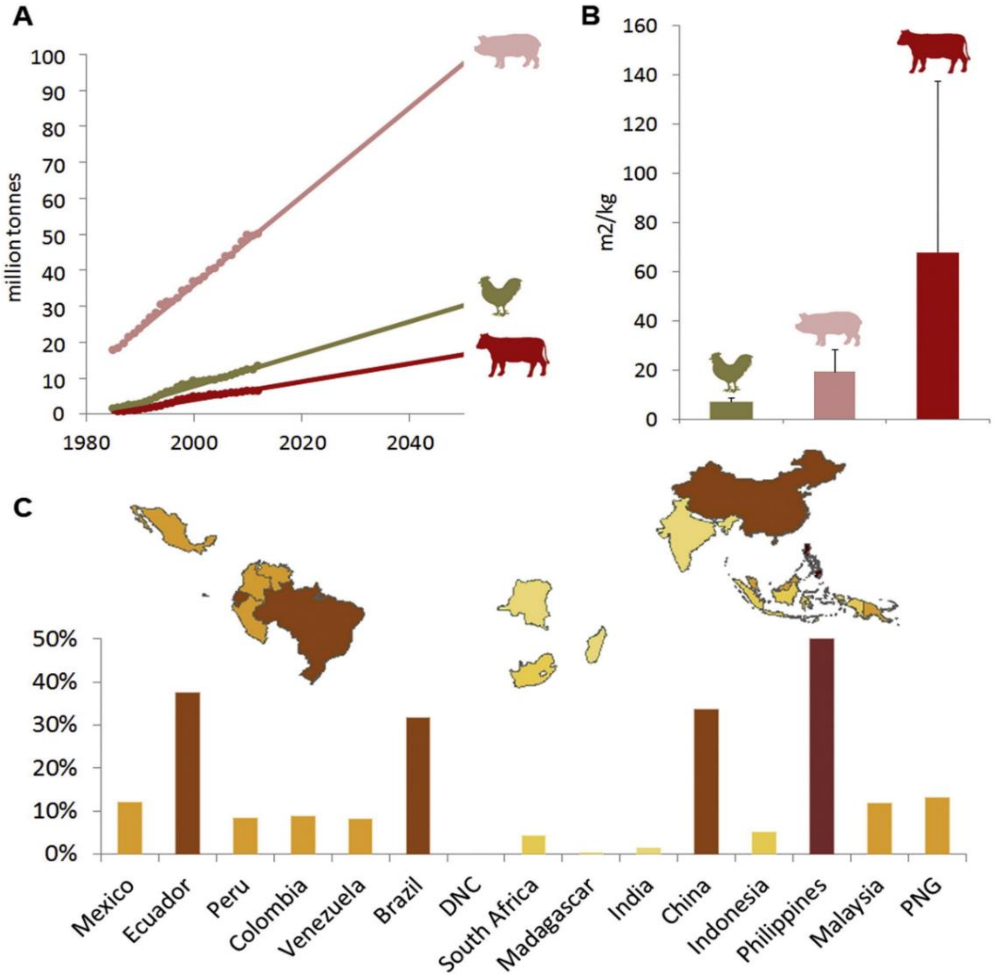


Figure 5.23: Projected increases in area required to produce meat in developing megadiverse (DMD) countries by 2050. (a) Extrapolating recent (1985–2012) production data for beef, chicken, and pork (FAOSTAT 2014) in each DMD country to 2050 (data for China shown) multiplied by (b) mean area required to produce livestock biomass (Röös, Sunderg, Tidaker, Strid & Hansson, 2013) provides (c) an estimate of area in each country required to produce livestock in 2050 as a percentage increase beyond total current agricultural area (2012) (FAOSTAT 2014). Agricultural area expansion needs can be met by internal expansion or by agricultural expansion in other countries and importation of feedcrops and/or meat products. This analysis addresses only beef, chicken, and pork. It does not include eggs, other meat sources, or dairy, which would increase area projections. Retrieved from (Machovina, Feeley & Ripple 2015.

Extrapolating from the rates of production of cattle, pigs, and chickens from 1985-2013 in these countries (FAOSTAT, 2017) and the land area needed to produce them (Röös, Sundberg, Tidåker, Strid & Hansson, 2013) point out that the developing tropical megadiverse countries (in the figure 5.23) could need to expand their agriculture land base by an estimated 3,000,000 km^2 over the next 35 years to muster the required necessities of its population in meat production (Machovina et al, 2015).

In essence, eleven of the tropical megadiverse countries demonstrate rates of increasing per capita meat (beef, pork, chicken) production, and by 2050, several of them (Ecuador, Brazil and China) are on trajectory to crave for new areas of land for meat-production that are > 30 percent expansions of their total current agricultural areas. The supplementary land depended on is equivalent to approximately 10, 10, and 18 percent of the total country areas, and 26, 24 and 111 percent of size of the total protected areas in Ecuador, Brazil and China, respectively. In the Philippines, the area of land requisitioned to fill the demand of a growing population is prognosed to exceed 50 percent of the country's total current agricultural lands, and is equivalent to approximately 20 percent of the total country's area and 73 percent of the size of its protected areas (Machovina et al, 2015). To help meet these meat production settlements needs, developing countries are both acquiring land in other countries as well as selling or leasing land within their borders to fulfil other nation's food demands (Rulli et al, 2013).

All things considered, and in accordance with a paper published in the journal *Science of the Total Environment* (2015) consumption of meat is, to all appearances, "the leading cause of modern extinctions." Not only is livestock farming the principal motive for habitat desecration and the killing of predators, but its waste products are overpowering the world's capacity to absorb them (Monbiot, 2015b). Comparatively, factory farms in the US beget 13 times as much sewage as the human population. As an illustration, the dairy farms in Tulare County, California (the state with the highest human population, close to 40 million) produce five times as much as New York City (Philpott, 2015).

On the other hand, although ruminants convert roughly 2.7 billion metric tons of grass dry matter, of which 65 percent grows on land not suited for crops (Mottet et al, 2017) into human-edible protein each year, the environmental repercussions of this conversion are tremendous under any production method practiced today (Poore & Nemecek, 2018).

In the *Intelligence Squared* debate *The Battle for the Countryside: Britain Should Rewild its Uplands* (2018) the discussion took a very thought-provoking turn. As the speaker for the motion, George Monbiot, author and *The Guardian* columnist presented his case regarding the spread and propagation of the sheep populations, the ecological devastation they spawn and the overall relevance in the diet of British citizens. Monbiot asserted, and I quote:

> "According to my estimates, which are the only thing going at the moment cause there are no official figures and no academic figures, sheep in the uplands of Britain occupy roughly 4 million hectares. That is more or less the same amount of land as all the arable and horticultural land in Britain, and yet they produce 1 percent of our food. Those 4 million hectares are incidentally more than twice the area all of the built-up environment, all the town, roads, airports, everything. Sheep in this country have done more ecological damage than all of the building that has ever happened here. They are a fantastic means of scouring the land, seek out tree seedlings because it's their favourite food, and seek out all other edible plants leaving behind the unpalatable grasses, and in doing so they empty the ecosystems of its richness, of its diversity, of the habitats that animals and other plants make use of."

Monbiot eloquently quotes Thomas More in *Utopia* (1516) and reminds us of the prescience of More:

> "Your sheep that were wont to be so meek and tame, and so small eaters, now, as I heard say, be become so great devourers and so wild, that they eat up, and swallow down the very men themselves…"

Thomas More continued (1516):

> "They consume, destroy, and devour whole fields, houses, and cities. For look in what parts of the realm doth grow the finest, and therefore dearest wool, there noblemen, and gentlemen, yea and certain Abbots, holy men no doubt, not contenting themselves with the yearly revenues and profits, that were wont to grow to their forefathers and predecessors of their lands, nor being content that they live in rest and pleasure nothing profiting, yea much noying the weal public, leave no ground for tillage: they inclose all into pastures, they throw down houses, they pluck down towns, and leave nothing standing, but only the church to be made a sheephouse. And as though you lost no small quantity of ground by forests, chases, lawns, and parks, those good holy men turn all dwelling places and all glebeland into desolation and wilderness."

Back to the *Intelligence Squared* debate, on the side of the opposition to the motion, Rory Stewart, Conservative MP and Justice Minister delivered the "killing blow" when he vindicated that:

> "The more fundamental point, which I think we keep hedging around is that land in Britain is contested. We are a very densely populated island, we are more densely populated than India, that is one of the reasons why this is so much under pressure, so we have to weight up biodiversity that is under serious threat alongside food production to answer this question of hypocrisy. We need not only think about how much food we produce but how much food we consume, and unless like George you become a vegan, if you continue to eat sheep but if you drive those sheep out of the British uplands, all you're doing is pushing the environmental damage onto somebody else's country. Those same sheep are out there, they are eating up some of someone else's country and releasing methane into the air and destroying the climate from somebody else's country."

Monbiot straightforwardly retorts and concludes:

> "Rory is so right, we do really need to stop eating sheep!"

In addition to ecological and biodiversity-related effects, augmented animal product consumption also directly impinges on human health (Tilman & Clark, 2014). For instance, heart disease, the leading cause of human death, is strongly correlated with the consumption of animal products and can be largely obviated or everted by switching to plant-based diets (Campbell, Parpia & Chen, 1998; Ornish et al, 1998). Increased animal product consumption is closely tied to a plethora of 'diseases of nutritional extravagance' such as obesity and associated higher rates of heart disease, cancer, and diabetes, among other ailments (Menotti et al, 1999; Lock et al, 2010; Popkin et al, 2012; Pan et al, 2013). Under circumstances of food profusion, diets based largely on plant foods are associated with health and longevity, and shifts towards diets richer in animal products often emblematize less-healthy populations (Nestle, 1999).

Additionally, as livestock densities heighten and assemble in closer confines with wildlife and humans, there is an augmented risk of disease that threatens every single human. In fact, 66 percent of the emerging diseases in humans have animal origins (zoonosis) and one or two of these maladies are unknown to mankind and surge every year. Together with this, hormones and antibiotics used in industrial meat production also end up affecting human health (FAO, 2012).

In addition, studies have proposed that even modest admissions of foods of animal origin are coupled with noteworthy plasma cholesterol concentrations, which are correlated with considerable rises in chronic degenerative disease mortality rates (Campbell & Junshi, 1994). This has been proven indisputable with recent trends in China since diets of Chinese people that are higher in animal products and associated with increases in many diseases (Shu et al, 1993; Popkin, Adair & Wen Ng, 2012). On the other hand, vegetarian, and specifically vegan diets can occasionally be impaired in B vitamins (McDougall, 2002), however, this scarcity can be addressed through small amounts of animal products (especially fish) in the diet, dietary diversity, or supplements (Davis & Kris-Etherton, 2003).

Finally, and before moving forward to other segments that will include human carnivory and the vast repercussions of the livestock 'community', a reflection is in order. As Joseph Poore, lead author of the *Science* paper *Reducing food's environmental impacts through producers and consumers* (2018) said in an interview with *The Guardian* (Carrington, 2018c):

> "Agriculture is a sector that spans all the multitude of environmental problems. Really it is animal products that are responsible for so much of this. Avoiding consumption of animal products delivers far better environmental benefits than trying to purchase sustainable meat and dairy."

Poore completes his reasoning by stating:

> "A vegan diet is probably the single biggest way to reduce your impact on planet Earth, not just greenhouse gases, but global acidification, eutrophication, land use and water use. It is far bigger than cutting down on your flights or buying an electric car."

Although Poore got it right when asserting the manifold maledictions of human carnivory, he is incorrect when stating that changing to a vegan diet is the single best solution to bypassing the considerable environmental repercussions, and to this extent I will cite Blake Alcott's retort to the study led by Poore in a Letters Edition in *The Guardian* (Smith, Climie & Alcott, 2018):

> "Your report on the study (Carrington, 2018c) is right about everything concerning our production of meat and dairy foods except that by far the single most effective thing you can do to reduce your environmental footprint is to not reproduce. The most recent of many studies showing this published in 2017 by researchers at Sweden's Lund University and Canada's University of British Columbia (Carrington, 2017b) found that having one fewer child was about 60 times more effective than eating a plant-based diet, 30 times better than avoiding airplane travel and 20 times better than living car-free. Since the study by Poore did not rigorously compare the environmental impact of our diet with such other factors, he cannot base his claim that diet is "the single biggest way" for us to lower our footprints on that study. It is not in the interest of either sustainability or quality of life for *The Guardian* to continue to almost always regard population size as a negligible impact factor. All environmental and animal-welfare problems are much easier to solve at the present human population level - or of course lower - than after the highly likely addition of 2 or 3 billion more people in the next few decades."

This is exactly the point that we need to home in on. Despite the many and pervasive effects of the livestock population, we need to remain intellectually honest on the spectrum of mitigation strategies, and so far, the literature has been unambiguous on the evident influence of choosing to reduce one's family size compared to changing one's diet. Moving forward, I will continue to unearth a myriad of reverberations from the livestock sector, but regardless of its corruption of the natural world we need to keep our priorities in place, and population must stand at the top.

Competitive Displacement

"Except for giant meteorite strikes or other such catastrophes, Earth has never experienced anything like the contemporary human juggernaut. We are in a bottleneck of overpopulation and wasteful consumption that could push half of Earth's species to extinction in this century."

- E. O. Wilson

Five thousand years ago the Earth most likely accommodated fewer than 20 million people; at the beginning of the Common Era the total was about 200 million; a millennium later it had risen to about 300 million; in 1500, at the onset of the early modern era, it was still less than 500 million, and one billion was surmounted shortly after 1800. In 1900 the total was about 1.6 billion, in 1950, 2.5 billion, in 2000, 6.1 billion, and in 2017 it surpassed 7.5 billion. Consequently, there has been a 350-fold increase in 5,000 years, more than a 20-fold gain during the last millennium, roughly a quadrupling between 1900 and 2010 (Smil, 2011), and as the late William R. Catton said in an interview in 2009, "my generation was the only one in the history of mankind to see its population more than triple in size" (Gardner, 2017).

The world's 7.6 billion people epitomize just 0.01 percent of all living beings (figure 5.24), according to a new study, *The biomass distribution on Earth* (2018), authored by Yonon Bar-On and colleagues. However, since the dawn of civilization, humanity has elicited the loss of 83 percent of all wild mammals and half of plants while livestock and other domestics nursed by humans overflow and displace the natural world in their wake (Carrington, 2018d).

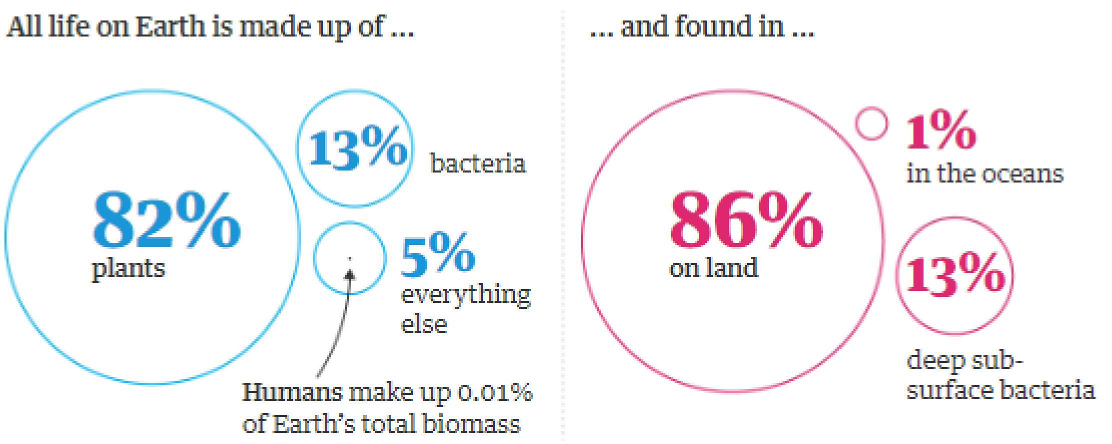
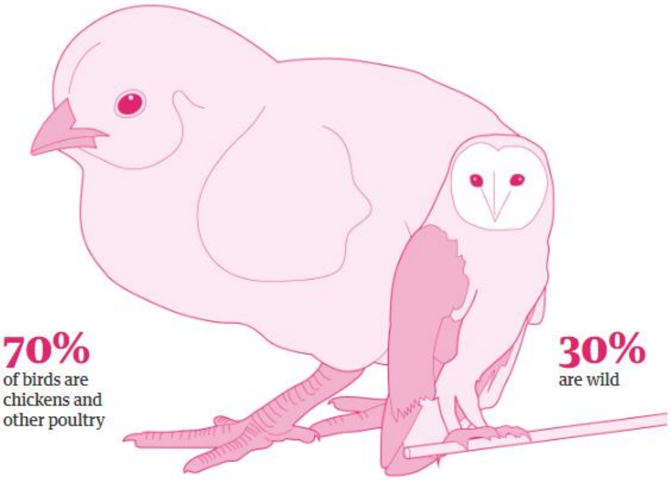


Figure 5.24: The total biomass of the human race accounts for just 0.01 of the life on Earth. Source: The Guardian; Proceedings of the National Academy of Sciences of the United States of America. Retrieved from Carrington, 2018d.

The integral metamorphosis of the planet by human activity has convinced scientists to declare a new geological Epoch, the Anthropocene (Carrington, 2016a) (this subject was addressed in the chapter Where the Wild Things Were), in which, one suggested indicator for this transmutation of the planet was the widespread existence of bones of domestic chicken, that have now become ubiquitous and pervasive across the globe (Carrington, 2016b).

The new work from Bar-On et al. (2018) has divulged that farmed poultry accounts for up to 70 percent of all bird species on the planet, with a dwindling number of 30 percent being wild (figure 5.25). To say nothing of mammals, in which the circumstances are even more severe - 60 percent of all mammals on Earth are livestock, mostly cattle and pigs, 36 percent are human and a bare 4 percent are wild animals (Carrington, 2018d) (figure 5.26).



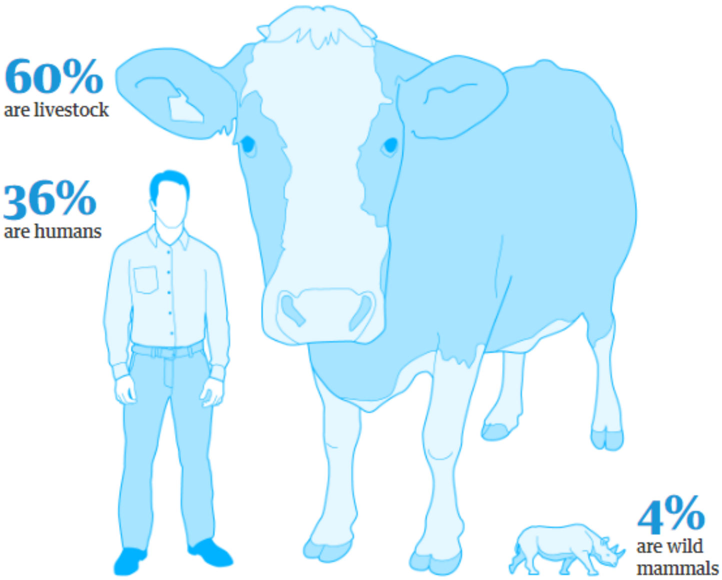


Figure 5.25: Of all the birds on Earth, 70 percent are chickens and other poultry and less than 30 percent are wild. Source: The Guardian; Proceedings of the National Academy of Sciences of the United States of America. Retrieved from Carrington, 2018d.
Figure 5.26: Of all the mammals on Earth, 96 percent are livestock and humans, only 4 percent are wild mammals. Source: The Guardian; Proceedings of the National Academy of Sciences of the United States of America. Retrieved from Carrington, 2018d.

The ravaging and wrecking of wild habitat for farming, logging, urban development, material acquisition and an amalgamation of other human activities have resulted in the start of what scientists are dubbing the sixth mass extinction of life (Carrington, 2017c) to occur in the Earth's four billion year biography. Owing to the disorderly proliferation of the human species and its exertions, it is estimated that roughly half of the Earth's animals have been annihilated in the short geological time of just 50 years (Carrington, 2014a).

In order to understand how this ecological revolution came to be, there is a need to compare contemporaneous estimates with those for the time before humans had settled with agricultural developments and when the industrial revolution was gaining speed. To everyone's consternation and perplexity, just one-sixth of wild animals, from mice to elephants, endure. In the oceans, three centuries of whaling and providing for the nutritional needs of a growing populace has left just a fifth of marine mammals in the oceans (Carrington, 2018d) (figure 5.27).

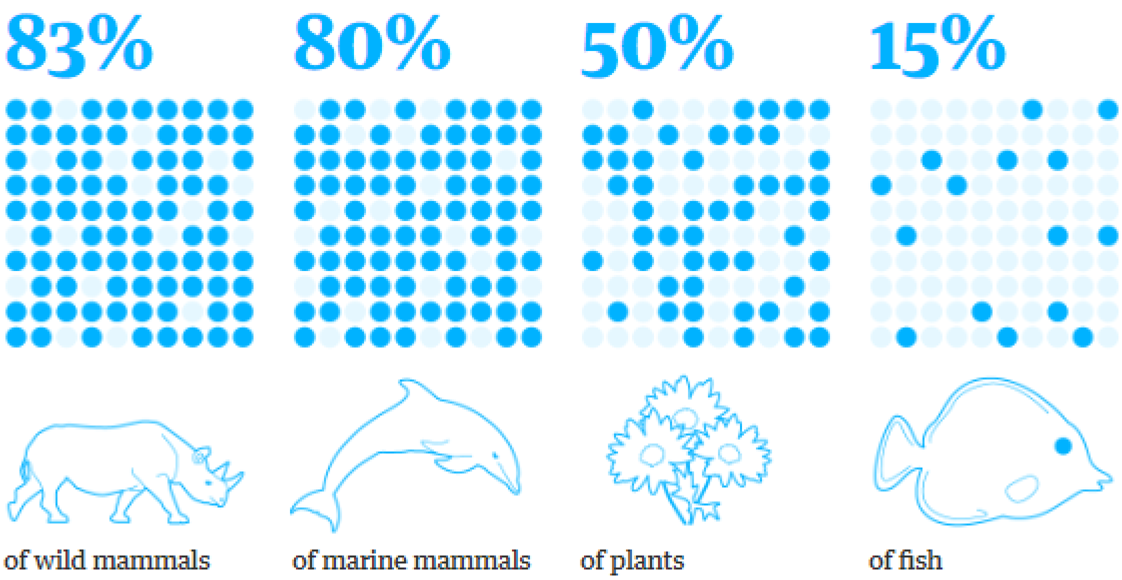


Figure 5.27: Since the rise of human civilization 83 percent of wild mammals, 80 percent of marine mammals, 50 percent of plants and 15 percent have been lost. Source: The Guardian; Proceedings of the National Academy of Sciences of the United States of America. Retrieved from Carrington, 2018d.

Commenting on the staggering results of the study, Ron Milo, one of the authors said to *The Guardian* (2018):

> "It is definitely striking, our disproportionate place on Earth. When I do a puzzle with my daughters, there is usually an elephant next to a giraffe next to a rhino. But if I was trying to give them a more realistic sense of the world, it would be a cow next to a cow next to a cow and then a chicken."

Notably, the human population is still growing by roughly 1.2 percent per year (UNDESA, 2015), but together with this problem there is still another one that looms and goes almost unnoticed, which is the 2.4 percent growth of livestock per year (Alexandratos & Bruinsma, 2012), that accompanies the augmentation and appetite of the human populace (Monbiot, 2015b).

Apart from the extremely disquieting fact that raising this 'other' population already uses three-quarters of the world's agricultural land, the food factory also consumes upward of 70 percent of the freshwater taken from ecological watersheds, thus dispossessing nonhuman species of the needing factors for their survival (Crist, 2016).

The bioecologist and ecological economist William Rees, co-creator of the "ecological footprint" concept, was interviewed in the *Peak Prosperity* podcast (Martenson, 2017), in which he asserted:

> At the dawn of agriculture, just ten thousand years ago, human beings accounted for less than 1 percent of the total mammalian biomass on the planet. Today, there's been a sevenfold increase, roughly speaking, in the biomass of vertebra species on the planet -- but most of that is human-induced. Today, human beings account for about 32 – 35 percent of the total biomass of mammals, a much greater biomass than at the dawn of agriculture. But when we throw in our domesticated animals and our pets, humans and their domesticated animals amount to 98.5 percent of the total weight of mammals on planet Earth.

So we're engaged here, through sheer growth, in the scale of the human enterprise in what ecologists refer to as "competitive displacement". This is a finite planet. There's a finite flow, a limited flow, of photosynthetic energy through the planet which we share with millions of other species. Now, on a finite planet with limited energy flow, the more any one species takes the less is available for everything else. So as humans have gone from less than 1 percent of the total biomass to over 98.5 percent of an increased biomass, it means that almost all other species with which we share that photosynthetic flow have been pushed off the planet.

So we've gone from millions to a few thousand elephants. We've gone from hundreds of thousands, maybe even millions, of tigers to a handful. And so on. Wildlife on the planet today is clinging to the edges of existence. They may not have gone extinct, but their populations have been reduced to a tiny fraction -- a few percent at best -- of what used to be.

North America used to have 40 to 60 million bison regularly migrating north and south through our great plains. Well, today there's only a few thousand bison on domesticated farms or in a couple of parks -- they've been replaced utterly by the food crops that we grow to feed humans or to support our domestic animals. Competitive displacement has revealed humans to be the fiercest competitors on Earth for the planet's living resources, forcing nearly all other species to essentially disappear."

It is important to realize that global anthropomass is now an order of magnitude greater than the mass of all wild terrestrial mammals. In effect, the addiction of harvesting the products of photosynthesis for food, animal feed, raw materials, and energy has amplified immensely, making considerable global impacts (Smil, 2011). Today, the biomass of humans is roughly equal to 0.06 Gigatons of Carbon (Gt C), while the biomass of livestock, dominated by cattle and pigs, is predicted to be around 0.1 Gt C. Conversely, the biomass of wild mammals, which has a mass of 0.007 Gt C, is far surpassed by that of humans and livestock put together. Moreover, the same applies to wild and domesticated birds, for which the biomass of domestic poultry (0.005 Gt C), which is dominated by chicken, is about three times higher than that of wild birds (0.002 Gt C). In fact, humans and livestock outweigh all vertebrates combined, with the exception of fish (figure 5.29) (Bar-On, Phillips & Milo, 2018).

The zoomass of wild vertebrates is now vanishingly small compared to the biomass of domestic animals (figure 5.28). To demonstrate the dimension of this predicament, in 1900 there were a predicted 1.6 billion large domesticated animals, which included about 450 million head of cattle and water buffalo (History Database of the Global Environment, 2010); a century later the count was 4.3 billion domestic ruminants on Earth in 2011 (1.65 billion cattle and water buffalo, 1.1 billion sheep, 0.9 billion goats as well as around 900 million pigs) (FAOSTAT, 2017), and on average, 25 million domestic ruminants have been supplied to the planet each year over the past 50 years (Ripple et al, 2014). Moreover, cattle zoomass alone is now at least 250 times superior to the zoomass of all surviving African elephants, which in turn is less than 2 percent of the zoomass of Africa's nearly 300 million bovines (Smil, 2011).

For instance, in some countries, domestic animals have attained unparalleled densities. In 2009 the Netherlands had nearly 4 million head of cattle, more than 12 million pigs, and 1.1 million sheep and goats (Product Boards for Livestock, Meat and Eggs, 2010). The live weight of this zoomass was about three times greater than the average anthropomass per hectare. Even more striking, this high density of domesticated zoomass was an order of magnitude superior to the biomass of all soil invertebrates and was overthrown only by the mass of soil bacteria. In either case, even very high Dutch crop yields cannot sustain such densities of domesticated zoomass, consequently, the country ends up becoming a major importer of animal feed (Galloway et al, 2007).

Furthermore, by 2050, the global cattle population may swell by more than a billion animals, and the global goat and sheep population by over 700 million animals (Hubert, Rosegrant, van Boekel & Ortiz, 2010) (figures 5.28 and 5.29). Together with this, total additional livestock biomass will be in the order of 400 million tonnes, or 400 billion kg. The average human weight is 52kg (Bailey, Froggatt & Wellesley, 2014) and the foreseen rise in population by 2050 will be of 2.3 billion or 29 percent rise relative to 2018 (median estimate is 9.9 billion by that date) (PRB, 2018). So, by 2050, the world's living systems will have to shoulder about 120 billion kg (120 million tonnes) of extra humans, and 400 billion kg of extra farm animals (Monbiot, 2015b).

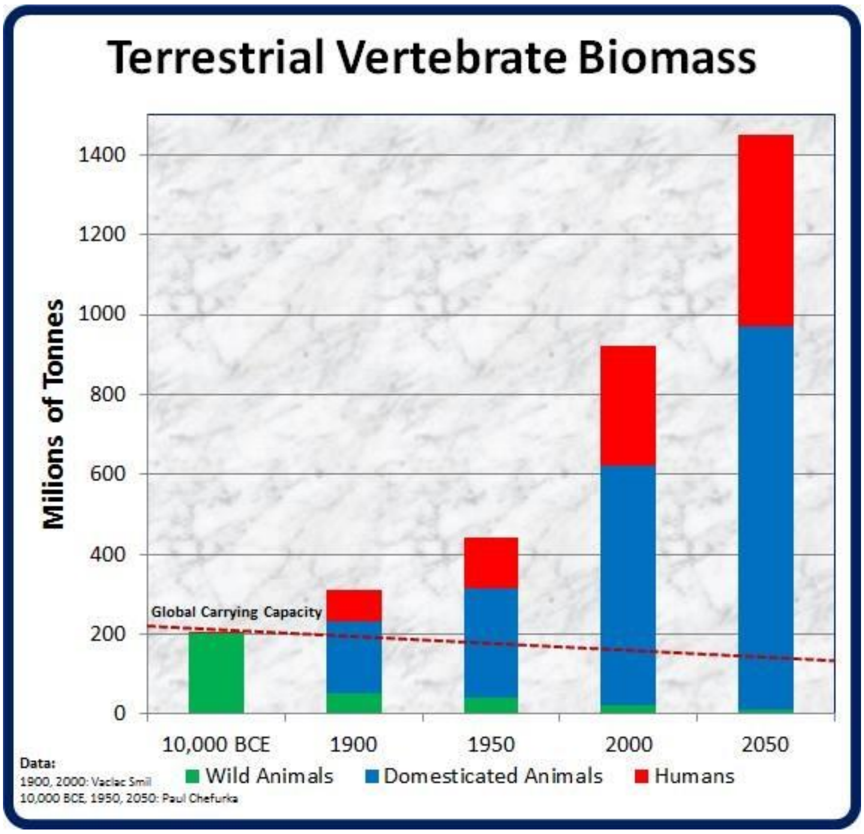


Figure 5.28: Terrestrial Vertebrate Biomass change over the last 10,000 years and projections to 2050. Source: Vaclav Smil, 2011. Retrieved from Patterson, 2017.

Consequently, this translates into the cattle zoomass now being at least 60 percent larger than the anthropomass with the live weight of the two species put together being about one billion metric tons. Even the largest wild mammals add up to only a small fraction of those masses: The 352,000 savanna elephants in Africa (Great Elephant Census, 2017), with an average body weight of 2,800 kg, have an aggregate zoomass of less than one million metric tons, less than 0.2 percent of cattle zoomass (Smil, 2017).

There is no doubt that the aggregate mass of humans, cattle and other domesticates (figures 5.28 and 5.29) is staggeringly larger than the total mass of all wild mammals, and it is apparent that insufficient space is left for a multitude of other species. It is unmistakable and unambiguous that cows and men monopolize much of the available land, devour much of its photosynthetic product, and generate an increasing amount of greenhouse gas (Smil, 2017).

Finally, I would like to call attention to the green, wild animal, portion of the graphs above. Notice the wild animal portion of the terrestrial vertebrate biomass, by 1900, had dwindled to about 20 percent of its historical value. Then by 2000, it had withered to half that amount. The prognosis is, by 2050, for that value to be cut in half again (Patterson, 2017).

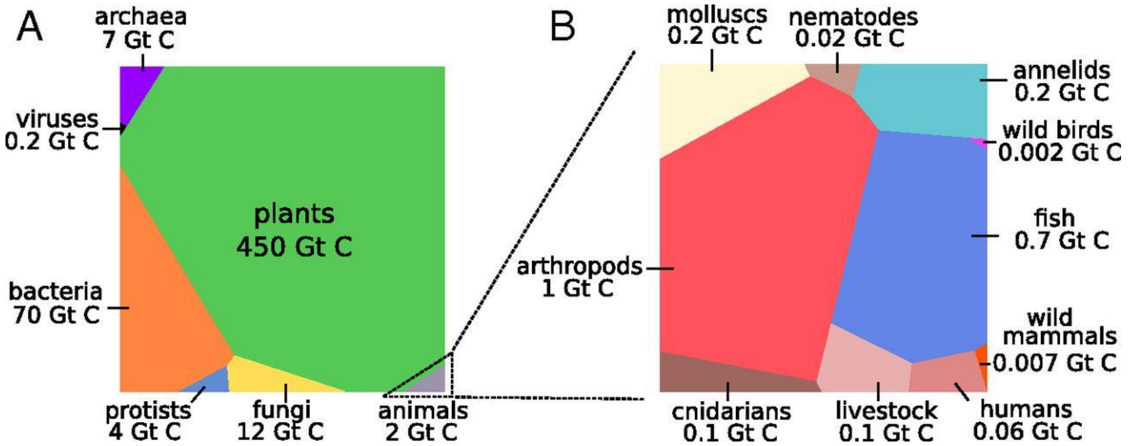


Figure 5.29: Graphical representation of the global biomass distribution by taxa. (*A*) Absolute biomasses of different taxa are represented using a Voronoi diagram, with the area of each cell being proportional to that taxa global biomass (the specific shape of each polygon carries no meaning). (*B*) Absolute biomass of different animal taxa. Related groups such as vertebrates are located next to each other. Authors estimate that the contribution of reptiles and amphibian to the total animal biomass is negligible. Retrieved from Bar-On et al, 2018.

By 2100, the most likely scenario will be for most of it to be gone (if all the projections already reviewed throughout this work have not been underestimating or on the conservative side of the extension of our impacts). The likely survivors will be rats and mice and perhaps other small vertebrates and other species that enjoy selective advantages of near-cohabitation with humans, but all the megafauna will be obsolete. At least on a biological scale, on a geological scale evolution continues to operate, and it may once again, in a few million years give rise to megafauna. But that will be on a planet in which the human population has been greatly reduced to a billion or even a few million people so that the biosphere can recuperate its former - biophysical - glory (Patterson, 2017).

But the far distant future is of little consideration to us now. The disheartening and tragic fact is that the descendants of everyone reading this will inhabit a world completely vacant and devoid of wild megafauna. I would like to be optimistic in this regard, but that would be intellectually dishonest since the data and evidence supports a vacant world (Patterson, 2017).

To summarize, the seeming expostulation that humanity is uniquely competent in keeping food production apace with (or ahead) of demographic growth manifests an abysmal deficit of perspicacity into the bigger picture of what elongating our food-producing capacity can premonish. In essence, the question should not be if there are limits to our food producing proficiency, which will (or not) withhold human demographic growth, rather, it is choosing the wisdom of limitations and humility, to not transform the planet into a human food factory and allow for the rewilding of vast expanses of the biosphere’s landscapes and seascapes (Crist, 2016).

Diet, Affluence and China

"Overconsumption and overpopulation underlie every environmental problem we face today."

- Jacques Yves Cousteau

"Affluence is not our greatest achievement but our biggest problem."

- Charles C. Mann, quoting William Vogt *in Can Planet Earth Feed 10 Billion People* (2018)

"The combination of population growth and the growth in consumption is a danger that we are not prepared for and something we will need global cooperation on."

- Maurice Strong

So far, it has been established that the human population and its domestics are rising almost in tandem. But it is not just these numbers that are problematic. Equally important is the fact that humanity is growing richer, and as humans acquire more affluence and better quality of life, they also tend to consume more meat and other animal products. This segment will focus on that change.

On the 25th of March 2014, the top executives of the Brazilian meat giant JBS were in New York to announce the results of their fiscal year, and the company couldn't be more elated and exultant since global meat consumption is escalating and JBS intended to not miss that train (JBS, 2014a). This Brazilian based company told their shareholders in Wall Street that a crucial aspect of their future prospects relied on the fact that a 30 percent increase in per capita global meat consumption to 48 kg by 2030, up from 37 kg per person in 1992, was to be expected (JBS, 2014b; IATP, 2018).

From what has been possible to discern so far in this work, there was a vital factor that JBS overlooked when presenting their contemplations of the future to its investors: climate change. If global meat production were to expand to 48 kg per capita, it would be inexecutable and unfeasible to maintain global temperatures from rising to perilous and jeopardous levels (Kim, Neff, Santo & Vigorito, 2015). To put these numbers from JBS into perspective, a report from Greenpeace (2018) claims that not only average per capita meat consumption cannot rise any further, it must be curtailed to 22 kg by 2030, and then to 16 kg by 2050, in order to avoid the worst repercussions of climate change, as it is described in the figure 5.30 below (IATP, 2018).

Despite the fact that the Food and Agriculture Organization of the United Nations (FAO) published the first global accounting of greenhouse emissions from meat and dairy, more than a decade ago, revealing the global livestock's connection and impact with climate change (Steinfeld et al, 2006) and ensuing studies strengthening that initial assessment (Gerber et al, 2013), the biggest meat and dairy companies prevail committed to a narrative of growth that is comprehensively and entirely at odds with the agreement reached in Paris, 2015 by the world's governments to keep the global temperature rise to "well below 2 degrees Celsius (ºC)," with the aim of circumscribing it to 1.5 ºC (United Nations Framework Convention on Climate Change, 2018).

If humanity is serious about reaching its 1.5 ºC goal, total global emissions must precipitately decrease from 51 gigatons (1 gigaton = 1 billion tons) to 13 gigatons by 2050 (Figure 5.30). Important to realize is that under a business-as-usual scenario, the livestock sector could consume over 80 percent of the 13 gigatons budget, making it virtually inconceivable to keep temperatures from rising over 1.5ºC. In direct contradiction to JBS's and its counterparts standpoint for continued growth, climate change's urgency and exigent action require a scaling down and complete reformulation of business practices (IATP, 2018). Besides the herculean task of reforming the whole economic system to prioritize even humanity's survival in the long term rather than short-term profit, our biggest problem is the simple fact that demand will keep on rising, fueled by an ever-increasing population growth and the expansion of the global middle class.

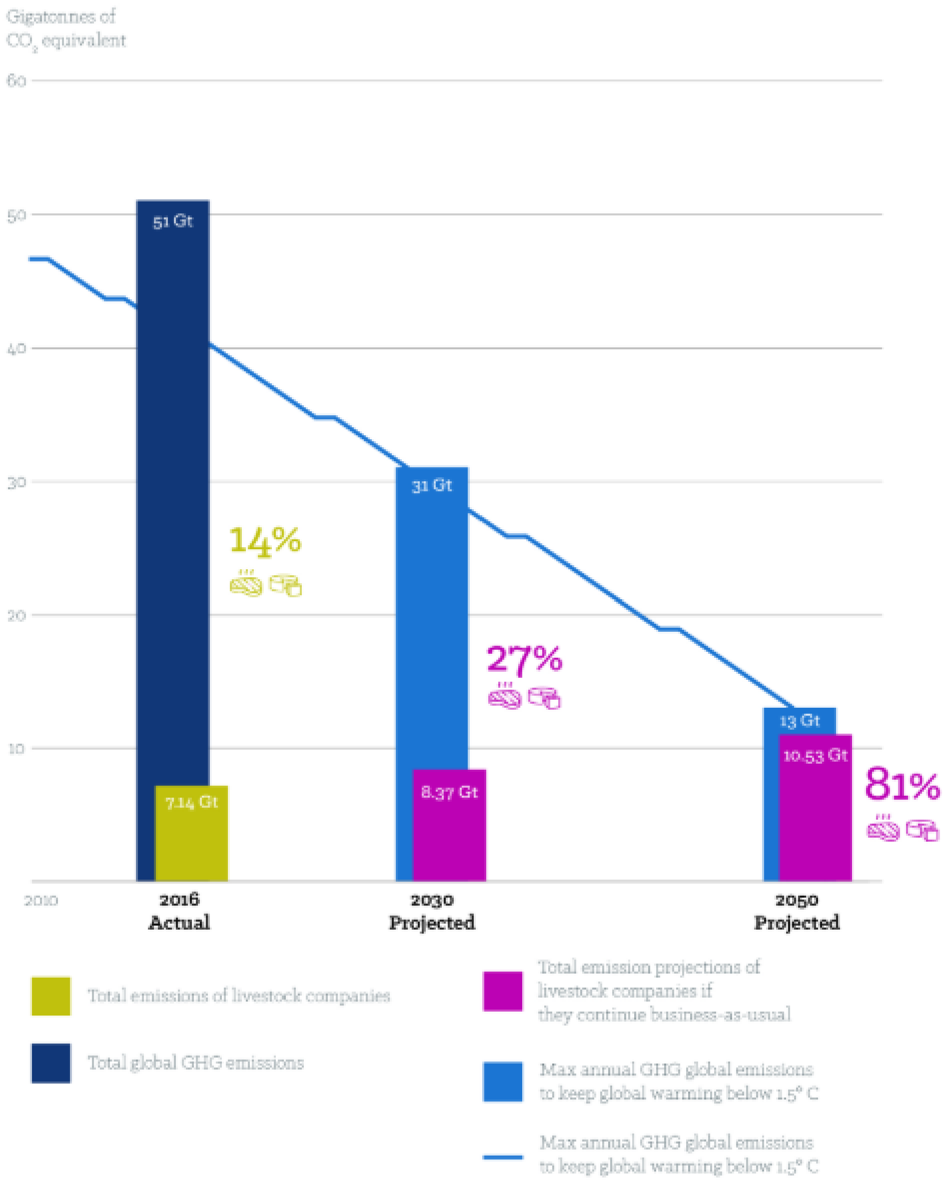


Figure 5.30: Estimated global greenhouse gas emission (GHG) targets to keep within a 1.5ºC rise in temperature compared to emissions from global meat and dairy production based on business-as-usual growth projections. Sources: GRAIN and IATP. "Climate Action Tracker: Global emissions time series." Climate Action Tracker project (2017). Retrieved from Institute for Agriculture & Trade Policy (2018).

With current diets and production practices, feeding 7.6 billion people is affecting the integrity and maintenance of terrestrial and aquatic ecosystems, depleting water resources, as well as begetting the onset of runaway climate change (Godfray et al, 2010; Foley et al, 2011).

Before moving forward in this segment, I do have to introduce one much-needed equation. To the readers who are not well-versed in mathematics, you can rest assured because this equation is quite simple and straightforward and also crucial in the study of Population and per capita wealth (Affluence). Obviously, I am talking about the **I = PAT** equation, which is used to describe the impact of human activity on the environment.

I = P x A x T

This expression is commonly known as the Ehrlich and Holdren (1971) equation, and it tells us quite openly that the impact (I) of human activity is the product of three factors: the size of the population (P), its level of affluence (A) expressed as income per person and a technology factor (T), which gauges how resource intensive the production of affluence is; how much environmental impact is implicated in creating, transporting and disposing of the goods, services and amenities used. In the interest of this segment, and chapter as well, I will focus the analysis on the factors of Population (P) and Affluence (A). Nevertheless, this equation is pertinent to the entirety of this work, so the reader is invited to mark this page for a future reminder.

In effect, a wealthier population (with higher affluence) will as a rule, consume more than a poorer population of the same size, but will also be better able to invest in the development of new technologies (T) that may cut down their impact on resources - or augment it (Kuhlemann, 2018). In theory, for an economy to rise while solving the environmental crisis, decoupling needs to happen. So far, expanding economies, also have swelling consumption of materials, food, and energy needs, as well as augmented carbon, water and ecological footprints. Under these circumstances, economists postulate that to grow without harming the environment, one needs to 'decouple' the economy from its ecological impact (William, 2012).

For this reason, technology can be used to increase efficiency in resource use, give us carte blanche to make more with less. But it can also be employed to extract resources faster and more cheaply, concealing their scarcity, encouraging overuse or otherwise accelerating resource depletion (Kuhlemann, 2018). Moreover, for as long as the T factor is decreasing, then we are safe in the knowledge that we have relative decoupling (definitions). But for absolute decoupling (definitions) we need (I) to go down as well. And that can only materialize if (T) goes down expeditiously enough to outpace the rate at which population (P) and income per capita (A) go up (Jackson, 2009).

Inasmuch as the standard assertion in neoclassical economics maintains that (T) will forge the necessary space, Tim Jackson in *Prosperity Without Growth* (2011) contends that (with a focus on carbon emissions), augmentations in population and affluence will, under business-as-usual, extend CO_2 emissions by 80 percent by 2050, inducing atmospheric concentrations that go way beyond what is considered bearable, let alone secure for human flourishing. To counterbalance this trend, (T) would have to be revamped approximately by 7 percent per year – ten times faster than at present. When adding to the mixture the yearly revised population trends, which keep boosting population numbers by 2050 (most up-to-date revisions upgraded the projection to 9.9 billion by 2050 (PRB, 2018; Higgs, 2014).

Correspondingly, the contribution of population size to our environmental impact is comparatively univocal and indubitable. For any given level of affluence, technology use or environmental limitation, and regardless of which way these factors pull, a smaller population size will translate into lesser environmental impacts, delayed resource depletion and a greater range of alternatives to grapple with resource scarcity. On the other hand, a more considerable population will have a greater environmental impact, an accelerated rate of resource depletion, fewer alternatives for coping with scarcity by virtue of the succession of multiple deficiencies, greater competition for resources, and a more preeminent number of human lives at risk than would otherwise be the case (Kuhlemann, 2018).

For Jackson (2011, quoted in Higgs, 2014), this is the crux of the issue:

> "The scale of improvement required is daunting. In a world of nine billion people, all aspiring to a level of income commensurate with 2 percent growth on the average EU income today, carbon intensit[y]… would have to fall… 16 times faster than it has done since 1990. By 2050, the global carbon intensity would need to be only six grams per dollar of output, almost 130 times lower than it is today."

Population size *always* matters, and in our present age, a more undersized population is a more resilient one (Kuhlemann, 2018). This subject will be properly investigated in an upcoming volume, in the chapter Energy Bill.

One crucial and vital aspect of the human diet that is severely affected by population growth and overconsumption and that has been superficially touched throughout this work is the fact that one-third of global fisheries are functioning at unsustainable levels. As it currently stands, roughly 3.2 billion people around the world depend on fish for nearly 20 percent of their animal protein. That translates into more than 150 million metric tons of fish every year being excised from the ocean - and as the human populace expands by a couple billion over the next decades, that number is guaranteed to rise (Gaworecki, 2018a).

Just like the meat and dairy industry that is eager to capitalize on this human growth to elevate their profits, the same situation is proceeding with the fishing industry. Then again, overfishing is already jeopardizing the global supply of fish and there is an array of reasons to be skeptical that this growth could be achieved in a sustainable fashion, when taking into account the scale of demand/essentiality to feed the people that are already here and the billion more passengers to come, as well as the rise in affluence of the growing middle-class that will ask strongly for more fish protein in their meals (Gaworecki, 2018a).

In accordance to FAO's latest report *The State of The World Fisheries and Aquaculture* (SOFIA) (FAO, 2018c), José Graziano da Silva, FAO's Director-General stated (FAO, 2018d):

> "Since 1961 the annual global growth in fish consumption has been twice as high as population growth, demonstrating that the fisheries and aquaculture sector is crucial in meeting FAO's goal of a world without hunger and malnutrition. The sector is not without its challenges, however, including the need to reduce the percentage of fish stocks fished beyond biological sustainability."

Notwithstanding the fact that the amount of fish captured in the wild reached its zenith in the 1990s, remained stable ever since, and the explosive growth of aquaculture is showing signs of slowing down, *SOFIA*'s report claims that fish production will swell to 201 million metric tons by 2030. That will materialize into a growth of 20 percent over the 171 million metric tons produced in 2016, when the world's human population ate 20.4 kilograms of fish per capita, compared to 10 kilograms per capita in the 1960s. The report elucidates that roughly 91 million tons of the fish consumed in 2016 were caught in the wild, while production from aquaculture accounted for another 80 million metric tons (Gaworecki, 2018a). Moreover, around two-thirds of global fisheries production is absorbed by humans and a third is processed to create fishmeal and fish oils as feed for aquaculture and livestock industries (Naylor et al, 2000; Naylor et al, 2009; Smith et al, 2011; Merino et al, 2012).

But feeding this voracious human appetite for fish has come at a substantial cost, with a third of the fisheries being monitored by FAO currently facing extirpation at unsustainable levels (Gaworecki, 2018a).

The *SOFIA* (FAO, 2018c) report asserts:

> "The state of marine fishery resources, based on FAO's monitoring of assessed marine fish stocks, has continued to decline. The fraction of marine fish stocks fished within biologically sustainable levels has exhibited a decreasing trend, from 90.0 percent in 1974 to 66.9 percent in 2015. In contrast, the percentage of stocks fished at biologically unsustainable levels increased from 10 percent in 1974 to 33.1 percent in 2015, with the largest increases in the late 1970s and 1980s."

In light of this, the most unsustainable fisheries are to all appearances being found in the Mediterranean Sea, the Black Sea, the Southeast Pacific Ocean and the Southwest Atlantic Ocean. In spite of the extended growth of fish stocks being expunged at unsustainable rhythms, the report discloses that some progress has still been made toward attaining the UN's Sustainable Development Goal 14 (UNDESA, 2017), which sets forth an effective regulation of fish harvesting, science-based management plans to restore stocks, and an end to overfishing, illegal fishing, and other ravaging practices. *SOFIA* (FAO, 2018c) reports that most of those gains have been specifically regional, with the United States and Australia, for example, revealing better fishing practices. In contrast, the report admonishes the worsening situation in developing countries, which are eclipsing the gains made by developed countries (Gaworecki, 2018a).

Andy Sharpless, CEO of the Washington, D.C.-based NGO Oceana contended that:

> "If we want to feed nearly 10 billion people by 2050 in a responsible way, wild seafood will have to play a significant role. That's why the new report from the FAO is discouraging: it shows that the world still has a long way to go toward responsible management of our oceans. The number of overfished marine fisheries has risen over the last four years. And, despite increasingly sophisticated and aggressive fishing techniques, global, catch has continued to decline" (Gaworecki, 2018).

Coupled with all of this, a report published in *Science* (Kroodsma et al, 2018) reveals that commercial fishing now covers a greater surface (>55 percent of ocean) area than agriculture (four times as large), which raises some very necessary questions to the current health of the oceans in the face of an overwhelming need to feed more people with more purchasing capacity. Among their dire findings of how far and wide industrial fishing has reached and breached into, the authors also demonstrate that merely five countries are responsible for 85 percent of commercial fishing measured by million hours at sea. Those are China (responsible for half of all hours measured), Taiwan, Spain, Italy and France. The reader can find the graph with extended information in the Appendix section, figure IV.

Besides this “Malthusian Overfishing” (Pauly, 1990) and aquaculture production exacerbating the growing impacts of agriculture on the world’s native ecosystems is the concurrent increase in the consumption of meat and dairy products around the planet (Bittman, 2008). Animal products presently comprise roughly 21 percent of the weight of food in global human diets - a 24 percent boost since 1960. However, an inordinate discrepancy exists among developed and developing countries. Many developed countries have persistently maintained high animal product consumption rates constituting 40 percent or more of diets by mass (Machovina et al, 2015). This is contrasted with the majority of sub-Saharan countries and most of Southeast Asia which have had a steady pattern of low animal product consumption rates (< 10 percent). Moreover and of concern are the historically-low, but augmenting animal consumption rates found in several countries throughout Asia, Africa and South America - most notably China which quadrupled its animal product consumption from 5 to 20 percent of diets since the 1960s (Bonhommeau et al, 2013).

Since World War II, global meat consumption has amplified by fivefold (Nierenberg, 2005). In addition, demand is rising more rapidly where population is also swelling the most. In the last twenty years alone, meat consumption in the developing world has doubled. Likewise, meat and dairy production is foreseen to double again by 2050 (Steinfeld et al, 2006).

It is important to realize as Brian Machovina and colleagues (2015) claim, that:

> “Though difficult to quantify, animal product consumption by humans (human carnivory) is likely the major driver of deforestation, pollution, climate change, overfishing, sedimentation of coastal areas, facilitation of invasions by alien species (Steinfeld et al, 2006) and loss of wild carnivores (Ripple et al, 2014) and wild herbivores (Ripple et al, 2015).”

Notably, the ramifications of animal products can markedly outstrip those of vegetable substitutes to such a degree that meat, aquaculture, eggs, and dairy usurp roughly 83 percent of the world’s farmland and are partly responsible, with 56 to 58 percent of food’s different emissions, in spite of the fact that they only provide 37 percent of our protein and 18 percent of our calories (Poore & Nemecek, 2018).

To illustrate this reality, in Kenya the growing urban population is envisioned to trigger high consumption of high-value food products specifically meat, milk and eggs. FAO’s representative in Kenya, Gabriel Rugalema told *People Daily* (Waitathu, 2017) that the consumption of such products is in all probability is going to soar by 170 percent by 2050, and that:

> “The country will have to invest adequate resources in the livestock sub sector to enable production of high value food products to feed the growing population.”

Equally important is the testimony from Agriculture, Livestock and Fisheries cabinet secretary Willy Bett, who claims (Waitathu, 2017) that the:

> “Key challenges facing the livestock sector are lack of water, low pasture and poor health. As of today, the livestock is estimated to use 255 million litters of water annually. Extrapolation suggests that nearly 650 million litters of water will be used by livestock in 2050. It bears in mind that Kenya is a water deficit country.”

Rugalema cautions that the country will be grappled with an outlandish growth in the demand for food in the next 30 to 40 years and that, at present time, it is coming to grips with high insufficiency of maize, sugar and milk prompting skyrocketing prices. With this in mind, Kenya’s population is still anticipated to reach 96 million, up from 46 million today, out of which 41 million people will live in urban areas (Waitathu, 2017).

A point often overlooked it that as people improve their wealth, they consume more – more energy, more water and usually more meat, all of which exacerbate the burden on the environment. In Kenya, a piece of meat is one of the first things people treat themselves to when they get a little extra cash, and as the nation's economy grows, so does the taste for beef. Cows have regularly been a traditional form of wealth; now they're big business. In the past 15 years, the number of cows in Kenya has escalated by more than 60 percent to around 20 million, driving a contend for grazing lands (Gettleman, 2017).

As incomes in many developing countries have surged in recent decades, per capita consumption levels of animal products have also increased (Wassenaar, Steinfeld & Jutzi, 2006), including strong growth in the tropics (State of the Tropics, 2017) (figure 5.31). With persistent economic growth, per capita, meat consumption in some developing countries can be scheduled to quickly resemble levels found in high-income industrialized countries of between 80 kg and 130 kg yr^{-1} (Wassenaar et al, 2006). For this reason, heightened per capita consumption of animal products linked with rapidly growing populations in most developing countries will be a potent force driving habitat and biodiversity loss (Machovina et al, 2015).

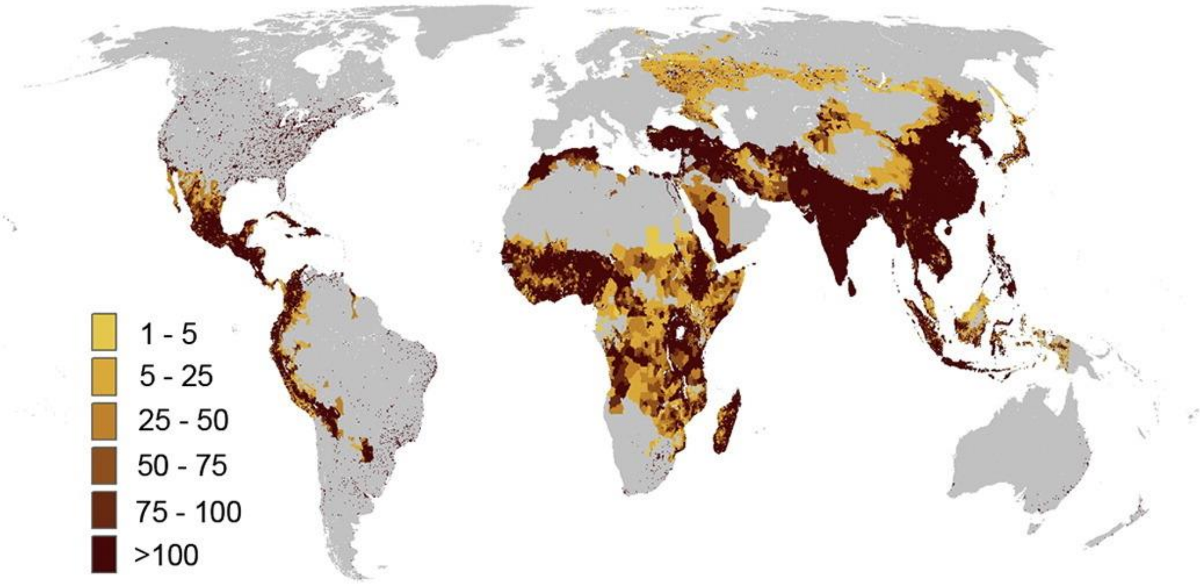


Figure 5.31: Map showing projected global increases of demand for meat (beef, pig, chicken) from 2000–2030. Legend indicates kg/km2 demand increase (FAO, 2011b). Developing countries of Latin America, Africa, and Asia exhibit the highest levels of demand increase. Data for Europe were not available. Retrieved from Machovina et al, 2015

By virtue of altering dietary habits and inflated population densities, China will have especially abysmal future repercussions on biodiversity far beyond its own borders (Machovina et al, 2015). That is to say, from 2000-2030, China will presumptively add over 250 million new households, more than the total number of households in the entire Western Hemisphere in 2000 (Liu & Diamond, 2005).

At present, 20 percent of China's food consumption by mass is animal product-based, bordering the global median, but consumption of animal products is on course to reach 30 percent in 20 years (Keyzer, Merbis, Pavel & van Wesenbeeck, 2005; Bonhommeau et al, 2013; FAOSTAT, 2017). Moreover, already for the past 20 years, animal products have dilated from 10 to 20 percent of Chinese diets and were only 5 percent in 1960. Comparatively, between 1978 and 2002, China's per capita consumption of meat, milk and eggs increased four-, four- and eight-fold, respectively (Liu & Diamond, 2005). Production within the nation has mounted enormously over the past 50 years, with most growth occurring since the 1980s (FAOSTAT, 2017).

It must be remembered that meat has gone from a rare treat to a regular staple for a considerable segment of the Chinese population (Watts, 2008). In 1982, the average Chinese person consumed roughly 13 kg of meat a year and beef was nicknamed "millionaire's meat" due to its scantiness (Milman & Leavenworth, 2016).

The emergence of China as a global economic power has thoroughly revamped the diets of a newly wealthy population. The average citizen now eats 63 kg of meat a year, with a further 30 kg of meat per person expected to be supplemented by 2030 if the trend is not disrupted.

If China latches onto dietary habits akin to those of the United States during the next 35 years, each of its estimated 1.3 to 1.5 billion inhabitants would increase their consumption of meat and other animal-products by an average of 138 percent (Liu & Diamond, 2005; Bonhommeau et al, 2013). India, the world's second most populous country, that is prognosticated to become number one by 2023-24, has also demonstrated ascending animal product consumption with increasing affluence, but its rates of escalation have been lower than China, rising in the vicinity of 15 percent of diets by mass in the 1960s, to 21 percent in the late 2000s (Bonhommeau et al, 2013).

As in India, China's population and income swelled, and many individuals relocated to the cities since 1961. During the last half-century, China's population doubled, while GDP multiplied over 45 times, expanding by nearly 10 percent *every year.* Uniquely, the country has elevated more than 800 million people out of poverty, and reached all the Millennium Development Goals (MDGs) by 2015, while making major strides to the achievement of the MDGs globally (The World Bank, 2018c).

As they multiplied and prospered, the average Chinese consumed twice as many calories, including calories from 8 times more eggs and 14 times more milk and meat. Despite the fact that rising meat consumption in China did contrast with that in India, the amplification of meat consumption was far slower than the augmentation of affluence: 45 times more affluence gave rise to only 14 times more meat consumption (Ausubel et al, 2013).

Presently, China is consuming 28 percent of the world's meat, including half of all pork. Nevertheless, China still drops behind a dozen other countries that have higher per capita meat consumption (figure 5.32) (Myers, 2015), with the average American or Australian devouring twice as much meat per individual compared to Chinese citizens (Milman & Leavenworth, 2016). Australia tops the list, with each resident exhausting on average nearly 100 kg of meat a year - or around 250 g a day (Myers, 2015).

According to a report by WildAid (Grager et al, 2016), the anticipated heightening in China's meat consumption and the tremendous population size of roughly 1.3 billion people would administer an extra 233 million tonnes of greenhouse gases to the atmosphere each year, as well as intensifying the strain on the country's water supply, that is already corrupted by pollution and denuded rivers and groundwater. Additionally, the report states that unchecked Chinese meat consumption will also degenerate its arable land and worsening the country's problems with obesity and diabetes (an estimated 100 million Chinese people suffer from diabetes, more than any other country) (Milman & Leavenworth, 2016).

To put it another way, Asians may be getting wealthier, but their money may not be able to buy them all the food they require, as the region faces a lack of arable land and low agricultural productivity, according to Dutch cooperative lender Rabobank. Diane Boogaard, CEO of Rabobank Asia, said in an interview (Ho, 2017):

> "Although the population growth has slowed down quite a lot in China, the demand for food is still increasing very, very much because of the wealthier population."

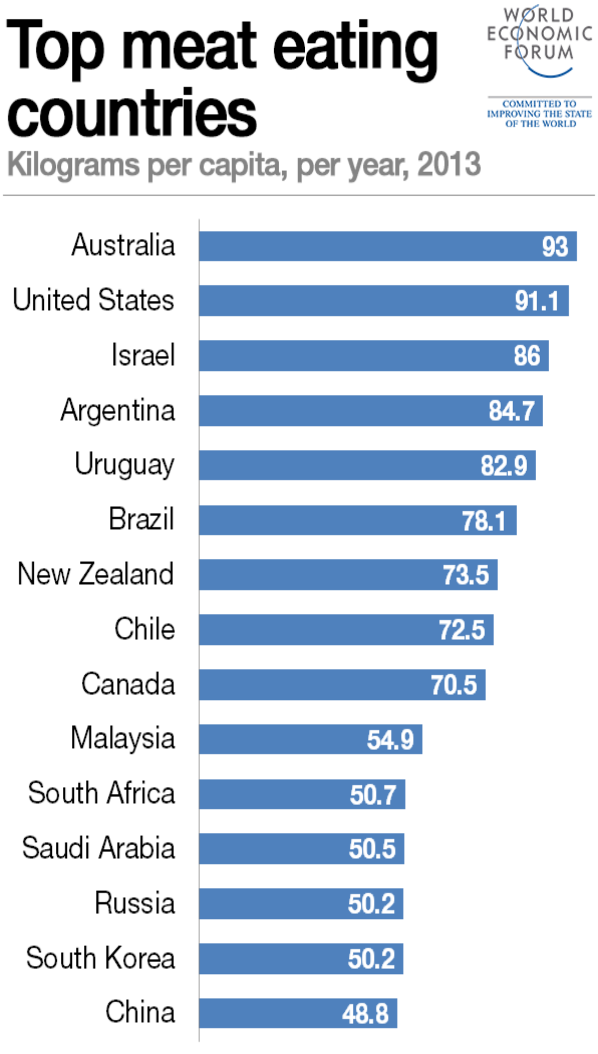


Figure 5.32: Consumption of meat in kilograms per capita, for the year 2013. Retrieved from World Economic Forum by Myers, 2015

She noted that there was not enough land to assuage the demand for more food by the Asian middle class, despite the region being home to the biggest rice producers in the world - China, India and Indonesia. It is important to realize, as Boogaard states that, "Asia imports most of their food and agri products" (Ho, 2017).

It must be remembered that three-quarters of the world's farmers are in Asia but the region has on average less than one hectare of arable land per person to feed its population. In detail, this can be compared with five hectares per person in the U.S., according to Boogaard, who submitted the problem was aggravated by low productivity due to low adoption of advanced technology (Ho, 2017).

Given the rising requirement and its reverberations on food production (Tilman et al, 2001), an illustration is in order, and the production and trade of soybeans and palm oil are perfect examples.

Chinese soybean imports grew from $75 million in 1995 to $38 billion in 2013. On the basis of present trends, one agribusiness study prognosticated that by 2024, Chinese soybean demand could transcend the ongoing soybean production of the United States, Brazil and Argentina combined (Hansen & Gale, 2014; Maverick, 2014). How such demand, echoing the booming meat consumption in only one developing nation, can be consummated without conversion of more forested or other uncultivated lands is unclear (Crist et al, 2017).

Furthermore, growing demand for soybeans (and other feed grains) will to all appearances be recognized as an economic opportunity by third-parties unconcern with the need for sustainable intensification (Maverick, 2014). Another trend has been the diffusion of oil palm plantations replacing tropical forests (Vijay, Pimm, Jenkins & Smith, 2016) by which, palm oil has become a crucial ingredient in processed foods (and non-food commodities). The lucrative contemplation of increasing palm oil production might also supersede the mandate to fend off additional biodiversity extirpation (Crist et al, 2017).

To point out, even though animal product demand has been on the rise, the capaciousness of agricultural land in China has been subsiding under encumbrances of urbanization and land appropriation for mining, forestry and aquaculture. Furthermore, grasslands have been markedly deteriorated by overgrazing and other pressures, with 90 percent of China's grasslands now recognized as degenerated to some extent. Thus, production rates of grasslands have shrunk more or less 40 percent since the 1950s (Liu & Diamond, 2005).

With this in mind, China's inflating propensity for animal products will need to stretch far beyond its own borders to satisfy its needs, importing both meat products as well as feedstocks to generate meats locally (Rae & Hertel, 2000). Much of the livestock production in China is propelled by soy-protein feedstock originated in the Amazon, with annual imports of soy from Brazil mushrooming from zero in 1996 to approximately 7,000,000 tons only 10 years later. Similarly, in 2003 China imported 21,000,000 tons of soybeans - 10 percent of world production - 83 percent more than it imported in 2002, with 29 percent of this soy coming from Brazil (Nepstad et al, 2006). Equally so, in the 10 years from 2002 to 2012, this enlarged nearly 3x to reach 60,000,000 tons (FAOSTAT, 2014). Comparatively, 4,000,000 ha of Brazilian cropland is utilized for exports of soybean to China for livestock feed (MacDonald et al, 2015).

Land grabbing, passing possession to the right to own or use land from local communities to foreign investors through large-scale land acquisitions, first and foremost for agriculture, has heightened perilously since 2005. The increment commenced initially as a feedback to the 2007-2008 global increase in food prices and sprouting food demand (especially in China and India) (Machovina et al, 2015).

In 2010 the World Bank prognosticated that about 45,000,000 ha had been obtained by foreign investors since 2008 (Rulli et al, 2013). Grabbed areas are often in developing tropical countries with sufficient freshwater resources and can constitute a large fraction of a country's area (e.g. up to 19.6 percent in Uruguay, 17.2 percent in the Philippines, or 6.9 percent in Sierra Leone). Other tropical developing countries such as Liberia, Gabon, Papua New Guinea and Mozambique have high grabbed-to-cultivated area ratios, demonstrating that the grabbed land may not have been cultivated before the acquisition but was developed through deforestation or land-use change (Hansen, Stehman & Potavov, 2010; Rulli et al, 2013).

On a global scale and given current tendencies, the expansion of land area transformed into agriculture to comply with growing global food demands is vaticinated to undergo a boost of roughly 18 percent from 2000 to 2050. This equates to a loss of 1,000,000,000 ha of natural habitats - an area larger than the USA (Tilman et al, 2001).

The globalization of food trade, production of foreign fodder sources, and standardization of food products are concocting the substitution of wild and biodiversity-rich agriculture lands with extensive monoculture landscapes (Machovina et al, 2015). Identically, the diversity found within traditional mix-cultured systems is imperiled by this industrialization, including dwindling in bees, butterflies, and plants (Idel, 2013, pp. 157). In addition, the biodiversity encountered within crops of traditional farming systems is subsiding as industrial agriculture expands (Altieri & Merrick, 1987), driven by global requisitions for uniform products that ship and store well (Machovina et al, 2015).

The prevailing discourse creates a crisp dichotomy between the global North and the global South, on shifting the blame for our current predicament, in which the global North has a problem of consumption while the global south has the population issue. International developments further contradict binary expostulations of disproportionate consumption as a developed-world botheration and population concerns as a developing-world predicament (Crist et al, 2017).

Correspondingly, the swelling of the global consumer class, which has increased by hundreds of millions of people in the past two decades and will continue to surge by billions in the decades ahead (Ravallion, 2010; Kharas, 2017) will constitute, nothing less than an existential threat. A global middle class of 3.2 billion people in 2016 is envisioned to ascend to roughly 5 billion by 2030 (Kharas, 2017). Coupled with this seventy percent of India's population is foreseen to enroll the ranks of the middle class by 2026, supplementing almost half a billion consumers to the global economy (up from 50 million in 2006) (Gupta, 2011). Equally important is Africa, which is predicted to reach between 3 billion and 6.1 billion people by 2100, from 1.2 billion people today (Engelman, 2016). Likewise, as the middle class in Africa, Asia, and Latin America continues to amplify - a reasonable expectation and policy orientation - the stress added to that of the developed world on the biosphere will become severe (Crist et al, 2017).

As the global middle class grows, the world is merging in the trajectory of increased consumption. But the rising meat consumption is just the tip of the iceberg in ascending affluence. With it there is an increase in purchases of processed and packaged foods, more international travel, and multiplying numbers of automobiles, personal computers, and electronic devices to name just a few areas in which the impacts from consumer demand for food, energy, materials, and infrastructure are poised to escalate. For the most part, the global consumer society surfacing in our time requests recognition that stabilizing and eventually reducing the global population is essential for lowering total consumption. Reducing excessive per-person consumption, along with other shifts and policies, is also needed (Crist et al, 2017).

On a positive note, it seems as though the Chinese government has taken notice into the gargantuan predicament that is brewing in the country and is set out to outline a plan to reduce its citizen's meat consumption by 50 percent (Milman & Leavenworth, 2016).

The new dietary guidelines (The Chinese Dietary Guidelines, 2016) designed by the China's health ministry recommend that the nation's 1.3 billion people should strive to consume between 40g to 75g of meat per person each day, which would translate into 14 to 27 kg a year, from the contemporaneous 63 kg (and due to increase by 30 kg) (Milman & Leavenworth, 2016).

In the long run, and if the measures are applied successfully, they could have major beneficial impacts, not just on public health, but also in applying a substantial cut to greenhouse gas emissions, which would result in a dwindling of carbon dioxide emissions from the livestock industry equivalent to 1 billion tonnes by 2030, from a projected 1.8 billion tonnes in that year (Milman & Leavenworth, 2016).

Li Junfeng, director general of China's National Center on Climate Change Strategy and International Cooperation affirmed that (Milman & Leavenworth, 2016):

> "Through this kind of lifestyle change, it is expected that the livestock industry will transform and carbon emissions will be reduced. Tackling climate change involves scientific judgement, political decisions, entrepreneurial support, but at last, it still relies on involvement of the general public to change the consumption behaviour. Every single one of us has to believe in the low-carbon concept and slowly adapt to it."

In spite of the Chinese's - and other national governments - commitment to contract the consumption of meat, it may prove more challenging and strenuous to sway the rising middle classes to scale down their expenditure.

Let us shift gears and for a moment contemplate the hamburger…. Bringing forth this staple of the U.S. diet takes 25 kilograms of animal feed, 25 square meters of land, and about 220 liters of water (Langin, 2017). In fact, it has been estimated (figure 5.33) that an omnivorous diet (O) carries with it higher environmental impacts, which reveal themselves in more evident and substantial carbon footprints (a); water footprints (b) and ecological footprint (land-used) (c), than ovo-lacto-vegetarian (VG) and vegan (V) diets (Rosi et al, 2017).

It becomes quite evident that the simplest thing one can do is bypass red meat, as cows and sheep require a lot of resources and emit more greenhouse gases as a part of their digestive process (figure 5.34) (Tomorrow, 2018).

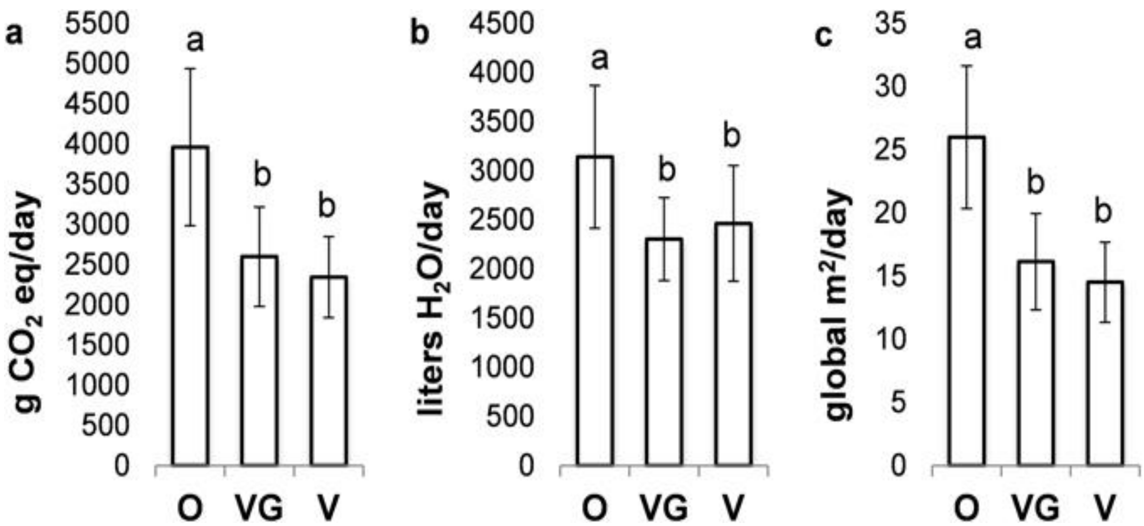


Figure 5.33: Environmental footprints: Daily carbon (**a**), water (**b**), and ecological (**c**) impacts expressed as average of 7-d food records (grams of CO_2equivalent/d, litres of H_2O/d, and square meters of land/d, respectively). Values are means ± standard deviation of fifty-one independent measurements for each diet group. Different letters indicate significantly different values ($P < 0.001$) as calculated by one-way ANOVA with *post hoc* Tukey HSD test among the three diet groups. O, omnivores; VG, ovo-lacto-vegetarians; V, vegans. Retrieved from Rosi et al, 2017.

As a matter of fact, in a paper published in the journal *Science* titled *Reducing food's environmental impacts through producers and consumers* (2018), their analysis divulged that even producing the same food results in tremendous variability. Demonstrably, beef cattle nurtured on deforested land results in 12 times more greenhouse gases and occupies 50 times more land than those grazing rich natural pasture (which, is running out as previously described, so countries are colonizing tropical forests and other habits and converting them to pastures). Moreover, the contrast of beef with plant protein such as peas is even more stunning, with even the lowest impact beef liable for six times more greenhouse gases and 36 times more land. Not to mention grass-fed beef, presumed to be relatively low impact and still responsible for much higher repercussions than plant-based food (Carrington, 2018c).

On top of this, research published in *Nature* (Vanham, Comero, Gawlik & Bidoglio, 2018), describe that, when taking the socio-economic factors of food consumption and recommended diets into account, their study revealed that vegetarian and pescatarian diets also reduce a society's water footprint.

Joseph Poore, co-author of the *Science* study affirms in *The Guardian* (Carrington, 2018c):

> "Agriculture is a sector that spans all the multitude of environmental problem. Really it is animal products that are responsible for so much of this. Avoiding consumption of animal products delivers far better environmental benefits than trying to purchase sustainable meat and dairy."

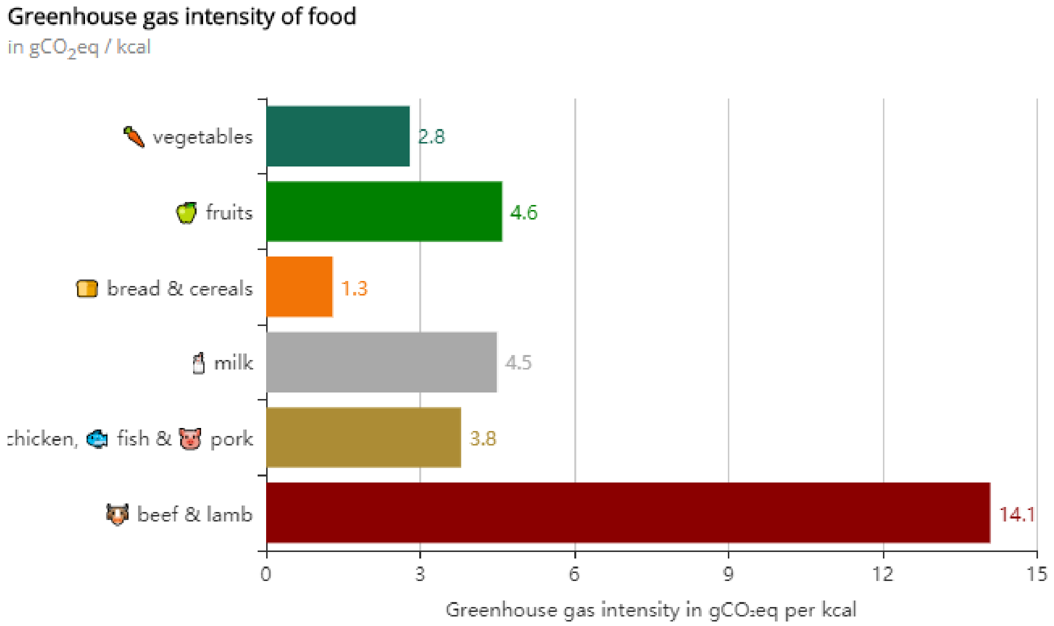


Figure 5.34: Greenhouse gas intensity of food. Source: Live cycle emissions from Electricity Map (data) and How Sustainable is Stored Sunlight (Decker, 2015)? for solar + storage intensity estimations. Retrieved from Tomorrow, 2018.

Poore supplements his argument by stating that if the most noxious half of meat and dairy production was substituted by plant-based food, this would still redeem about two-thirds of the benefits of getting rid of all meat and dairy production, without a need for the global population to become vegan (Carrington, 2018c).

Another conclusion that was rather unanticipated in this study was the colossal impact of freshwater fish farming, which caters for two-thirds of such fish in Asia and 96 percent in Europe, and was assumed to be relatively environmentally friendly (Carrington, 2018c). Poore again:

> "You get all these fish depositing excreta and unconsumed feed down to the bottom of the pond, where there is barely any oxygen, making it the perfect environment for methane production."

But as the team from *Tomorrow* (2018) assert and quite rightly:

> "It is important to note that although doing differently might help, reducing your absolute level of consumption might be the only way to reduce one's carbon footprint. Even a low-carbon activity can cumulate to great amounts when repeatedly carried out."

So, by all means, the advantages of switching to a vegetarian and vegan diet are immense and desirable. So, in the interest of intellectual honesty, and to dismantle the fable and fantasy that humanity can keep on growing in number and be fed without any issue if only we could all be vegetarians and vegans, demands a revision of the current science so that its disadvantages can be known and discussed accordingly, that way propelling the deliberation in a more clear and transparent fashion, as well as realizing that no matter how noble the cause, it is futile without addressing population growth.

According to a recent study (White & Hall, 2017), a nation of 320 million vegans would curtail greenhouse gas emissions from agriculture by some 28 percent. But the authors assert the adjustment could also prompt deficiencies in key nutrients - calcium, vitamins A and B12, and a few key fatty acids. Robin White, the study's lead author and an animal sciences researcher at Virginia Polytechnic Institute and State University in Blacksburg and Mary Beth Hall, of the U.S. Department of Agriculture's Dairy Forage Research Center in Madison, says:

> "With carefully balanced rations, you can meet all of your nutrient requirements with a vegetarian diet, but the types of foods that seem to do that, we don't currently produce in sufficient quantities to make it a sustainable diet for the entire population" (Langin, 2017).

Furthermore, the authors launched an appraisal of the repercussions of remodeling all land now used by the livestock industry to cropland for human food. They arrived at the conclusion that it would amplify the bulk of agricultural waste - corn stalks, potato waste, and other inedibles now fed to livestock - and phase out the animals that now eat much of it. Burning the surplus waste would add some 2 million tons of carbon to the atmosphere. On top of that, fertilizer provision would also go up while the supply of animal manure subsided. That would portend designing more artificial fertilizer, pouring in another 23 million tons of carbon emissions per year (Langin, 2017).

In a final analysis, White and Hall (2017) substantiate that although animals make up some 49 percent of agricultural emissions in the United States, a vegan nation would liquidate far less than that. Annual emissions would dwindle from 623 million tons to 446 million tons a year. This assessment indicates that dethroning animals from US agriculture would reduce agricultural GHG emissions, but would also create a food supply incapable of supporting the US population's nutritional requirements (Langin, 2017).

Notwithstanding, Mario Herrero, an agricultural researcher at the Commonwealth Scientific and Industrial Research Organisation in St. Lucia, Australia, considers the team's estimate of reductions in greenhouse gas emissions may be too low. The reason for that, Herrero states, is due to the study not accounting how animal-free diets would impinge on imports, which make up a large part of the U.S. meat market. If Americans ceased importing meat, it could instigate a reduction in greenhouse gas emissions in the countries that produce it, like Brazil, he says. "The full repercussions of doing something like this are rarely complete," Herrero adds (Langin, 2017).

Despite the fact that veganism and vegetarianism might not be the silver linings that they are painted out to be, the alternative is worse and I chose to review this literature not because personally, I have some vendetta against that way of life, that is totally not the case, but because it bears the obligation for reflection due to the fact that the argument of a dietary change is usually employed in any serious discussion on sustainability, while discarding the need to stabilize and reduce the human populace.

Notwithstanding the need to include the rise in per capita income (affluence) and population in policy discussions, the reality is that plant-based diets are surfacing and that is something to be celebrated and promoted, since the connections to health, climate change and animal welfare are well established. The numbers speak for themselves, as in the case of Britain's vegan population, which has soared from 150,000 to 600,000 in the space of twelve years (The Vegan Society, 2018) alongside a vegetarian population of 1.14 million (Hancox, 2018), with demand for meat-free food having surged by 987 percent in 2017, as well as veganism being the biggest food trend in 2018 (Just Eat, 2018; Food Revolution Network, 2018).

Not only on a personal choice level have plant-based diets become paramount, but also on an entrepreneurial perspective, as Katrina Fox (2017) writes for *Forbes* in *Here's Why You Should Turn your Business Vegan in 2018*. Fox cites the rise in plant-based food in the US, which went up by 8.1 percent (Simon, 2017) during 2017, surpassing $3.1 billion; vegan cheese is estimated to be worth under $4 billion by 2024, which signifies a compound annual growth rate of 7.6 percent (Book, 2017); while plant-based milk sales were extended by 3.1 percent and cow's milk has declined by 5 percent (Simon, 2017), with the projected drop seeming to reach 11 percent until 2020 (Mintel, 2015) and the global meat substitutes market is foreseen to harness a revenue of $5.2 billion by 2020 (Prasannan, 2018). These appear to be just the tip of the iceberg as veganism seems to be making a jump from the fringes into mainstream culture.

As the figure 5.35 demonstrates, there is an overabundance of detrimental repercussions in continuing to increase the demand for animal products, in ecosystem integrity, biodiversity maintenance and human health. While I fully support the reduction of animal products, I will not put all eggs in that basket, simply because humans are not willing to forgo acquired wealth and comfort, and as it was portrayed in this segment, as per capita affluence increases, one of the first things humans endeavour in doing is augmenting their carnivory behaviours. This goes hand in hand with the research from the Royal Institute of International Affairs, that recognized that there is a huge gap in awareness of the impacts and commitment on the part of governments and environmental groups to pursue policies or campaigns to shift consumer behaviour (Bailey, Froggatt & Wellesley, 2014), maybe by reason of being simply too challenging. But that doesn't mean that they should stand idly by, every engagement on those actions is welcome, as long as it accompanied by a recognition of the population factor. Ultimately, given the challenge of providing adequate nutrition for a growing global population, addressing the question of why we feed animals to feed human society is of crucial paramountcy.

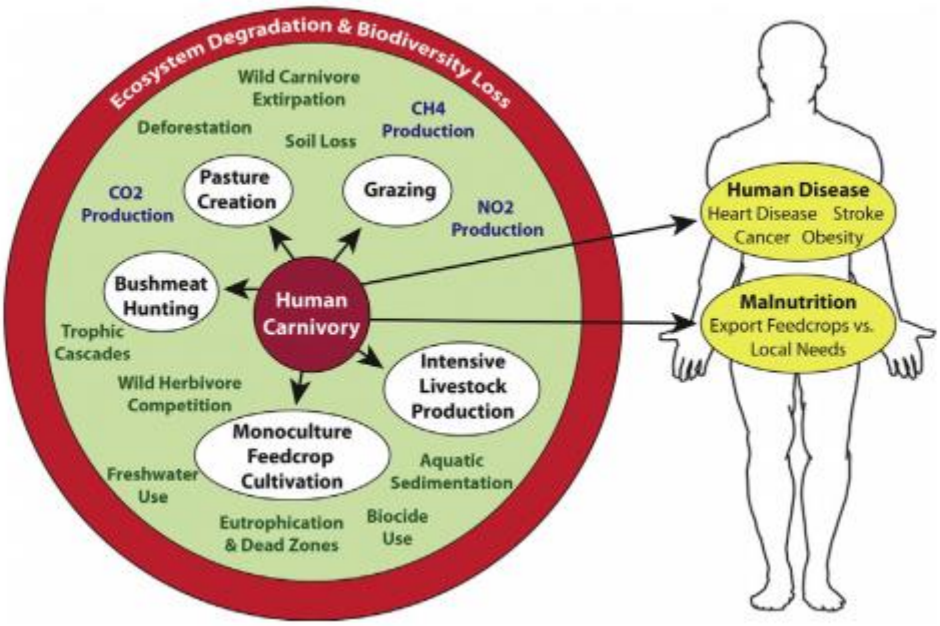


Figure 5.35: Detrimental effects of human carnivory in ecosystem degradation, biodiversity loss and human health. Retrieved from Machovina et al, 2015

As the environmentalist and activist Tristram Stuart (2009) says:

"It is all very well for 2 percent of the population to live in a monastic state of meatlessness while everyone else gorges their way towards environmental meltdown or the nearest heart clinic. Vegetarianism is good for the willing minority, but doesn't have much use as a campaign tool."

Stuart concludes with the quintessential remonstrance (2009):

"When is population going to become an accepted part of the food debate? If it's fine to encourage people to think about halving their meat consumption, can we really not cope with a conversation about how many children we have?"

In brief, it is apparent that there is no quick fix to the amalgamation of problems generated by the dietary requirements of humans. As it is usually said: "Damned if you do, damned if you don't." With the projected population to expand by a roughly 2.3 billion people by 2050 (from a present 7.6 billion); with per capita affluence rising almost concurrently, and the proclivity to include more meat-based products in diets, it becomes obvious and perceptible that in order to provide for the current and new human passenger's needs, the natural world will have to be immolated and renounced, to suit not just the basic and fundamental requirements of a large proportion of humans, but also the more sybaritic and hedonistic of whims, characteristic of the more affluent individuals. If we want to "grab the bull by the horns," discussions of desirable and acceptable family sizes need to become mainstream. The alternative is neglecting the Population factor in the 'I = PAT' formula and ending up immiserating a substantial percentage of humanity and eviscerating the natural world.

Wasted Opportunities

"Throwing away food is like stealing from the table of those who are poor and hungry"
- Pope Francis

"Food redistribution is economically sensible, ecologically pressing, and socially responsible; it is high time food corporations woke up to it and governments started funding the organisations that facilitate it."
- Tristram Stuart

Food waste is yet another classic and quintessential assertion that is employed to dismiss the need to act on population management. The argument often follows that if humanity were to cease to squander such large amounts of food then there would no caps on the number of humans that could be fed. Moreover, an effective food redistribution would, at present, eradicate world hunger.

Notwithstanding, there is truth to these claims, humanity does spoil massive volumes of food and a more competent redistribution would alleviate human and non-human misery, but then again, the principle is also the same, more consumers will always lead to more waste, and that premise becomes even more relevant when taking into account that most of the waste created is in the hands of the consumer. Although that represents more room for behavioral changes, it also implies that an ever-growing human populace will bring about ever more food waste alongside it. But for the time being, a review of the science relative to food waste and its redistribution is in order.

Food waste is an issue of relevance to global food security and praiseworthy governance, directly associated with environmental (e.g. energy, climate change, water, vacancy of resources), economic (e.g. resource efficiency, price volatility, expanding costs, consumption, waste management, commodity markets) and social (e.g. health, equality) repercussions (Stenmarck, Jensen, Quested & Moates, 2016).

Food waste materializes along the entire spectrum of food production, from the farm to distribution to retailers to the consumer. The U.S. Department of Agriculture defines it as the edible amount of food after harvesting that is available to eat but is not used. Justifications for that include losses from mold, pests, or faulty climate control; misadventures while cooking and intentional food waste (USDA, 2017).

As a matter of fact, different studies demonstrate that between one third and half of the world food production is not consumed (Gustavsson et al, 2011; European Commission, 2010) engendering negative reverberations throughout the food supply chain including households (Stenmarck et al, 2016). Demonstrably, the yearly quota of food waste is estimated to be roughly 1.3 billion tonnes of food, which includes about 45 percent of all fruit and vegetables, 35 percent of fish seafood, 30 percent of cereals, 20 percent of dairy products and 20 percent of meat (Lyons, Swann & Levett, 2015).

In addition to this, we have to take into account how population growth will alter these statistics. That is exactly what a study conducted by the Boston Consulting Group (BCG) and reported by the *Thomson Reuters Foundation* (Elks, 2018) did. Their findings point to a surge in food waste from the present 1.3 billion tonnes per year, to around roughly 2.1 billion tonnes per year by 2030. The researchers disclose that this crisis will be impelled by a "booming world population and changing habits in developing nations." Moreover, the research pinpoints that household waste will increase in developing countries as consumer's per capita affluence rises.

Another key point is what all this waste means for agriculture. Practically 1.4 billion hectares, or close to 30 percent of the available agricultural land, is exploited for the subsequent squandering of its output. This becomes even more alarming when taking into account the population projections for this century and the need to augment food production by 60 percent - compared with 2005 levels - to feed this growing human populace. Evidently, contracting and eventually eradicating food loss and waste would ease the burden on natural resources and avoid the transmogrification of the natural world into a human factory (Lyons et al, 2015).

Fortunately, food waste is getting a lot of attention lately, after slipping under the radar for a long time. Even though humanity produces 17 percent more food than it did 30 years ago, most of it never reaches a plate. The most effective way to describe this food predicament was made by Tristram Stuart back in 2012 in his viral Ted Talk (2012).

He illustrated that nine slices of bread represent the world's food supply. Every year, one slice perishes from poor handling, lack of sufficient storage and the lot. Moreover, three slices are fed to animals to produce meat, eggs and cheese (Rowland, 2017). Unfortunately - and has it was described in previous segments - animals are appallingly inefficient when it comes to producing protein, so they restitute only one slice of bread, and the other two end up as waste (manure). That leaves only 6 slices of the original nine. Then, two more are forsaken due to diverse reasons such as spoilage, sell-by-date confusion, imperfect appearance, and others, so they end up in the garbage and then on landfills. Ultimately, humanity is left with four slices to consume from the original nine (Rowland, 2017).

To demonstrate, in developing countries there are elevated levels of 'food loss', which is an unintentional and inadvertent wastage, usually due to faulty equipment, transportation and infrastructure (figure 5.36). On the other hand, in wealthy countries, there are low levels of haphazard losses but elevated levels of 'food waste', which is mostly done by consumers who purchase in excess, or by retailers who decline food by virtue of exacting aesthetic standards (Lyons, et al, 2015).

To add fuel to this fire is the fact that this prodigalizing of food that could ameliorate to a large extent, world hunger, is also burning up the planet's resources in the process. That is to say, in the United States food production currently devours 50 percent of the surface area, 30 percent of all energy resources, and ingurgitates 80 percent of all freshwater (USDA, 2018).

Figure 5.36: Where, how and when is most of the food wasted? A comparison between Developed and Developing Nations. Source: *The Guardian.* Retrieved from: Lyons et al, 2015.

As reported by the European Commission (2016), roughly 88 million tonnes of food are misemployed, with associated costs ranging in the order of 143 billion euros. Likewise, wasting food is not only an ethical and economic issue, but it also produces a vast array of environmental encumbrances (Stenmarck et al, 2016).

The disposal of the food waste is yet another incumbrance with an amalgamation of environmental problems associated. Landfills produce tremendous quantities of greenhouse gases and are still the destination of up to 48 percent of food waste in parts of the United Kingdom (House of Lords, 2014). Likewise, incineration and composting also generate these gases, and wastewater from anaerobic digestion begets eutrophication and acidification of local ecosystems (Evangelisti, Lettieri, Borello & Clift, 2014; Salemdeeb & Al-Tabbaa, 2015; Whiting & Azapagic, 2014). In the United States, food waste is the single largest component going into municipal landfills, where it exudes methane, contributing to make landfills the third largest source of methane in the US (EPA, 2018).

Equally important, and mostly overlooked is the opportunity cost of food waste. All the labor, water, and resources used to generate, process, transport, package, store, and discard food waste could have been used in a vast array of ways that are beneficial to society while suspending some of the strain of the natural world. In the case of the US, contracting food losses by 15 percent would be enough to feed 25 million Americans every year (Rowland, 2017).

In accordance with the 'food waste pyramid' (figure 5.37), making sure that food is consumed by people is the top priority. When that plan ceases to function, the next best thing is to feed it to farm animals (Stuart, 2012).

The Environmental Protection Agency of the United States adjoins a fourth category that should come after the feed of livestock, which is donating used fats, oils, and grease to make biodiesel fuel (EPA, 2017).

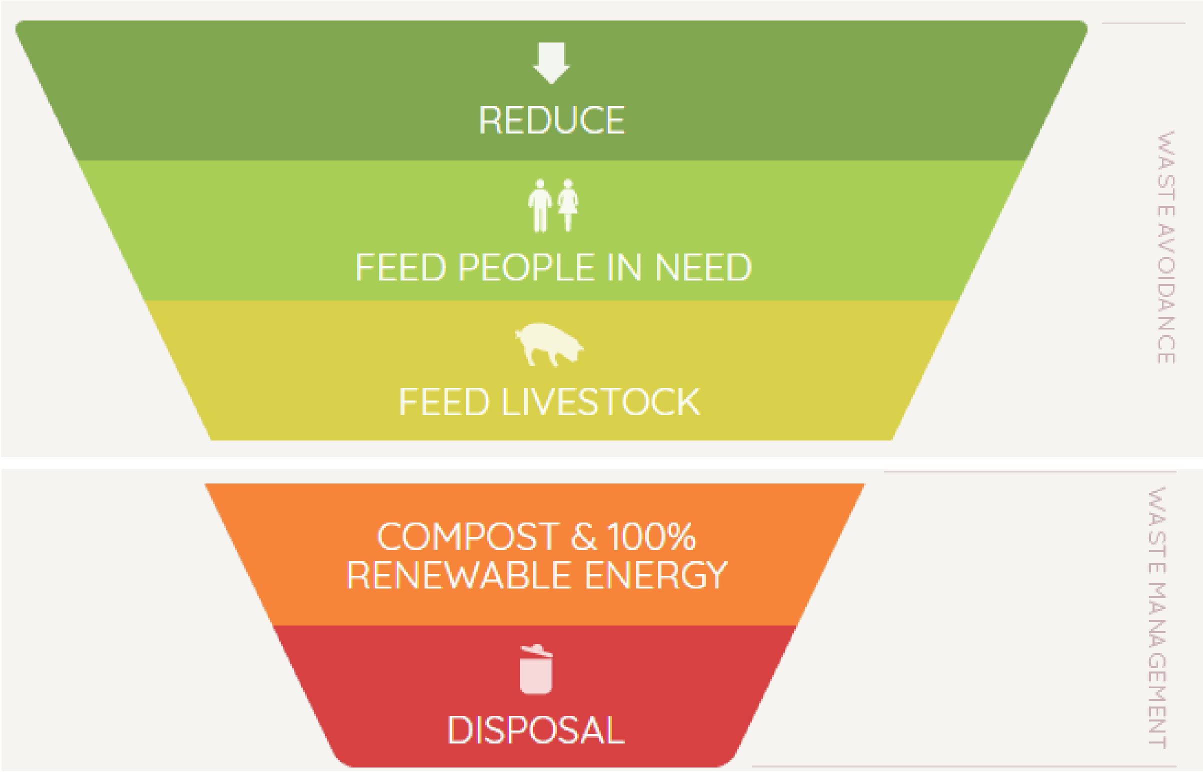


Figure 5.37: Food Waste Pyramid for London designed by Tristram Stuart in collaboration with the Feeding the 5000 steering group: the Mayor's Waste Strategy team, the London Food Board, Recycle for London, Friends of the Earth, WRAP, FareShare & FoodCycle. Retrieved from Feeding the 5000.

To this effect, and to emphasize on the importance of the food pyramid in reducing environmental implications, Carol Browner says:

> "A food waste reduction hierarchy […] feeding people first, then animals, then recycling, and composting […] serves to show how productive use can be made of much of the excess food that is currently contributing to leachate and methane formation in landfills."

In a report prescribed by the European Union, entitled *Reducing food waste through social innovation* (2016) the results point out that:

> "The sectors contributing the most to food waste are households (47 million tonnes ± 4 million tonnes) and processing (17 million tonnes ± 13 million tonnes). These two sectors account for 72 percent of EU food waste, although there is considerable uncertainty around the estimate for the processing sector compared to all the other sectors. Of the remaining 28 percent of food waste 11 million tonnes (12 percent) comes from food service, 9 million tonnes (10 percent) comes from primary production and 5 million tonnes (5 percent) comes from wholesale and retail."

The results from the report are illustrated in figure 5.38.

As an illustration, in the UK, 15 million tonnes of food is lost or wasted each year (234 kg/person/year or 50 percent of food) (WRAP, 2015), as consumers throw away 4.2 million tonnes of edible food. As figure 5.38 portrays, this waste consists mostly of bread, vegetables, fruit and milk (Lyons et al, 2015).

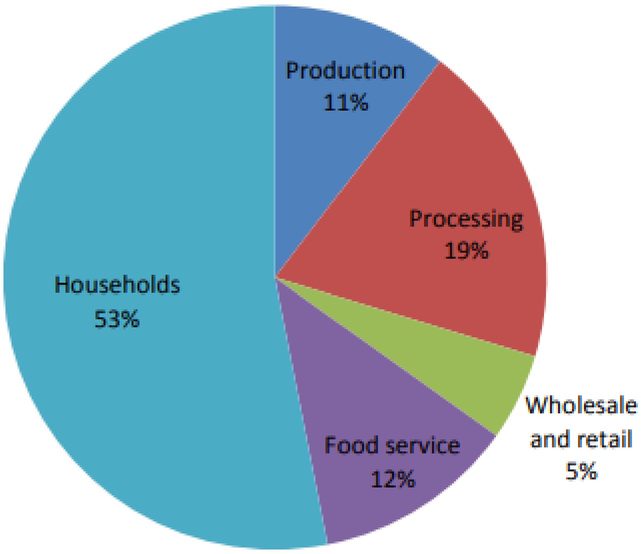


Figure 5.38: Split of EU-28 food waste in 2012 by sector; includes food and inedible parts associated with food. Retrieved from Stenmarck et al, 2016.

In economic terms, this translates into the average family dispensing with £700 (around 800 euros) of food on a yearly basis in the UK. By the same token, the average weekly spending on food and non-alcoholic drinks in 2013 was £58.80 according to governmental data, which means that a typical family casts off a week's worth of groceries each month (Lyons et al, 2015).

In line with Alexander et al (2017), only 25 percent of harvested food, by weight, finds its way into people's plates. Additionally, they assert that livestock production is a tremendously inefficient way of converting crops (used as feed) into food for humans, with loss rates varying from 82 percent (in terms of protein) up to 94 percent (by dry weight) when all the feed they consume during their lifespans is taken into account. In the end, it is food that doesn't go to the garbage or landfills, but it epitomizes a colossus loss to the potential global supply of food for people (Boucher, 2017).

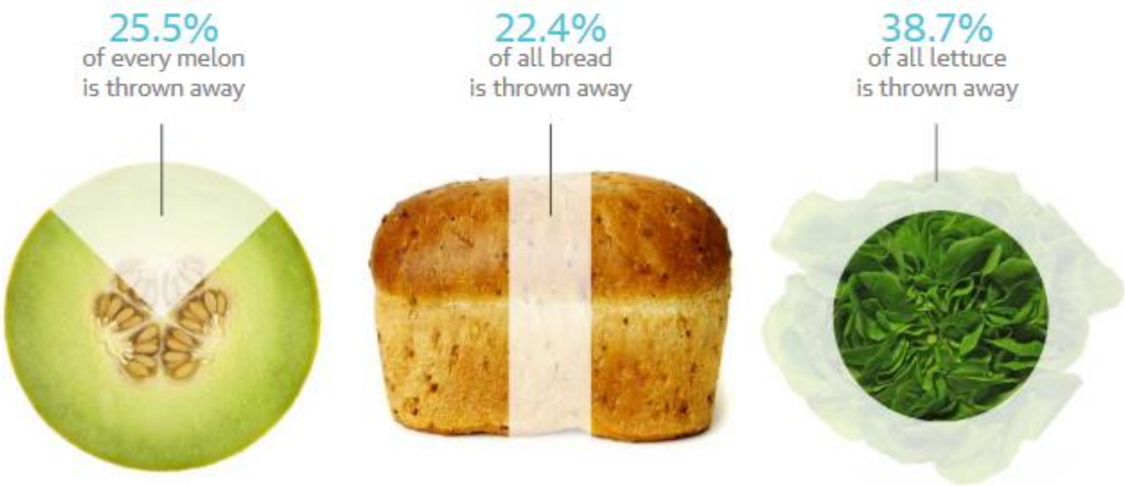


Figure 5.39: Types of food that are found on British bins. Source: *The Guardian.* Retrieved from Lyons et al, 2015.

It is important to realize that both consumer behaviour and practices play imperative roles in the efficiency of the food system. Alexander and colleagues (2017) report the meaningful squanderings occurring during the food chain process (figure 5.39) and expose the magnitude of losses from consumption of food in exuberance.

To point out, the greatest rates of loss are associated with livestock production (figure 5.40), and consequently changes in the levels of meat, dairy and egg consumption can considerably modify the overall efficiency of the food system, and combined environmental impacts (e.g. greenhouse gas emissions) (Lamb et al, 2016). It is therefore regrettable from an environmental and food security viewpoint that rates of meat and dairy consumption are scheduled to continue to increase as average incomes rise (Kearney, 2010; Keyzer, Merbis, Pavel & van Wesenbeeck, 2005; McMichael, Powles, Butler & Uauy, 2007), conceivably depreciating the effectualness of the overall food system, as well as augmenting associated negative health implications (e.g. diabetes and heart disease) (Hu, 2011; Tilman & Clark, 2014).

Equally important is the fact that wasting 1 kg of feedlot-raised boneless beef is predicted to have ±24 times the effect on available calories as wasting 1 kg of wheat (± 98,000 kcal versus ± 3800 to 4125 kcal), by virtue of the inefficiencies of caloric and protein conversion from plant to animal flesh. Furthermore, waste differs tremendously between countries, especially developing and developed. For example, food loss in India for vegetables and pork is < 3 kcal per person day^{-1}, and this is dramatically higher at 290 kcal per person day^{-1} for beef in the United States. This equates to roughly 7 to 8 times more land appropriated to maintain this waste in the United States than in India. Altogether, the riddance of waste of major plant-based foods and meats in China, India and the United States is envisioned to be able to feed over 400 million people per year (West et al, 2014).

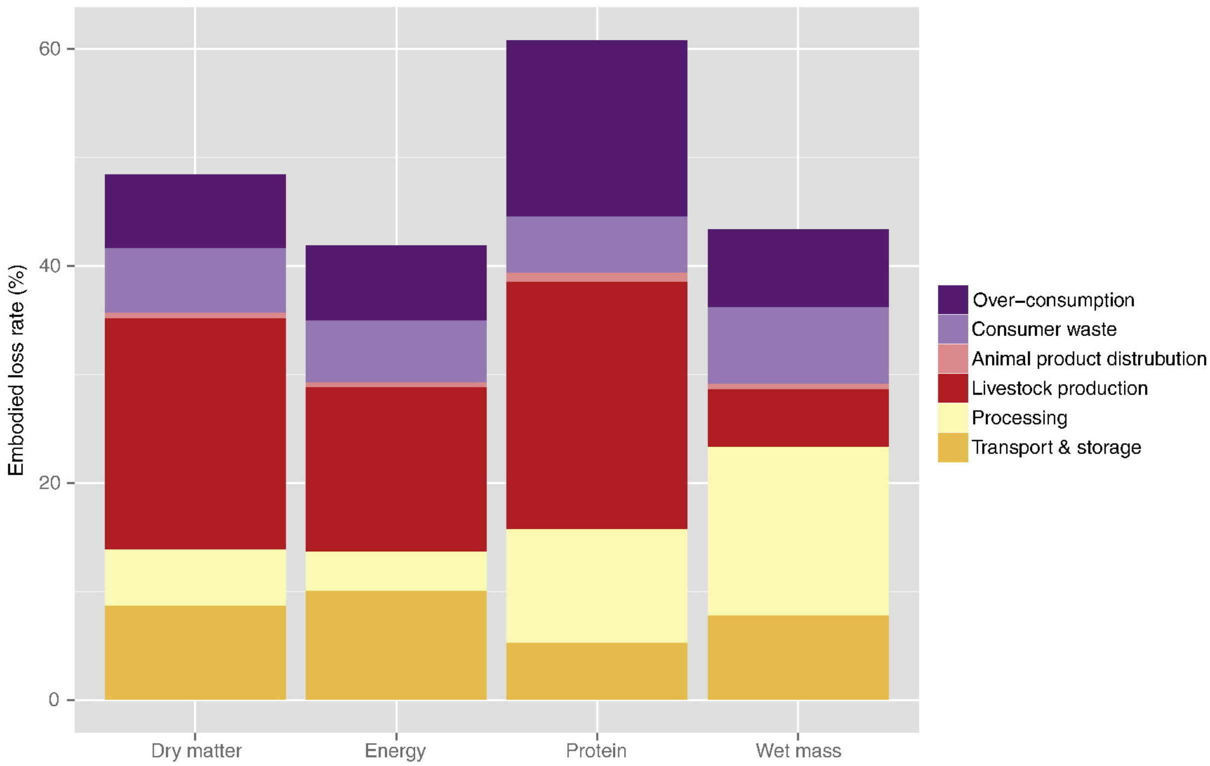


Figure 5.40: Losses of harvested crops (excluding grassland and forage crop inputs to livestock production) by stage in the food system, using embodied loss rates. Retrieved from (Alexander et al, 2017).

Until recently, not much consideration appears to have been given to the sustainability significance of over-consumption (Springmann, Godfray, Rayner & Scarborough, 2016), which can be portrayed as the supplementary food intake over that which is vital for human nutrition (Blair and Sobal, 2006). Henceforth, the figure above denotes that system losses from over-consumption of food are at least as significant as the costs from food discarded by consumers, therefore having tantamount food security and sustainability implications. Ultimately, changes that shape consumer behaviour, e.g. eating fewer animal products, diminishing food waste, and abbreviating per capita consumption to be closer to nutrient requirements will all help to provide the rising global population with food security in a sustainable manner (Alexander et al, 2017).

The following is an excerpt from Tristram Stuart's TED Talk mentioned at the start of this segment, given in London in the spring of 2012. The full video can be found here:

> What this shows is a nation-by-nation breakdown of the likely level of food waste in each country in the world. Unfortunately, empirical data, good, hard stats, don't exist, and therefore to prove my point, I first of all had to find some proxy way of uncovering how much food was being wasted. So I took the food supply of every single country and I compared it to what was actually likely to be being consumed in each country (figure 5.41). That's based on diet intake surveys, it's based on levels of obesity, and it's based on a range of factors that gives you an approximate guess as to how much food is actually going into people's mouths. That black line in the middle of that table is the likely level of consumption with an allowance for certain levels of inevitable waste.
>
> There will always be waste. I'm not that unrealistic that I think we can live in a waste-free world. But that black line shows what a food supply should be in a country if they allow for a good, stable, secure, nutritional diet for every person in that country. Any dot above that line, and you'll quickly notice that that includes most countries in the world, represents unnecessary surplus, and is likely to reflect levels of waste in each country.
>
> As a country gets richer, it invests more and more in getting more and more surplus into its shops and restaurants, and as you can see, most European and North American countries fall between 150 and 200 percent of the nutritional requirements of their populations. So a country like America has twice as much food on its shop shelves and in its restaurants than is actually required to feed the American people.
>
> But the thing that really struck me, countries rapidly shoot towards that 150 mark, and then they level off, and they don't really go on rising as you might expect. But if you include not just the food that ends up in restaurants, but also the food that people feed to livestock (figure 5.42), the maize, the soy, the wheat, that humans could eat but choose to fatten livestock instead to produce increasing amounts of meat and products, what you find is that most rich countries have between three and four times the amount of food that their population needs to feed itself. A country like America has four times the amount of food that it needs."

Altogether, Stuart's research has exposed that most rich countries produce between three and four times more food than it is indispensable to meet its population's nutritional needs. Yet, roughly one billion people endure malnutrition worldwide (Daugherty, 2014).

As Stuart conveys:

> "Producing this huge surplus leads to deforestation, depleted water supplies, massive fossil fuel consumption, and biodiversity loss. Excess food decomposing in landfills accounts for 10 percent of greenhouse gas emissions by wealthy nations."

Stuart has also been in the forefront of the campaign movement for retailers to relax strict cosmetic standards for fruits and vegetables. He acknowledges that:

> "Farmers leave up to 40 percent of harvests rotting in fields because their produce doesn't conform to the perfect nice shape big supermarkets demand. This even happens in countries like Kenya where millions of people are hungry."

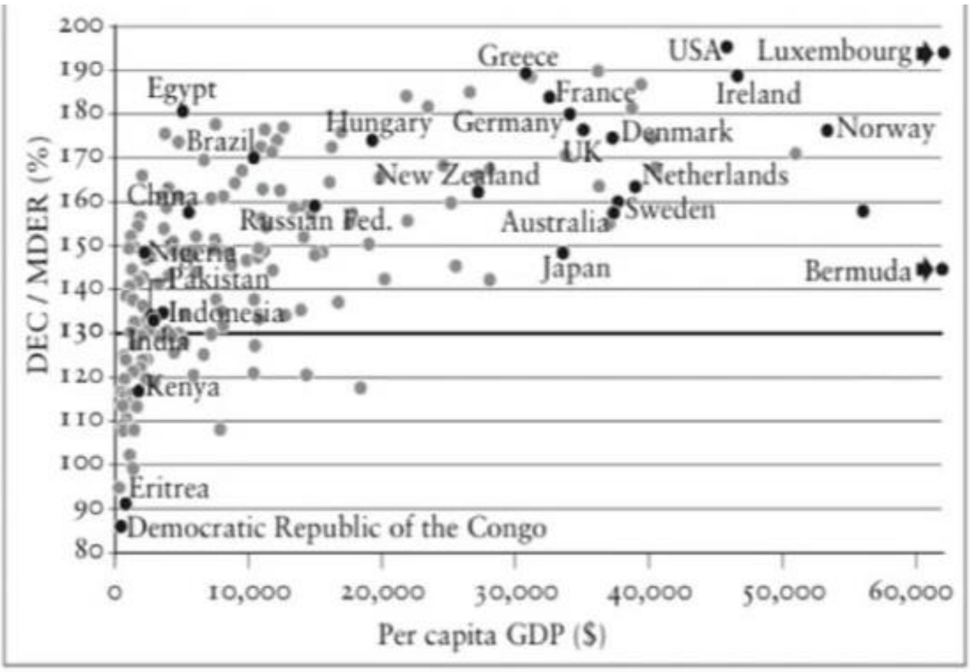


Figure 5.41: Food supply as a percentage of nutritional requirements vs GDP. Retrieved from [Stuart, 2012].

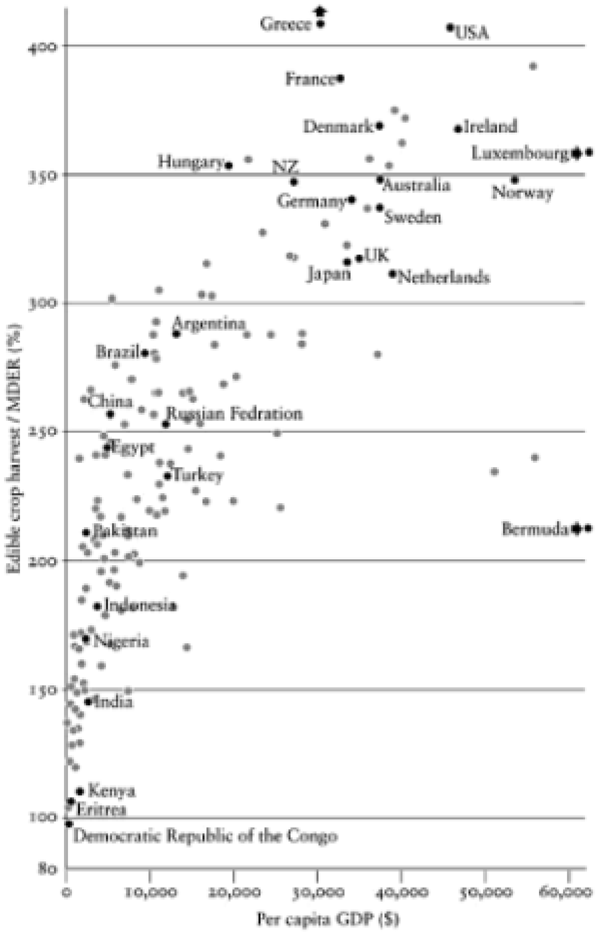


Figure 5.42: Percentage of excess food a country has when taking into account what is fed to livestock when compared to per capita GDP. Retrieved from [Stuart, 2012].

But Stuart isn't done just yet. One of his many projects is *'The Pig Idea'*, which endeavours to change laws that restrict using food waste to feed pigs. As he declares:

> "Pigs were originally domesticated for the sole purpose of recycling human food waste back into food, a process that has worked for thousands of years [...] these days many countries import millions of tons of soy from South America to feed pigs - causing massive deforestation throughout the Amazon. We also feed pigs' wheat and maize, which hungry people in Africa and Asia could eat."

His initiative calls for a vigorously regulated system that would allow pigs to be securely fed food waste once again. The campaign has motivated supermarkets to forward waste that is legal for livestock, such as bread, to farms rather than landfills. Stuart maintains that:

> "Feeding food waste to pigs saves 20 times more carbon than the next-best recycling method" (Daugherty, 2014).

For the most part, food loss and waste are perhaps of all the problems that population growth magnifies, the one that can be alleviated and improved with the greatest success rate. Under these circumstances, the National Resources Defense Council (Gunders, 2017) promulgated a summary paper providing specific guidelines on how to reduce waste throughout the food production chain, and these are some of its focal points (Harvard School of Public Health, 2017):

- **State and local governments** can embody food waste prevention and education campaigns, and enforce municipal composting programs. Moreover, governments can indulge tax credits to farmers who subscribe to give away excess produce to local food banks.
- **Businesses such as restaurants, grocery stores, and institutional food services** can appraise the extent of their food waste and adopt the best practices. In this case, supermarkets selling damaged or nearly expired produce at discounted prices, or making available "half-off" promotions instead of "buy-one-get-one-free" campaigns. Likewise, restaurants can offer contracted portions and donate excess ingredients and prepared uneaten food to charities. Schools may venture with concepts that allow children to produce their own meals to avert less discarded food.
- **Farms** can gauge food losses during processing, distribution, and storage and put in place better practices. Farmers markets can sell "ugly" produce, which is generally repudiated, misshapen fruits and vegetables that do not meet the usual standards for aesthetics. Farms can sell fresh but unmarketable produce (due to appearance) to food banks at a reduced rate.
- **Consumers** can adequately learn when food is no longer safe and edible, to store it properly, how to compost, and most important of all to have the conscience to reduce buying excess products that are on discount format for example.

In the *Nature* article mentioned at the beginning of this chapter, *Options for keeping the food system within environmental limits* (Springmann et al, 2018), the authors also address how wasteful the current food system still is, and how much room for improvement can be accomplished. Since much of the food waste comes from spoilage, the authors state that reducing waste by 75 percent is theoretically possible (Achenbach, 2018). The paper declares:

> "We estimate that halving food loss and waste would reduce environmental pressures by 6-16 percent compared with the baseline projection for 2050, and that reducing food loss and waste by 75 percent would reduce environmental pressures by 9-24 percent."

Much change will also come from a social transformation where food wasting will be regarded as unacceptable as throwing trash on the street, or misusing water by having caps on the amount a household can produce. Changes in consumer behaviour and a shift in attitudes were mentioned in the *Reuters* (Elks, 2018) article cited in this segment, providing solutions to the food waste problem, with for example Liz Goodwin, director of the food loss and waste program at the World Resources Institute saying:

> "We need a shift in our attitudes to food waste – I think we need to get to the point where it just isn't acceptable to throw food in the bin."

Although this revision of our demeanor in dealing with food is vital and crucial, it is incredibly frustrating to observe how a research that even puts population growth as the catalyst for change, generates no evaluation and criticism of our reproductive rights, specifically in the developing nations where not only the human expansion will be more abundant, but where household incomes will continue to increase, prompting more food waste in the process. This silence regarding population is completely detrimental to any pragmatic and sober solution. For more on this subject please consult the third chapter, Judas and the Elephant in the Room.

All things considered, if the reader is someone who cares deeply about eliminating food waste, that is a virtuous and irreprehensible task to devote one's efforts. Nevertheless, one should not lose sight of the bigger picture, and that is the increase in the appetite itself, by an expanding human populace, which will always end up generating more food waste, even if we do manage to increase the efficiency of the system. John Kenneth Galbraith's perennial thoughts (1958) come to into mind here:

> "If we are concerned about our great appetite for materials, it is plausible to seek to increase the supply, to decrease waste, to make better use of the stocks that are available, and to develop substitutes. But what of the appetite itself? Surely this is the ultimate source of the problem. If it continues its geometric course, will it not one day have to be restrained? Yet in the literature of the resource problem this is the forbidden question. Over it hangs a nearly total silence. It is as though, in the discussion of the chance for avoiding automobile accidents, we agree not to make any mention of speed!"

◆

The Great Nutrient Collapse

"Expecting that more and richer people will demand more from the land, cultivating wider fields, logging more forests, and pressing Nature, comes naturally."

- Jesse H. Ausubel, Iddo K. Wernick and Paul E. Waggoner (2013)

Before closing up this chapter and moving on to climate change in Category: Chaos, this segment will make the bridge between food security in an overpopulated world, and how anthropogenic climate change is altering the micronutrients and vitamin content of important food staples, propelling humanity to not only have less sustenance for everyone, but food destitute of its nutritional value.

One of the far-reaching and eventful repercussions of rising carbon dioxide concentration ([CO2]) and climate change is an anticipated impingement on food security (Smith et al, 2014). This foreseen impact is due, in part, to the susceptibility of the global population to food supply: Depending on the definition, up to 1 billion people are conjectured to be food insecure. As an illustration, the harvests of staple cereal crops, such as rice and maize, could face contractions of 20 to 40 percent as a function of augmented surface temperatures in tropical and subtropical regions by 2100, and this is without accounting for the destructive reverberations of extreme weather and climate events (Battisti & Naylor, 2008). On the whole, there has been a directed endeavour to interpret the consequences of rising [CO2] and climate on agricultural production (Schlenker & Roberts, 2009; Lobell et al, 2008; Zhu et al, 2018; Myers et al, 2014).

The past half-century has been described by a conspicuous growth in food production, allowing for a dramatic contraction in the proportion of the world's people that are hungry, in spite of a doubling of the total population (World Bank, 2007; FAOSTAT, 2017). Notwithstanding, more than one in seven people today still do not have access to adequate protein and energy from their diet, and even more undergo some form of micronutrient malnourishment (FAO, 2009). This frailty in nutrition can prompt direct (cognitive development, metabolism, and immune system) and indirect (obesity, type 2 diabetes mellitus) alterations in human health in an all-embracing scale (Stein, 2010).

With this in mind, the link between food security and well-being stretches beyond production per se; in fact, dietary quality has a meaningful influence on human health (Murray et al, 2012). On a global scale, unsatisfactory micronutrients, protein, vitamins etc. can be conducive to nutritional deficiencies among 2 billion people in developing and developed countries (Bailey, West & Black, 2015).

To this effect, surprisingly enough, a new consequence of fossil fuel burning and other anthropogenic activities is now being correlated with higher [CO2] on field trials of wheat, rice, maize, soybeans for example, that have been shown to have reduced essential nutrients like iron and zinc, as well as contracted protein levels (Carrington, 2014b). This is due to the elemental chemical composition of a plant (ionome) that mirrors a balance between carbon, secured through [CO2], and the remaining nutrients, retrieved through the soil (Zhu et al, 2018). Moreover, the foreseen heightening in atmospheric [CO2] is set to result in an ionomic imbalance for most plant species, through which carbon increases will be disproportionate to soil-based nutrients (Taub, Miller & Allen, 2007; Myers et al, 2014; Loladze, 2014).

In an interview to the *Politico* (Evich, 2017), Irakli Loladze, author of the much-cited paper *Rising atmospheric CO_2 and human nutrition: toward globally imbalanced plant stoichiometry* (2002) that was published in the journal *Trends in Ecology and Evolution*, which was the first to tie the impact of CO_2 on plant quality and human nutrition, recounts the story that 'shined some light' on this entire undertaking, that involved zooplankton and algae, still in the late 90's:

> "Scientists found that they could make algae grow faster by shining more light onto them - increasing the food supply for the zooplankton, which should have flourished. But it didn't work that way. When the researchers shined more light on the algae, the algae grew faster, and the tiny animals had lots and lots to eat - but at a certain point they started struggling to survive. This was a paradox. More food should lead to more growth. How could more algae be a *problem?*
>
> The biologists had an idea of what was going on: The increased light was making the algae grow faster, but they ended up containing fewer of the nutrients the zooplankton needed to thrive. By speeding up their growth, the researchers had essentially turned the algae into junk food. The zooplankton had plenty to eat, but their food was less nutritious, and so they were starving.
>
> In the outside world, the problem isn't that plants are suddenly getting more light: It's that for years, they've been getting more carbon dioxide. Plants rely on both light and carbon dioxide to grow. If shining more light results in faster-growing, less nutritious algae - junk food algae whose ratio of sugar to nutrients was out of whack - then it seemed logical to assume that ramping up carbon dioxide do the same. And it could also be playing out in plants all over the planet. What might that mean for plants that people eat?"

What Loladze discovered was that scientists were simply unaware of this possibility. It was already well documented that CO_2 levels were rising in the atmosphere, but he was astonished at how little research had been done on how that would influence the quality of plants humans profoundly rely on (Evich, 2017).

Loladze pursued this hypothesis and started to explore the scientific literature for any studies and data related to the theory. The results, as he collected them, all appeared to imply that: The junk-food effect he had witnessed on the algae was making its way into the fields and forests around the world (Evich, 2017). Loladze attested that:

> "Every lead and every grass blade on earth makes more and more sugars as CO_2 levels keep rising. We are witnessing the greatest injection of carbohydrates into the biosphere in human history - [an] injection that dilutes other nutrients in our food supply."

In the field of agricultural research, it has been known that many of the most crucial and essential foods in the global human diet have been getting less nutritious. Not only cereals but also fruits and vegetables reveal that their minerals, vitamin and protein contents have substantially contracted over the past 50 to 70 years. Researchers have, as a rule, assumed the reason was that humans had been breeding and choosing crops for higher yields, rather than nutrition, and higher-yielding crops - whether broccoli, tomatoes, or wheat - have a tendency to be less nutrient-packed (Evich, 2017). To reinforce that inference, in 2004 (Davis, Epp & Riordan, 2004) a landmark study of fruits and vegetables concluded that everything from protein to calcium, iron and vitamin C had deteriorated substantially across most garden crops since 1950 (Evich, 2017).

But Loladze and a few other scientists have come to harbour doubts and calculated that there was something more to this story and that the atmosphere itself may be changing the food humans eat. To that effect, plants require carbon dioxide to live just like humans need oxygen, and certainly, that is one thing that isn't up for debate (figure 5.43) (Evich, 2017). Before the industrial revolution, the earth's atmosphere had about 280 parts per million of carbon dioxide. In 2013, it surpassed 400 ppm for the first time in recorded history (NASA, 2013).

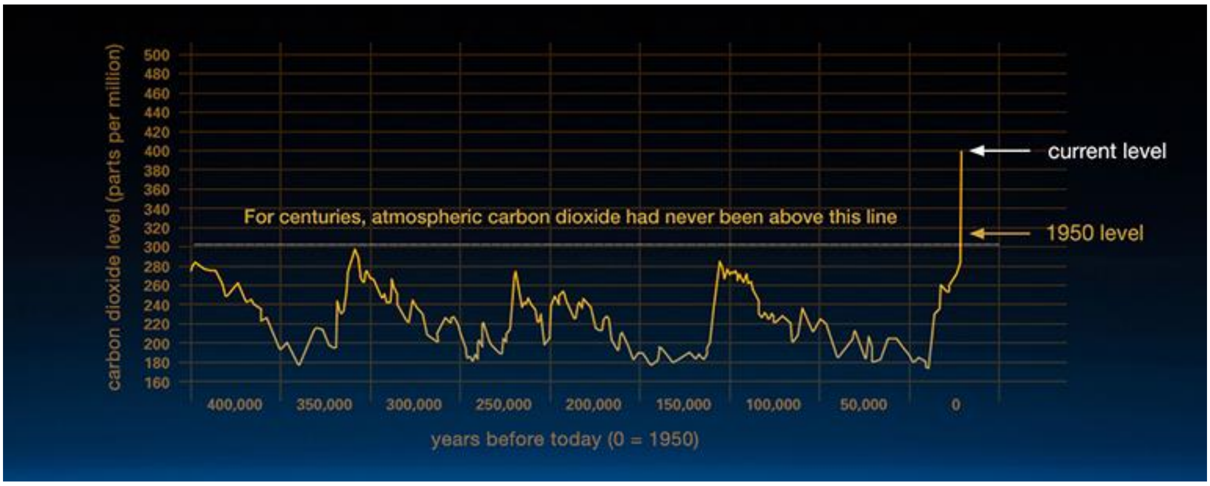


Figure 5.43: The relentless rise of carbon dioxide. Data: National Oceanic and Atmospheric Administration (NOAA). Retrieved from NASA, 2018a.

As NASA (2018a) states:

> "If fossil-fuel burning continues at a business-as-usual rate, such that humanity exhausts the reserves over the next few centuries, CO_2 will continue to rise to levels of order of 1500 ppm. The atmosphere would then not return to pre-industrial levels even tens of thousands of years into the future. This graph (figure 5.43) not only conveys the scientific measurements, but it also underscores the fact that humans have a great capacity to change the climate of the planet."

If the reader is someone who thinks about plant growth, this appears to be a good thing. Likewise, it has also been used as argumentation for politicians and climate deniers looking for reasons not to act on the implications of anthropogenic climate change. As an illustration, Rep. Lamar Smith, a Republican who chairs the House Committee on Science, argued (Smith, 2017) that humanity shouldn't be concerned about rising CO_2 levels on the grounds that it is good for plants, and what's good for plants is even better for us (Evich, 2017).

The Texas Republican wrote:

> "A higher concentration of carbon dioxide in our atmosphere would aid photosynthesis, which in turn contributes to increased plant growth. This correlates to a greater volume of food production and better quality food."

Likewise, the Competitive Enterprise Institute (Lewis, 2017) also declared:

> "So-called carbon pollution has done much more to expand and invigorate the planet's greenery than all the climate policies of all the world's governments combined."

The chief executive of the Heartland Institute issued the following statement (Heikkinen & Bravender, 2017):

> "The best messages are positive: CO_2 increases crop yields, the earth is greening."

On the other hand, and how the zooplankton experiment demonstrated, greater volume and better quality might not share an intimate relation. In fact, they could be inversely associated. At present, science conjectures that rising CO_2 levels accelerates photosynthesis [process in which plants convert sunlight to food], this, conversely, makes plants grow, but it also generates higher concentrations of carbohydrates like glucose at the expense of other nutrients that humans rely on for their diets, like protein, iron and zinc (Evich, 2017), and plants themselves end up embodying lower concentrations of nutrients such as nitrogen, copper and potassium (Zimmer, 2018).

This, in fact, has been proven by Elliott Campbell, an environmental scientist at the University of California Santa Cruz, and his colleagues in the paper *Large historical growth in global terrestrial gross primary production* published in *Nature* (Campbell et al, 2017). Their conclusion pointed that plants are now converting 31 percent more carbon dioxide into organic matter than their ancestors were before the Industrial Revolution. But unfortunately, more photosynthesis doesn't mean more food (Zimmer, 2018).

Manifestly, we now get far more food from each acre of farmland (Roser & Ritchie, 2018) (please bring to mind or quickly inspect the segment *Lebensraum*) than it was attainable a century ago. But extra carbon dioxide is only a fragment of the full story. Dr Campbell proclaims that:

> "A 30 percent increase in photosynthesis does not translate into a 30 percent increase in strawberries off the land."

Even though photosynthesis does remove carbon dioxide out of the atmosphere, much of the gas slips right back into the air, and the reason is that at night the chemical reactions in plants basically function in a backward manner. During the process denominated *respiration,* plants pump out carbon dioxide instead of dragging it in (Zimmer, 2018). Now back to the nutritional side of this question.

Worth mentioning, is a more recent research published in *Current Opinion in Plant Biology* (Uddling, Broberg, Feng & Pleijel, 2018) that speculates on the association between rising carbon dioxide levels speeding up photosynthesis, which may be in turn augmenting the rate at which soil microbes take up nutrients, leaving behind less for plants to ingurgitate (Zimmer, 2018).

Kristie Ebi, a researcher at the University of Washington who has studied the intersection of climate change and global health for two decades, is one of the few scientists in the U.S. to grasp the full ramifications of the CO_2-nutrition dynamic, and brings it up every time she gives a talk:

> "It's a hidden issue. The fact that my bread doesn't have the micronutrients it did 20 years ago - how would you know?" (Evich, 2017)

Samuel Myers, an environmental health expert at Harvard University and lead author of the study *Increasing CO_2 threatens human nutrition*, published in the journal *Nature* (Myers et al, 2014), attested in an interview with *The Guardian* (Carrington, 2014b):

> "We found rising levels of CO_2 are affecting human nutrition by reducing levels of very important nutrients in very important food crops. From a health viewpoint, iron and zinc are hugely important."

With this in mind, how much of the long-term nutrient drop is caused by the atmosphere and what will this mean for human nutrition?

Within the category of plants known as "C3" - which consists of approximately 95 percent of plant species on earth, specifically ones human eat like wheat, rice, barley and potatoes - elevated CO_2 has been proven to reduce crucial minerals like calcium, potassium, zinc and iron. Present data postulates that plants would respond to the levels of [CO_2] expected in this century, by contracting mineral presence by 8 percent, on average. The same conditions have been shown to drive down protein content in C3 crops, in some cases substantially, with wheat and rice dwindling by 6 and 8 percent, respectively (Evich, 2017).

Now the first studies to attempt to gauge what these shifts could mean for the global population are seeing the light of day. In *Estimated Effects of Future Atmospheric CO_2 Concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region* (2017), Danielle E. Medek and colleagues estimated that plants are a paramount source of protein for people in the developing world and that by 2050, they assess, 150 million people could be in peril of protein deficiency, specifically in countries like India and Bangladesh. Moreover, the study established that a loss of zinc, which is particularly fundamental for maternal and infant health, could throw 138 million people into a nutritional danger zone. Another study entitled *Effect of increased concentrations of atmospheric carbon dioxide on the global threat of zinc deficiency: a modelling study* (Myers, 2015), appraised that more than 1 billion mothers and 354 million children inhabit countries where dietary iron is projected to drop considerably, which could aggravate the already pervasive public health problem of anaemia (Evich, 2017).

As this work is written, there seems to be no projections for developed nations such as the United States, where for the most part, the population reaps the benefits of a diverse diet with no shortage of protein (quite the opposite as described in the previous segments), but some researchers analyze the expanding proportion of sugars in plants and theorize that a systemic shift in plants could further reinforce the already alarming and endemic rates of obesity and cardiovascular disease (Evich, 2017).

Equally important is the research that is being generated in the U.S. Department of Agriculture. Lewis Ziska, a plant physiologist at the Agricultural Research Service headquarters in Beltsville, Maryland, is raising questions and advancing what Loladze commenced almost two decades ago, with a number of new studies that focus on nutrition. One particularly fascinating experiment devised by Ziska, was set to determine to what extent these changes are being driven by the augmenting [CO_2] or the complicating factor of plant breeding. To this extent, he decided to look into bee food (Evich, 2017).

Goldenrod, a wildflower contemplated by many to be a weed, is a primary source of nutrition to bees. It flowers late in the season, and its pollen prepares the bees for the harshness of winter by administering the important source of protein they require. In consideration of goldenrod being wild and humans not having bred it into new strains, that has resulted in a scenario in which the plant hasn't been transfigured over human history, like corn or wheat have, for example (Evich, 2017).

By resorting to the Smithsonian Institution historical archive that accommodates samples of the plant dating back to 1842, Ziska and his colleagues have a chance to uncover how the plant has changed over time. Uniquely so, they discovered that the protein content of goldenrod pollen has dwindled by a third since the industrial revolution - and that transformation has kept tracks with the rise of [CO_2] (Evich, 2017).

For a long time now, scientists have been mesmerized in trying to unearth the causes of bee population declines around the world, due to their crucial importance in maintaining ecosystem function and processes running, as well as being major pollinators of an array of crops that humans depend on for their diets. To this effect, Ziska's paper (Ziska et al, 2016) proposed that a deterioration in protein prior to winter could be a supplementary factor making it distressing for bees to survive other stressors (Evich, 2017).

Albert Einstein (1965) probably summed it best when he foreshadowed:

> "If the bee disappeared off the surface of the globe, then man would have only four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man."

Despite the challenges, researchers are increasingly focusing on the link between atmosphere-nutrition, and Samuel Myers (quoted above), a doctor turned climate researcher at Harvard University who leads the Planetary Health Alliance, seeks to connect the dots between climate science and human health (Evich, 2017). As a matter of fact, Myers and his team's *Nature* study (2014), that demonstrated a relationship between rising [CO_2] and drops in protein, iron and zinc, was the first that attracted any real media attention. The researchers wrote the following:

> "The public health implications of global climate change are difficult to predict, and we expect many surprises. The finding that raising atmospheric CO_2 lowers the nutritional value of C3 crops is one such surprise that we can now better predict and prepare for."

In the same fashion, Loladze published his own paper (2014), the result of more than 15 years of gathering data on the subject, and it became the largest study in the world on rising [CO_2] and its repercussions on plant nutrients. His 2002 suspicion, eventually evolved and according to nearly 130 varieties of plants and more than 15,000 samples collected from experiments over the previous three decades, the development was conspicuous. The overall concentration of minerals like calcium, magnesium, potassium, zinc and iron had contracted by 8 percent on average, and the ratio of carbohydrates to minerals was increasing. In light of this, the plants, like the algae, were molding into junk food (Evich, 2017).

Finally, a new collaboration between Ziska and Loladze has now taken place and materialized into *Carbon dioxide (CO_2) levels this century will alter the protein, micronutrients, and vitamin content of rice grains with potential health consequences for the poorest rice-dependent countries* (Zhu et al, 2018), published in the journal *Science,* is one of the many advancing the discussion and also focusing on vitamins, which to date, has almost not been studied at all (Evich, 2017).

In this study the researchers are focusing on the repercussions of CO_2-induced qualitative changes that may be aggravated where food diversity is limited, that is, where populations depend heavily on a single plant-based food source (Zhu et al, 2018). Markedly so, rice consumption, which accounts for 25 percent of all global calories, varies immensely with socioeconomic status, specifically in Asia (Maclean, Dawe, Hardy & Hettel, 2003), correspondingly, it stands among the more crucial caloric and nutritional sources, notably for low - and lower-middle-income Asian countries (Kennedy, Burlingame & Nguyen, 2013).

Consequently, for those populations that are highly rice-dependent (or in any other staple food), any CO_2-induced transformation in the integrated nutritional value could inordinately influence human health (Zhu et al, 2018), and to that effect, as of 2013, approximately 600 million individuals, predominantly in Southeast Asia [the countries of Bangladesh, Cambodia, Indonesia, Lao People's Democratic Republic (PDR), Madagascar, Myanmar, and Vietnam], consume ≥ 50 percent of their per capita dietary energy and/or protein straight from rice (Seck, Diagne, Mohanty & Woperais, 2012, FAOSTAT, 2017) (figure 5.44).

The public health concern relative to the climate-change-nutrition link has been drawing ever more attention, with a recent study published in the journal *PLOS Medicine* (Weyant et al, 2018) from researchers at Stanford University establishing that in Southeast Asia, the rate of iron deficiency may surge from 21.8 percent to 27.9 percent by 2050. The researchers caution that such deficiencies in diet could make millions of people more susceptible to diseases such as malaria and pneumonia, prompting many premature deaths (Zimmer, 2018).

In figure 5.44, Chunwu Zhu and colleagues (Zhu et al, 2018) set out to compare qualitative changes observed with [CO_2], as a function of rice consumption in the top 10 highest-consuming rice countries as of 2013 and then matched with GDP per capita of that country. Following this reasoning, any protein and mineral deficits (Fe + Zn), linked with higher CO_2 values, are recognized to be more noticeable in the countries with the lowest overall GDP per capita (for example, Bangladesh and Cambodia). Together with this, the reductions in vitamin B (B1, B2, B5, and B9) availability were more extreme in the same countries. Correspondingly, the increment in vitamin E with higher CO_2 concentrations and the ensuing consumption is *pro rata* greater for the countries with more widespread poverty, which end up ingesting more rice (Zhu et al, 2018).

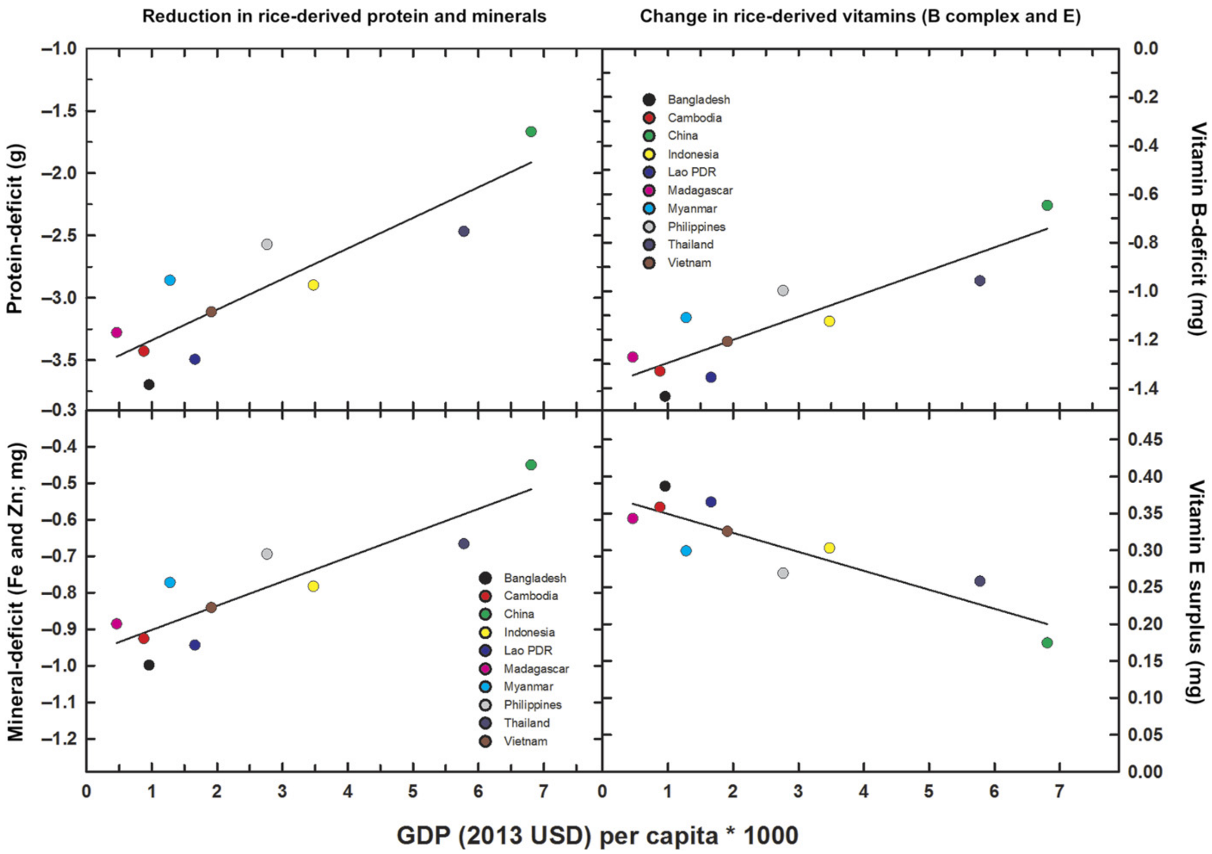


Figure 5.44: Projected [CO_2]-induced deficits in protein and minerals (Fe and Zn) and cumulative changes in vitamin B and cumulative changes in vitamin E derived from rice as a function of GDP per capita**.** Data are based on 2011/2013 FAO food balance sheets for rice consumption and 2011/2013 World Bank estimates of GDP per capita per country. Retrieved from Zhu et al, 2018**.**

As it becomes quite discernible from figure 5.44, the majority of these changes, and the highest degree of risk will transpire among the highest rice-consuming countries with the lowest GDP. On the other hand, as income rises, consumers tend to adopt more diverse caloric sources, with a greater insistence on protein from fish, dairy, and meat (Drewnowski, Barry & Popkin, 1997).

As an illustration, in Japan, rice accounted for 62 percent of total food energy consumption in 1959, but that quota decline to 40 percent by 1976 and, in recent years, it has been roughly < 20 percent (Smil & Kobayashi, 2012), likewise, in South Korea, per capita rice consumption underwent almost a 50 percent reduction since 1975 (Choi, Dyck & Childs, 2016). On the other hand, countries like Bangladesh, where economic growth has not been sustained, 75 percent of total caloric supply per capita was derived from rice in 1990; 23 years later, in 2013, it was 70 percent (FAOSTAT, 2017); similarly, in Madagascar, the percentage of rice consumption has increased since 1990 (FAOSTAT, 2017). Additionally, other countries, such as Guinea, Senegal, and Côte d'Ivoire, have become more subservient to rice as a percentage of their caloric supply (20 to 40 percent as of 2011) (GRISP, 2013).

As Loladze, Ziska and colleagues assert in the paper (Zhu et al, 2018):

> "Specific health outcomes of consuming rice with reduced nutritional quality are also difficult to forecast. Staple foods, such as rice, are widely available and affordable for most of the world's population, particularly the poor. It is understood that undernutrition can put people at risk in low-income countries for a wide range of other adverse health outcomes, particularly stunting, diarrheal disease, and malaria (King, Burgess, Quinn & Osei, 2016). For example, Kennedy et al. (2013) found that the percentages of children under 5 years of age who suffer from stunting, wasting, or are underweight are generally high in countries with very per capita rice consumption. Overall, the current data suggest that, for these countries, any [CO_2]-induced change in nutritional quality would likely exacerbate the overall burden of disease and could affect early childhood development."

For Sara Menker, founder and chief executive of Gro Intelligence, an agricultural data technology company, the world could be facing in less than 10 years a 214 trillion calorie deficit. Menker asserts that in most appraisals of food insecurity, it is mass and weight and not nutritional value that is esteemed as desirable. She attests that if we look at the nutritional value of current food production, global food security is even now, more insubstantial than we regard it to be. Furthermore, population and economic growth in China, India, and African countries will magnify this trend as those countries will continue to rely on net imports for food (Dahir, 2017).

As a matter of fact, Menker avouches that the year 2023, will be a crossover point and this stems from the population of China, India and Africa being combined to comprise half of the world's population. Provided that Africa already has to import food (Menker, 2016), and by 2023, it is foreseen that India will join that group as well and be dependent on imports to guarantee its food security. China, on the other hand, with its population projections anticipating a stabilization of the human populace, will not be free from food insecurities since the overall calorie intake in the country will keep on expanding through the early 2020's, Menker affirms (Dahir, 2017).

As described in the segment Diet, Affluence and China, people in the country have begun to administer more meat - especially red meat - to their diets (Milman & Leavenworth, 2016), and Menker is foreboding that more people continue to demand this sort of high-calorie diet (Gro Intelligence, 2016). This will materialize into a scenario in which, by 2023, even if all the surplus produced from countries in Europe, North and South America was exclusively exported to China, India and Africa, it still would not be proportionate to the required needs (Dahir, 2017).

If there is one thing that can be understood in this chapter is that the link between human overpopulation and food security is complex and exceedingly assailable. To suggest that this mesh is Daedalean and obscure in its inception would be an understatement. In effect, who would have thought that to come into a work regarding excessive human numbers would end up with an argumentation disentangling the intricacies of collapsing nutrients and imperilled diets, as a result of a swelling human population that keeps on injecting more CO_2 into the atmosphere and disrupting natural biochemical processes? But that is exactly the situation we are in. Unrelenting human population growth is a threat multiplier, and in the case of food security, its repercussions are considerable and scopious.

As it was described throughout this chapter, rising affluence and climbing on the food-chain have distinct and urgent ecological and environmental repercussions. And so we are faced with a dilemma. If people's economic condition does not improve they will be faced with malnourishment, disease, the lack of birth controls and overall human misery, on what became known as the Malthusian Trap. On the other hand, by lifting all those hundred million with economic growth, they will increase their caloric consumption, breaching carrying capacities and deepening our ecological convulsion. As Massimo Livi Bacci contends in *Our Shrinking Planet* (2017)*:*

> "The fact that breaking out of the 'Malthusian Trap' implies a dangerous growth in the consumption of energy and non-renewable raw materials, demonstrates [….] a heavy environmental impact."

In essence, I don't have an answer for this conundrum, but reason and logic would persuade an argument in which fewer individuals would have access to a greater share of resources, therefore leading to more sustainable and prosperous lives.

Coupled with this, in *Is Sustainability Still Possible?* Jennie Moore and William Rees (2013) explored what a one-planet lifestyle would look like (in a world with 7 billion not 7.6 billion) and their analysis shows (figure 5.45) that if we lived within Earth's limits, gone would be the days of driving personal vehicles, flying, eating meat, living in large homes, and fundamentally the entire consumer society that we presently know. One quick glance at figure 5.45 and one is struck by the abysmal contrast in lifestyles that would be required to attain this social justice scenario. To make things worse, this is but a snapshot for a 7 billion population. Each year we are adding roughly 83 million additional passengers to this planet, which means that the austerity required for each individual will only increase.

On top of this already dreadful report, an article published in *Nature Sustainability* titled *A good life for all within planetary boundaries* (O'Neill, Fanning, Lamb & Steinberger, 2018) clearly delineated that presently, no country meets the needs of its citizens at a sustainable level.

To help us understand the complex intricacies of this study, a panel converged in the *World Population Balance* Podcast (Overpopulation Podcast, 2018) to discuss the required cutbacks in consumption and affluence to meet a sustainable 'good life.' Here are some of the points that I found particularly interesting in answering the question, "If Everyone lived sustainably, what would their lives be like?"

> "To cut back on consumption sufficient enough for all of us to live sustainably, it would have to really be a dramatic drawdown. It's not just not having a swimming pool, its consuming everything about half to one-sixth […] within the bio-physical boundaries chosen by the authors, CO_2 emissions, nitrogen, phosphorous, freshwater, land-use change, ecological footprint and material footprint and the nations that have the average below the bio-physical limits are Morocco, Guatemala and the Phillíphines […] so these living standards are quite a bit below what most of us in the U.S. and the developed world would see as a good quality of life […] looking at the incomes, all of those countries were between 3-5 thousand/per capita income, while the US is at 55 thousand/per capita, so that's how unsustainable and how dramatically we would have to reduce consumption to work with these bio-physical boundaries [...] Taking a look at Chad, which has an ecological fooprint close to the 1.7 global hectares/per person (minimum biocapacity required for all humanity to live sustainably right now, even though it excludes the natural world from the equation) the most recent data found portrayed a life expectancy of 56, only 48 percent of urban

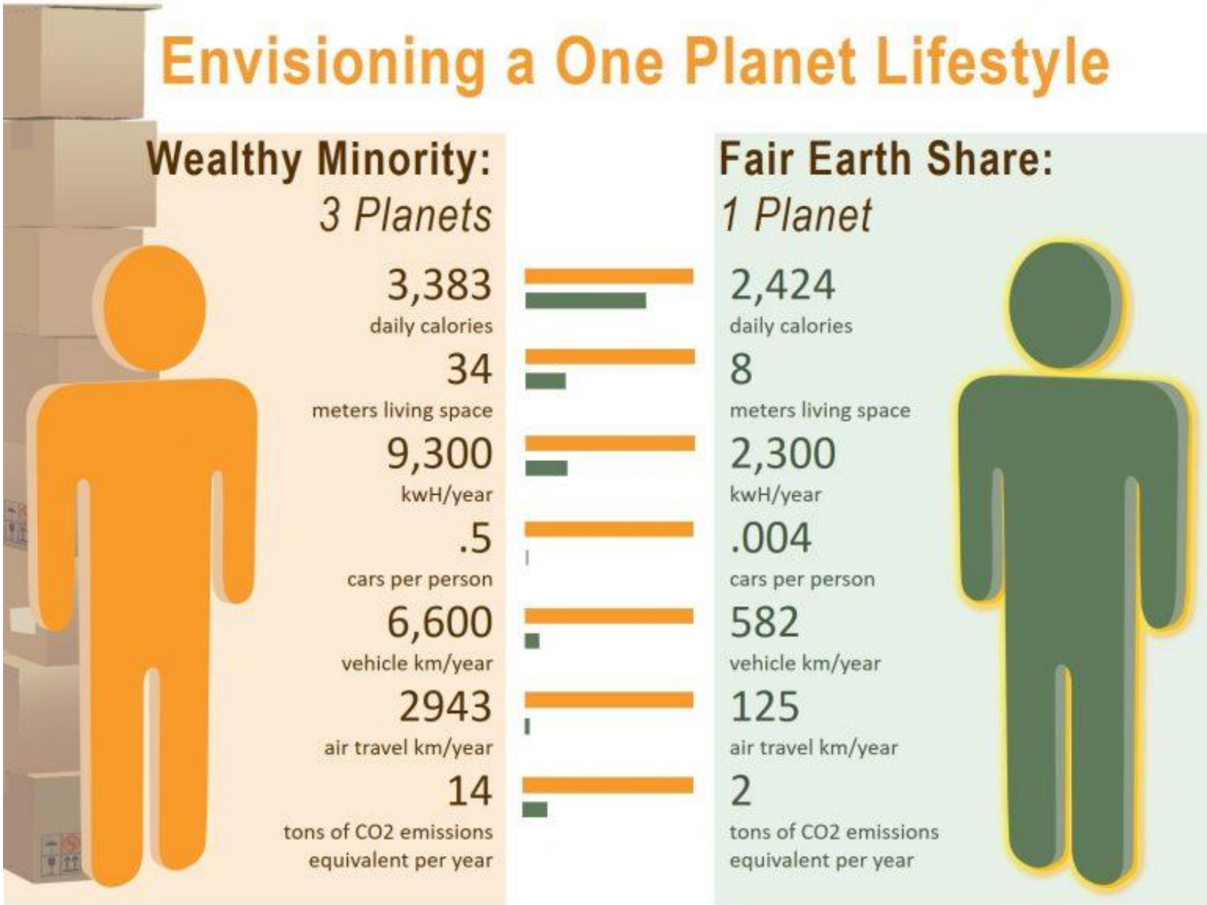


Figure 5.45: What would be required for 7 billion humans to live fairly and sustainably. Retrieved from Moore & Rees, 2013.

> […] residents have access to potable water and only 2 percent to basic sanitation, there is one television station in the whole country, 24 percent had cell phones in 2010, more than half the population is illiterate. So, **it is not exactly the typical eco-village that we envision in the US, when we think about living sustainably!** According to the study, if we were all to live all around the world within planetary boundaries, they found the associated life expectancy of 59 years, not all that different from Chad, sanitation only available to 60 percent, 18 percent would be below 1.90$/per day, this is the kind of world one would have to live in to not exceed any of these biophysical boundaries."

Finally, the good people at the *World Population Balance* Podcast go to the heart of the question when they ask, "Can we continue on our present course with our population (growth) and solve the sustainability challenge just by changing our lifestyles and move to Chad?" The panel pronounces:

> "There are so many things that we take for granted that make life more pleasant, I don't think we as a society are ready to make the necessary sacrificies to be sustainable with our current population. And even the *this* study (O'Neill et al, 2018) assumes a human population of 7 billion, so their assessment is already out of date and if we go to 9.9 billion by 2050 (PRB, 2018) it will just get worse and worse, the standard of living we can sustainably support."

In any event, without a significant reduction in the global population, in combination with a change in diet, the deleterious impact of agriculture on global ecosystems will only mount, since we can't honestly hope people will voluntarily abdicate of their affluent lifestyles and adopt something similar to what is practiced today in Chad.

Human population growth must be swiftly ended and ultimately reversed to maintain a healthy planet for people, and a viable planet for all other life on Earth. Without a commitment to population reduction and a scaling back of industrial agriculture, the planet's ecological integrity remains in serious jeopardy (Wuerthner, 2012).

Food security, climate change and biodiversity disappearance belong to the key challenges for a sustainable development of humankind. In particular, livestock production and the booming demand for meat, egg, milk and dairy products have prompted considerable environmental predicaments that are crucial hazards for food security (FAO, 2017b). So by all means, these burdens need to be deflated and downsized, particularly GHGs (Le Quéré et al, 2015*)* if international climate change goals are to be met (Benton & Bajželj 2016).

That is why I will dedicate the next chapter, Category: Chaos, to one of humanity's greatest challenges, anthropogenic climate change, that is being fueled by each and every one of us on this planet, irrespective of personal contributions, since at present, there is no discernible way of turning our footprint into a neutral one, much less a negative one. And so the decision to add more humans to this planet must enter the realm of discussion and debate since more people will always lead to the multiplicative effects being described so far in this work.

CHAPTER VI

CATEGORY: CHAOS

"Climate change is happening, humans are causing it, and I think this is perhaps the most serious environmental issue facing us."
- Bill Nye

"Climate change isn't just an environmental issue; it's a technology, water, food, energy, population issue. None of this happens in a vacuum."
- David Titley

"Climate change, demographics, water, food, energy, global health, women's empowerment - these issues are all intertwined. We cannot look at one strand in isolation. Instead, we must examine how these strands are woven together."
- Ban Ki-moon, 8th Secretary-General of the United Nations

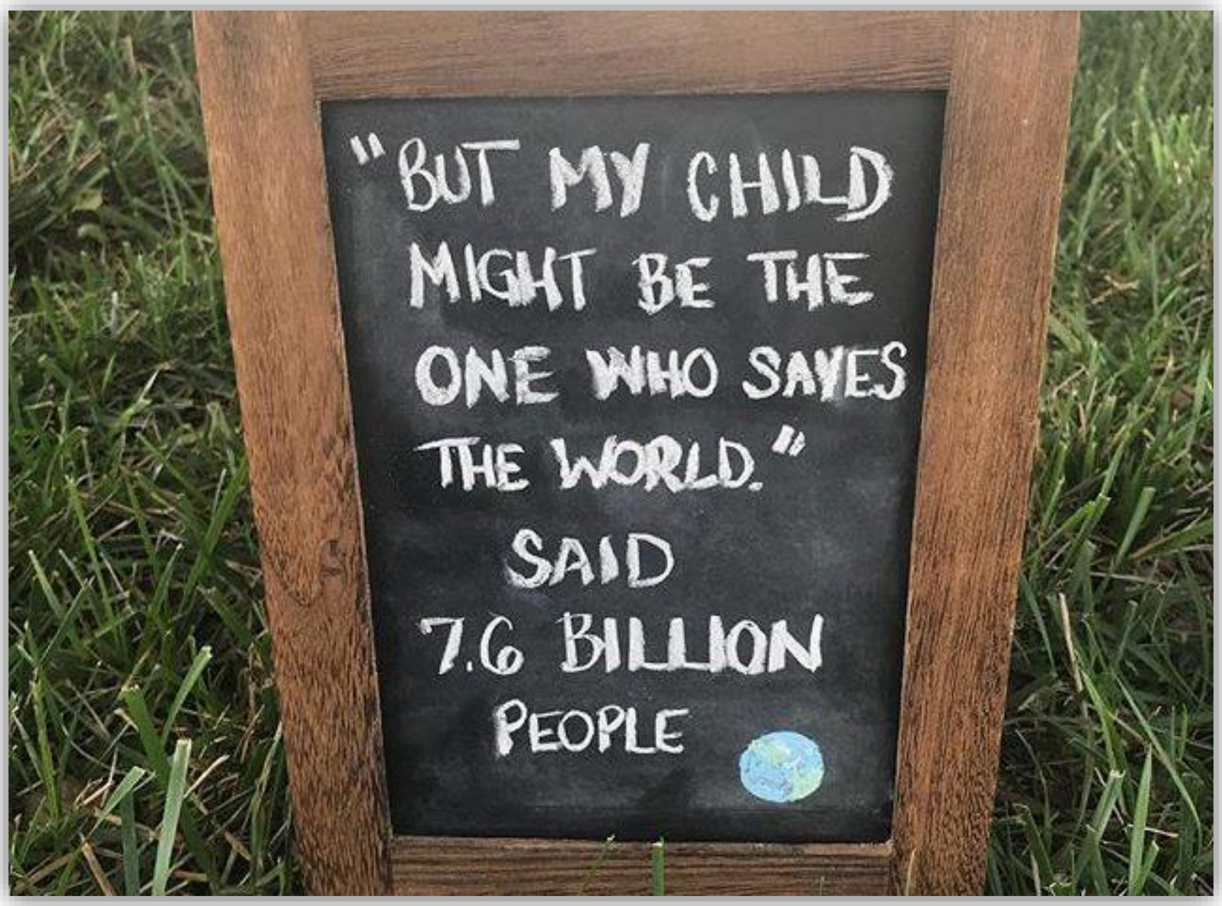


Figure 6.1: "But my child might be the one who saves the world." Credit to Leilani Münter.

This chapter starts at the AAAS, the American Association for the Advancement of Science where the National Climate Assessment was presented in March 2018. Robyn Williams, host of the influential *The Science Show* for *ABC Australia* was there to interview the four experts expounding this evaluation. Professor Katherine Hayhoe of Texas Tech University, Robert Kopp, director of the Institute of Earth and Atmospheric Science, Rutgers, Ben Sanderson at the National Centre for Atmospheric Research in Colorado, and leading the press conference, was Professor Donald Wuebbles from the University of Illinois, who said (the reader can complement the transcript with the audio here):

> “[Wuebbles]: The bottom line is that our climate is changing, it's happening now, it's not somewhere in the future, we are seeing major changes already, it's happening extremely rapidly, about 10 times more rapidly than nature tends to change the climate system, and severe weather is becoming more intense. [...] We are also seeing more precipitation coming as larger events than in the past. We expect this kind of trends to continue into the future, and changes in severe weather are also likely to become more intense. Climate will continue to change in the United States. It does depend in the long run on what choices we make about the emissions of greenhouse gases, our use of fossil fuels and land use change that contribute to those. One of the things the assessment does conclude is that the changes we are seeing are largely happening because of human activities and associated pollution, particularly those emissions that are leading to increases in amounts of carbon dioxide, methane, nitrous oxide and various particles, and that the climate will continue to change over the coming decades. But we can control how much it changes over the long-term by choices we make in terms of those emissions.
>
> [Hayhoe]: **This report**, the Climate Science Special Report, **can be summarised in just a few words**: **climate change is real, it’s us, and it’s serious**. Our report concludes that there is no credible natural explanation for the amount of warming we’ve seen. Human activities, especially emissions of greenhouse or heat trapping gases are the dominant cause [...] some of this information we have known for a very long time. We’ve had a good estimate of how much the world would warm if we doubled or tripled carbon dioxide levels the 1890s. But the newest and most emerging science in understanding the impact we are having on our world comes we look at sea level rise and what is happening at the ends of the Earth, at the poles.
>
> [Kopp]: The bottom line is that sea level rise is happening at an increasing rate, and this is leading to an increasing frequency of coastal flooding in many major US cities. In addition, high greenhouse gas emissions makes extreme sea level rise outcomes driven by the instability of the polar sheets more likely. This report concludes that global average sea level has increased by about 7 to 8 inches since 1900, with about three of those inches happening since 1993, which is the period that marked the start of the observations of global sea level. It also concludes that human caused climate change has made a substantial contribution to global mean sea level rise since 1900, contributing to a rate that is faster than during any preceding century in at least 2,800 years.
>
> So not only has the average rate of sea level rise over the last 25 years been faster than the average of the 20th century, but within this period that we have satellite records, the rate of sea level rise has increased by a quite rapid rate of about eight-tenths of an inch per decade. So the current rate of sea level rise in 2017 based on this analysis is more than twice as fast as the rate of sea level rise in 1993 when the satellite record began. A formal analysis supports the possibility that we could get to eight feet or more of sea level rise by 2100…” [Bold added by author]

“Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems. **Warming of the climate is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia**. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen,” the Intergovernmental Panel on Climate Change (IPCC) attests on their Climate Change Fifth Assessment Report (2014) (figure 6.2).

They supplement their findings with the following assertion:

> “Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.”

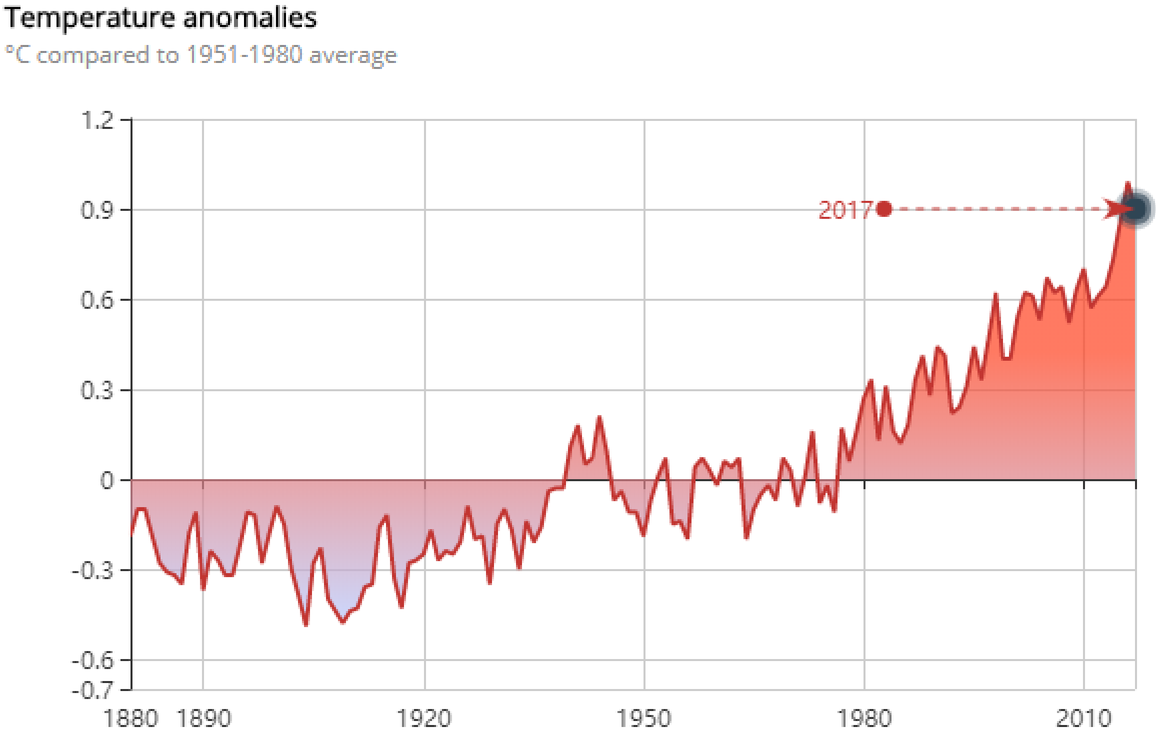


Figure 6.2: Temperature anomalies. Source: NASA's Goddard Institute for Space Studies (GISS) (NASA, 2018b) (data). Retrieved from (Tomorrow, 2018)

The National Aeronautics and Space Administration (NASA) links that statement with their own: “**Seventeen of the 18 warmest years in the 136-year record all have occurred since 2001, with the exception of 1998. The year 2016 ranks as the warmest on record**” (NASA, 2018b). What’s more, the National Oceanic and Atmospheric Administration (NOAA) expressed in August 2016 that each of the previous 16 months were the warmest they had ever gauged (NOAA, 2018a).

As the report *Beyond Borders - Our changing climate - its role in conflict and displacement* by the Environmental Justice Foundation (2017) states:

> "Global warming and the resulting climate change are scientific fact. There are no "alternative" truths. The evidence is clear, specific and overwhelming, as is the global scientific consensus that represents this view."

With this in mind, the most significant single threat to the ecology and biodiversity of the planet in the decades to come will be global climate disruption due to the accumulation of human-produced greenhouse gases in the atmosphere. People all over the globe have begun to devote themselves to this predicament by altering consumption patterns and relying on more efficient technology. Nevertheless, human population growth can subordinate those efforts, for this reason, the only adequate conclusion is that we not only need smaller footprints but fewer feet (Center for Biological Diversity, 2010).

Since the start of the industrial revolution, *Homo sapiens* have burned through enough fossil fuels - coal, oil, and natural gas - to charge up the atmosphere with roughly 365 billion metric tons of carbon. Deforestation has supplemented another 180 billion tons, and each year, humanity augments this by another nine billion tons or so (CO2.Earth, 2018), an amount that has been increasing by as much as 6 percent annually, as population and economic growth rises (Kolbert, 2014).

Humanity has now accomplished a 1ºC rise in temperature since the end of the 70s. A tempering of 1ºC in 50 years is unparalleled, as it is portrayed in figure 6.3, which depicts a reconstruction of temperatures in the last 11 000 years. Above all, what is distressing is not so much the change itself, but rather the speed at which this permutation is materializing (Tomorrow, 2018). This spells disaster for the continuance of humananity and many other species on this planet, as the IPCC asserts in their recent report *Global Warming of 1.5ºC – Summary for Policymakers* (2018):

> "Human activities are estimated to have caused approximately 1.0ºC of global warming above pre-industrial levels, with a *likely* range of 0.8ºC to 1.2ºC. Global warming is *likely* to reach 1.5ºC between 2030 and 2052 if it continues to increase at the current rate (*high confidence*)."

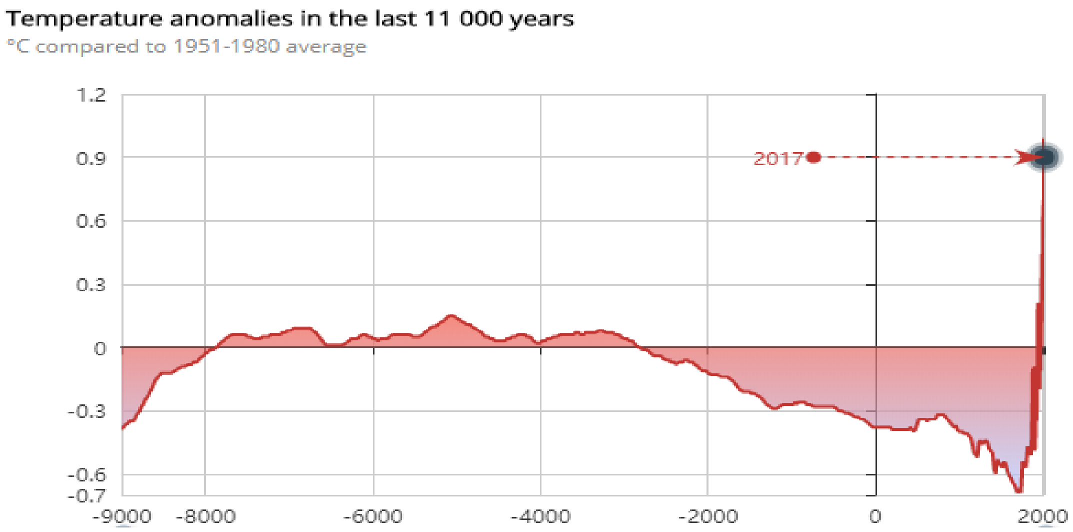


Figure 6.3: Temperature anomalies in the previous 11000 years. Source: *A Reconstruction of Regional and Global Temperature for the Past 11,300 Years* (Marcott, Shakun, Clark & Mix, 2013) (data) before 1880, NASA's Goddard Institute for Space Studies (GISS) (data) after 1880. Retrieved from (Tomorrow, 2018)

Historically speaking, a shift of 1ºC seems to transpire in thousands of years - not decades. What humanity (at least those who are encapsulated and insulated from our ecological reality) will have to realize is that the Earth is a complex ecosystem, and by tampering and deranging it by as little as a couple of degrees in the blink of decades (or even centuries) is a massive disturbance (Tomorrow, 2018).

Some percentage of readers might wonder if all these projections aren't just alarmist propaganda, but one thing we can be sure is that the planet has undergone substantial transformations in the past, and a couple of degrees change in the average yearly temperature is far from a negligible detail. Take this as an illustration, when the Earth's temperature was 5ºC lower, the sea level was **120 meters lower** and all of Northern Europe and Canada were coated by a Brobdingnagian ice cap (it was possible to hike from Vermont to Greenland). Moreover, average temperatures do not delineate the entire story (Tomorrow, 2018). As average temperatures swell, the likelihood of extreme temperature events might increase in tandem (Popovich & Pearce, 2017).

A distortion of a couple degrees over the surface of the Earth, initially prompts the oceans to assimilate the extra heat. In this process, they dilate (raising the sea level) and fomenting heightened evaporation, which engenders perturbed air and water currents. Equally important, this generates an elevated prospect of extreme weather events, such as drought, hurricanes, floods, fire and the lot. Correspondingly, longer-term repercussions will be a herculean task to quantify since a temperature change of this scale and abruptness has never been verified and validated by recovered data (Tomorrow, 2018).

So, what is causing this heating and disruption? To put it short, some gases are transparent to the sun's incoming rays heating the Earth but are opaque (act as mirrors) with respect to the ones leaving the planet. Those gases act as a blanket, trapping heat that is incapable of making its getaway. These are called greenhouse gases due to this warming performance. As a matter of fact, this greenhouse effect stabilizes our climate, maintaining nights warmer, to some extent, without the action of direct sunlight (Tomorrow, 2018).

One of those greenhouses is carbon dioxide (CO_2). By drilling the columns of ice containing small bubbles of old trapped air, scientists are capable of ascertaining historical CO_2 concentrations up to 800 000 years BCE (Riebeek & Simmon, 2005). As it is possible to interpret from the figure 6.4, this concentration has been somewhat steady up until the industrial revolution, where it catapulted to values double those observed 40 000 years ago. Above all, and as previously stated, it is the speed at which this transformation is occurring, as it is completely unrivaled by historical measurements. What this translates to, is that modern humans (*Homo sapiens)* have not lived through changes of this magnitude and speed, and we simply might not be able to adapt to the full repertoire of climatic repercussions in store, since we depend on the integrity and health of living systems, that we do not fully comprehend.

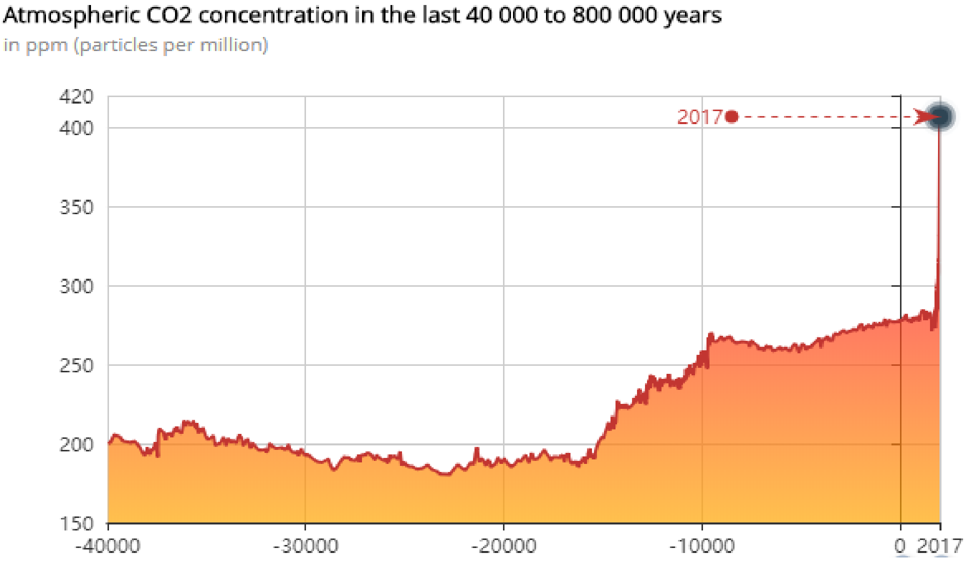


Figure 6.4: Atmospheric CO2 concentration in the last 40000 years in ppm (particles per million). Source: National Oceanic and Atmospheric Administration (NOAA) Ice Core records (Bereiter et al, 2015) (data) before 1959 and Mauna Loa records (Tans & Keelings, 2018) (data) after 1959.

Correspondingly, in 2015, the US Government's NOAA, through the Mauna Loa Observatory disclosed that annual CO_2 concentrations had augmented by a record 3.1 parts per million (ppm), exceeding 400 ppm for the first time on record (figure 6.4 and 6.5); moreover, by 2016, this had risen to 405.1 ppm, and in March 2018, to 408.75. For comparison, at the Mauna Loa Observatory, the value for May 2018, reached a record high of 411.25 ppm Tans & Keelings, 2018).

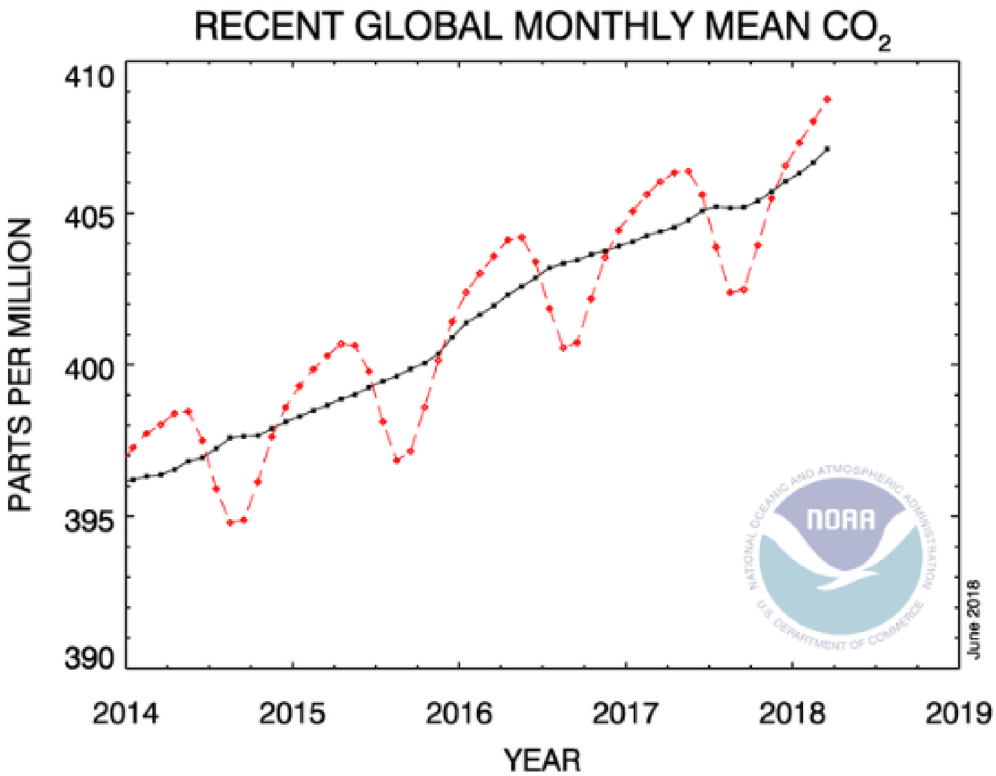


Figure 6.5: Recent monthly mean carbon dioxide globally averaged over marine surface sites. The dashed red line with diamond symbols represents the monthly values, centered on the middle of each month. The black line with square symbols represents the same, after correction for the average seasonal cycle. Retrieved from Earth System Research Laboratory, Global Monitoring Division, Tans & Keelings, 2018.

This almost 9 ppm surge in CO_2 concentration between 2015 and 2018 was unique in the observatory's history (Kahn, 2017a). On the whole, and as Pieter Tans, lead scientist of NOAA's (2017) Global Greenhouse Gas Reference Network affirms:

> "The rate of CO_2 growth over the last decade is 100 to 200 times faster than what the Earth experienced during the transition from the last Ice Age. Needless to say, this is a real shock to the atmosphere and the oceans alike."

Carbon dioxide concentrations have climbed over the past few years (Kahn, 2017b) due in part to natural factors like El Niño that prompt more CO_2 to remain in the atmosphere. Notwithstanding, most of that CO_2 and other greenhouse gases end up there due to anthropogenic activities, and the number of humans emitting those gases. Pieter Tans again:

> "The rate of increase will go down when emissions decrease. But carbon dioxide will still be going up, albeit more slowly. Only when emissions are cut in half will atmospheric carbon dioxide level off initially" (Kahn, 2017a).

Another key point is that even when concentrations of carbon dioxide subside the repercussions of climate change will be prolonged centuries into the future. The planet has already undergone a 1ºC rise in temperature, including at least 627 months in a row of above-normal heat (Kahn, 2017c). Under these circumstances, humanity is on track to terraform a climate that hasn't transpired on this planet for at least 50 million years, just by mid-century (Kahn, 2017a). Back then, during the period known as the Eocene, temperatures were up to 10ºC warmer, ice was virtually non-existent and oceans were dramatically higher than they currently stand. Dana L. Royer, co-author of the paper published in *Nature Communications* titled *Future climate forcing potentially without precedent in the last 420 million years* (Foster, Royer & Lunt, 2017) asserted:

> "The early Eocene was much warmer than today. There was little-to-no permanent ice. Palms and crocodiles inhabited the Canadian Arctic."

Royer assured, (surely to the dismay of many), that even if humanity reaches those carbon dioxide levels by mid-century, crocodiles won't suddenly surface on the 'Arctic' (a term most likely obsolete by then). Even though the Eocene was a time in which this planet was indistinguishable, it was quite possibly a place in which humanity could not have survived, or at the least, not thrived with the planetary expansion and swiftness it did. But if a 10ºC like in the Eocene seems like a far-fetched scenario, we need to go no further than the Pliocene Epoch, which Gavin Schmidt, Director of NASA's Goddard Institute for Space Studies (GISS) does an exemplary work of condensing:

> "The most recent era in which the Earth was believed to have experienced temperatures of 3ºC above pre-industrial levels was the Pliocene Epoch - around three million years ago. At that time, there was almost no ice anywhere. The sea level was 20 meters (65 feet) or so higher, and forests went to the edge of the Arctic Ocean where there is now tundra. It takes a long time for those changes to manifest, but if we see a 3ºC… it pushes us is that direction" (quoted in EJF, 2017).

Although not enough political action is achieved, the robustness of the planet's health (which is to say the fragile interval that corresponds to humans being capable of inhabiting the Earth) usually attracts the attention of the mainstream media and *Salon* (Kahn, 2017d) ran a piece on it, which contended that some of the implications:

> "Are some of the starkest reminders yet that humanity faces a major choice to curtail carbon pollution or risk pushing the climate outside the bounds that have allowed civilization to thrive."

Furthermore, *U.S. News & World Report* (Preidt, 2017) upheld that:

> "CO_2 levels in the atmosphere have varied over millions of years. But fossil fuel use in the last 150 years has boosted levels from 280 parts per million (check figure 6.4) (ppm) before industrialization to nearly 410 in 2018. If people don't halt rising CO_2 levels and burn all available fossil fuels, CO_2 levels could reach 2,000 ppm by the year 2250, the researchers said. CO_2 and other gases act like a blanket, preventing heat from escaping into space."

Current models vaticinate that levels of atmospheric GHG concentrations will arrive at the 450 ppm threshold in 2030 if business as usual continues (IPCC, 2014a). Correspondingly, our prevailing carbon-producing practices have us on a path to dangerous climate change. Population projections put us on track to supplement 2-3 billion more GHG emitters by 2050, which raises the imperativeness of mitigating and complying with climate change (Hickey et al, 2016).

In consonance with the most recent estimates from the IPCC, in order to meet the 450 ppm target mentioned above, global GHG emissions must unwaveringly recede until they are 40-70 percent lower in 2050 than they were in 2010, and then persisting to decline to near zero (or less) by 2010 (IPCC, 2014a).

But because CO_2 remains in the atmosphere for centuries, climate change will continue to transfigure the planet (Kahn, 2017c), and as the IPCC (Collins et al, 2014) vindicates:

> "It is important to state that **some greenhouse gases will keep warming the Earth many years after they have been emitted**, because they do not disappear instantaneously. Up to 40 percent of the CO_2 emitted today **will still be present 1000 years from now**, thus still causing warming."

Interviewed by *The Atlantic* (Brannen, 2018), David Naafs, an organic geochemist at the University of Bristol, who published a recent article alongside his colleagues in *Nature Geoscience* (2018) says:

> "If we do, in fact, push CO_2 up to around 1,000 ppm by the end of the century, the warming will persist and the earth will continue to change for what, to humans, is a practical eternity. And when the earth system finally does arrive at its equilibrium, it will most likely be in a climate state with no analog in the short evolutionary history of Homo sapiens."

If we were to cease emissions today, CO_2 levels would fundamentally never come back to its pre-industrial level on timescales relevant for our society (Jancovici, 2008), even if the current 7.6 and soon to grow to 9.9 billion by mid-century, somehow managed to live carbon-neutral lives, or develop the technology that would lead to negative emissions (both concepts stand as complete fiction at the moment, as it will be examined in the subsequent segments). One thing is certain, the International Panel on Climate Change (IPCC) affirms that in order to keep global warming to within 2ºC and confine the risk of dangerous climate change, the world will need to slash emissions by between 40 percent and 70 percent by 2050, compared to 2010, and eliminate them altogether by 2100 (Collins et al, 2014). Unfortunately, the Emissions Gap Report 2016 from the United Nations Environment Programme (UNEP, 2016) explicates that even if countries stay true to the commitments - known as Nationally Determined Contributions (NDCs) - that they made in Paris, the world would still warm by 2.9ºC to 3.4ºC.

As a matter of fact, the goal to keep global temperature levels below 1.5ºC could be breached as soon as 2026, according to analysis for the IPCC (Henley & King, 2017). Benjamin Henley, co-author in that research tells the *New Scientist* (Pearce, 2017):

> "Our paper, by showing the proximity of the 1.5ºC level, should be seen as a wake-up call for governments and send a catalyst for strong action."

The researchers point their fingers at two suspects. The first isn't strange to anyone, the continued rise in emissions by an ever larger and more affluent population. The second is the influence of the Interdecadal Pacific Oscillation (IPO), which is basically a cycle of sea-surface temperatures that exerts a warming or cooling effect on the atmosphere globally (Pearce, 2017).

This oscillation has been in a cooling phase for more than a decade, explicating the ostensible stalling of global warming in the early years of the century. Henley again:

> "This cool phase may have lulled us into a false sense of security" (Pearce, 2017).

Nevertheless, it is important to understand where these greenhouse gas emissions are deriving from, given that about three-quarters of these gases are of anthropogenic provenance and *ancestry* (seems adequate to describe it as such, when taking into account the half-life of their existence and how long humanity will have to deal with the mistakes of past generations) the other quarter hails from deforestation and the transmogrification of wildlands to agriculture. Here too, population growth is a crucial component shaping this complication, as governments embolden new settlements and the conversion of forests to agriculture, in order to feed and accommodate burgeoning human numbers (Cafaro, 2012).

As it is portrayed in figure 6.6, a sizable amount of agricultural emissions emanates from cows and other livestock emitting methane (CH_4) as part of their digestive process. Furthermore, deforestation ushers in fewer trees absorbing CO2 through photosynthesis (Tomorrow, 2018). Deforestation is one of the main factors of climate change and it is second only to the emission of CO_2 by fossil fuels. In Indonesia, rainforests are deliberately burned, with the cooperation of corrupt politicians, to clear land for palm oil plantations. Likewise, the rainforests of South America are also illegally burned, in this case for the sake of soybean plantations and cattle ranches. In both cases, loss of habitat accelerates the extinction of threatened species (Avery, 2017).

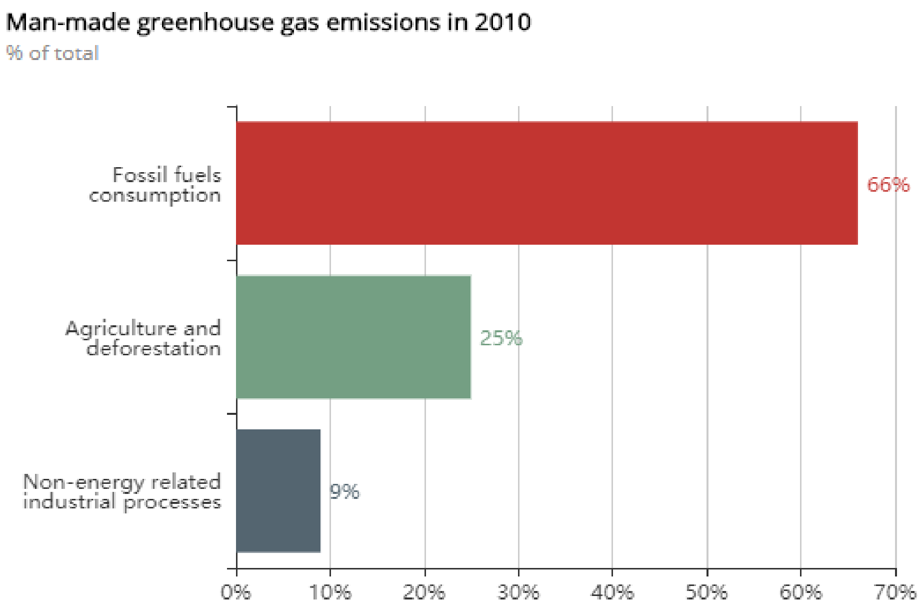


Figure 6.6: Man-made greenhouse gas emissions in 2010 (percentage of total). Source: Accenture Energy Perspectives - Consequences of COP21 for the Oil and Gas Industry (Debarre, Fulop & Lajoie, 2016). Retrieved from (Tomorrow, 2018).

Coupled with this, in recent research published in the journal *Nature Communications*, Thomas Guillaume and colleagues (Guillaume et al, 2018) compared the carbon costs of palm oil plantations with those of rubber production, and arrived at the conclusion that notwithstanding palm plantations having a record of more efficient land use (compared to biomass confiscated), they are responsible for much higher emissions than previously considered. As a matter of fact, their data indicates that the figures used by the IPCC and sustainable palm oil certification bodies are underestimating the volume of emissions from the transmogrification of habitats (Gaworecki, 2018b).

Uniquely, the researchers attest that each hectare of rainforest transformed into plantations of palm oil monocultures generates 174 tons of carbon emissions, with a substantial share finding their way into the atmosphere and strengthening our climate complication. Guillaume substantiated in an interview to *Mongabay* that the 174 tons of carbon are roughly equivalent to 530 people flying from Geneva to New York in economy class. On the other hand, intensive rubber farming is answerable for around 159 tons of carbon loss, while extensive rubber production accounts for 116 tons (Gaworecki, 2018).

Another crucial greenhouse gas with man-made origin are the nitrogen-based fertilizers in agriculture that generates Nitrous Oxide (N_2O). Note that the use of fossil fuels (or electricity) for the manipulation of agricultural machines is not even comprehended in these 25 percent (Tomorrow, 2018). By comparison, all CO_2 emissions from transportation accounted for 20 percent, in 2014 (The World Bank, 2018d).

Nevertheless, most greenhouse gases stem from burning fossil fuels (oil, gas, coal). That happens every time we decide to use a car, take a plane or use electricity. It also happens indirectly when we consume foods or purchase objects that demanded tremendous amounts to be produced, assembled and transported from afar (Tomorrow, 2018). Moreover, roughly 9 percent of global emissions are related to specific types of heavy industrial processes, such as kiln production for cement works, whose emissions are not associated to the generation of fossil-fuels per say, so they are accounted separately (Tomorrow, 2018).

Correspondingly, climate scientists make mention of the 'Kaya Identity': the four vital components which regulate overall greenhouse gas emissions. These are economic output/per capita, total population, energy used to generate each unit of GDP, and greenhouse gases emitted per unit of energy (Cafaro, 2012). In the light of this, over the past three and a half decades, enhancements in energy and carbon efficiency have been vanquished by the expansion in population and the rise of per capita wealth. In accordance with the 4th Assessment by the IPCC (2007):

> "The global average growth rate of CO_2 emissions between 1970 and 2004 of 1.9 percent per year is the result of the following annual growth rates:
>
> Population + 1.6 percent,
>
> GDP/per capita +1.8 percent,
>
> Energy-intensity (total primary energy supply (TPES) per unit of GDP) - 1.2 percent,
>
> And carbon-intensity (CO_2 emissions per unit of TPES) - 0.2 percent"

The IPCC gives an update on these trends in their Climate Change Fifth Assessment Report (2014):

> "Total anthropogenic GHG emissions have continued to increase over 1970 to 2010 with larger absolute increases between 2000 and 2010, despite a growing number of climate change mitigation policies [...] Emissions of CO_2 from fossil fuel combustion and industrial processes contributed about 78 percent of the total GHG emissions increase from 1970 to 2010 [...] **Globally, economic and population growth continued to be the most important drivers of increases in CO_2 emissions from fossil fuel combustion**. The contribution of population growth between 2000 and 2010 remained roughly identical to the previous three decades, while the contribution of economic growth has risen sharply."

Pressingly, the IPCC's prognostications for the next several decades describe a prolongation of these trends. More people living more affluently signifies that despite scheduled technical efficiency improvements, under 'business as usual', greenhouse gas emissions will soar by 25-90 percent between 2000 and 2030 (Collins et al, 2014). If we tolerate and indulge this to transpire, it will almost surely lock in global temperature increases of more than 2ºC beyond preindustrial levels, eclipsing the threshold beyond which scientists describe as potentially catastrophic climate change or runaway climate change (Cafaro, 2012).

John Scales Avery (2017) impeccably communicates the intendment of this climate emergency when he remarks that:

> "Immediate action is imperative if we are going to insure that future generations will be able to survive on planet earth. In order to avoid a catastrophe we must understand that climate change is a contrast of time scales [...] although some of the disastrous effects of climate change are already visible, the worst will occur in the distant future. Therefore, it is difficult to mobilize the political will for quick action. We need to act immediately, because the danger of passing tipping points beyond which climate change will become irreversible despite human efforts to control it [...] Fossil fuels must remain in the ground and forests must be preserved and not be destroyed in order produce beef and palm oil."

The *tipping points* Avery mentions are linked with feedback loops, such as the albedo effect and the methane hydrate feedback loop. The albedo effect can be explicated by whether sunlight that is falling on Polar Regions is reflected or absorbed. If a substantial extension of ice remains, most of the sunlight in reflect, but as areas of the sea surface become ice-free, more sunlight is absorbed, prompting rising temperatures and further melting of sea ice (Avery, 2017). (For more information on self-reinforcing feedback loops I would suggest the reader to consult McPherson, 2016. It is a fascinating read, although if it stands true it will usher in an episode similar to the Great Mass Extinction of the Permian, around 252 million years ago, most likely phasing out humanity along the way. Unfortunately, a substantial section of *Academia* still considers what became known as Runaway Climate Change to be on the fringe of climatic sciences, even though time and time again we have been shown that our models, forecastings and conjectures have been underestimating the repercussions of climate change and the anthropogenic role in its aggravation.)

In the meantime, as these climatic shifts settle in, take their toll and humanity drags their feet on real commitments for mitigation, reverberations are being felt all over the globe. One of the latest and bleakest research published in *the* journal *Nature* by the Ice Sheet Mass Balance Inter-Comparison Exercise (IMBIE) team (2018) basically reached the conclusion that Antarctica's ice sheet is melting at a much more quicker rate than foreseen and as a result 200 billion tons of ice are merging into the ocean, on a yearly basis, raising sea levels a half-millimeter every year, the team of 80 scientists reported (Mooney, 2018).

In comparison, this means that the melt rate has tripled in speed over the past decade, and if the acceleration continues unabated, some of the worst-case predictions raised by scientists regarding the invasion of land by the oceans, submerging low-lying cities and communities, could come to fruition, much sooner than anticipated (Mooney, 2018).

One of the more dismal inferences vindicated by the study is that nations might only have about a decade to cut greenhouse-gas emissions if they even aspire and contemplate the possibility of averting some of the worst consequences of climatic activity (Mooney, 2018).

In detail, Antarctica, the planet's most extensive ice sheet, forfeited 219 billion tons of ice annually from 2012 through 2017, which is in the vicinity of triple the 73 billion-ton melt rate of a decade ago, the researchers ratiocinated. Comparatively, from 1992 through 1997, Antarctica lost 49 billion tons of ice annually (Mooney, 2018).

In a piece for *The Washington Post* (2018)*,* Beata Csatho, one of the study's (Dow et al, 2018) authors and a glaciologist at the University at Buffalo, New York, substantiated that:

> "The detailed record shows an acceleration, starting around 2002 [...] actually, if you compare 1997-2002 to 2012-2017, the increase is even large, a factor of more than 5!!"

In light of this, the loss of ice from the period of 1992 forward has resulted in 3 trillion tons of ice, equating to just less than 8 millimeters of sea-level rise. Startlingly enough forty percent of that loss has occurred since 2013. By all means, this dashing cataclysm is almost exclusively driven by the West Antarctic ice sheet, to which scientists impute the melting from warm ocean waters from below, that render the glaciers unstable (Mooney, 2018; Dow et al, 2018).

This may remind many of a polemical study from former NASA scientist James Hansen and a team of colleagues (Hansen et al, 2016), in which they vouched that the Earth's sea level could rise above one meter within the period of just 50 years if polar ice-sheet loss doubles every 10 years. By following the results and prospects of the IMBIE team, of a tripling every decade, the deluge advanced by Hansen et al. could become a reality, much sooner than anticipated (Mooney, 2018).

Notwithstanding, longer-term reverberations are difficult and troublesome to anticipate since a temperature alteration has never been corroborated by evidence in the past (Tomorrow, 2018). For a rough idea, the map below (figure 6.7) originally from Gaia Vince of *New Scientist* (2009) and reprinted in Parag Khanna's book *Connectography - Mapping the Future of Global Civilization* (2016) portrays how the world would be transfigured by a 4ºC warming. One of the most conspicuous aspects is the "greening" of some of the icy regions, which seems to be substantiated by recent reports (Donahue, 2017).

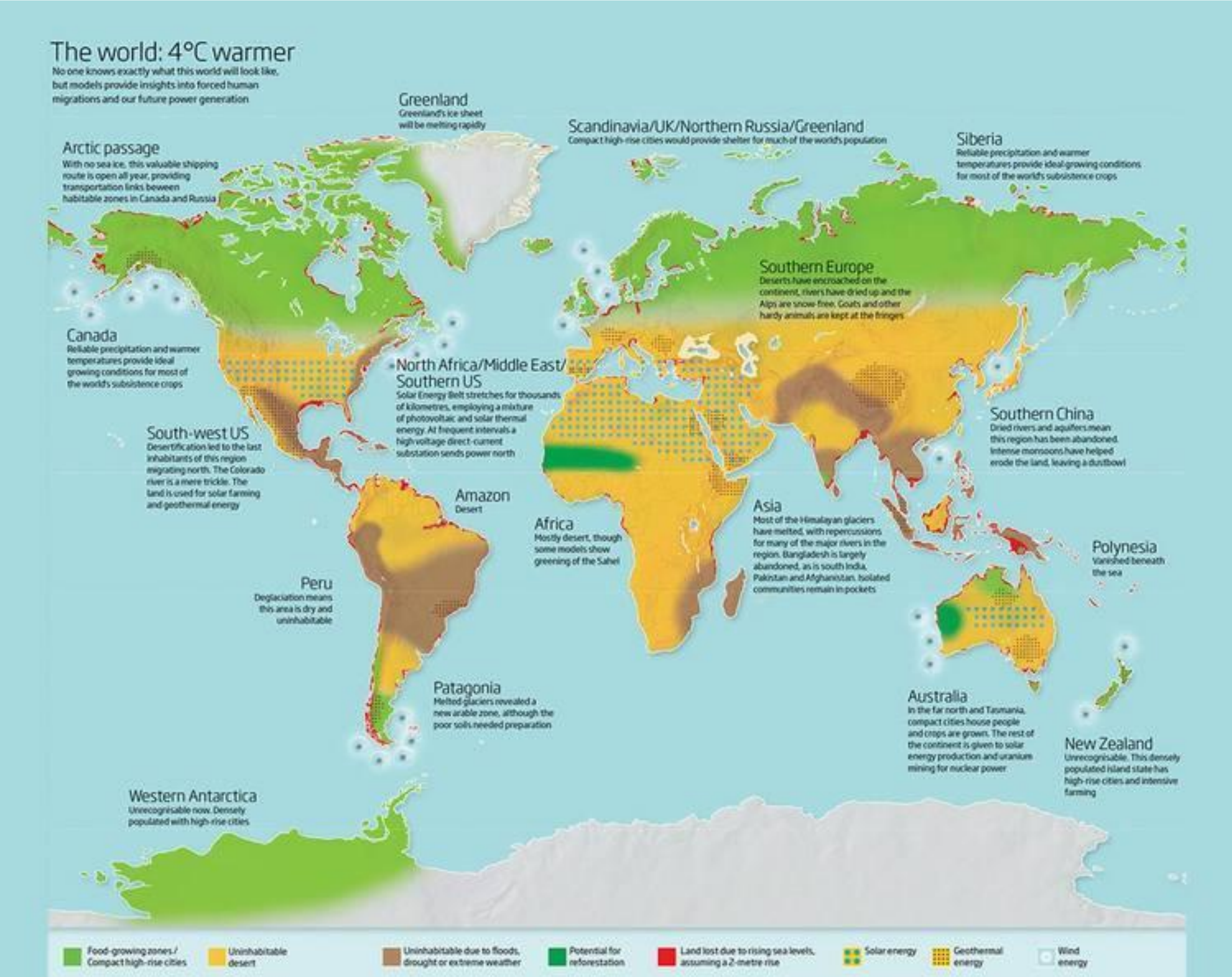


Figure 6.7: World map under a 4ºC rise in temperature. Source: *New Scientist* (Vince, 2009). Retrieved from Parag Khanna's book *Connectography - Mapping the Future of Global Civilization* (2016).

In a *National Geographic* piece (2017) by Michelle Z. Donahue, titled *Fast-Growing Moss is Turning Antarctica Green* scientists deliberate on some discernible changes this continent has already undergone with an average 1ºC rise in global temperature. Matthew Amesbury, a paleoclimate researcher at the University of Exeter in the U.K., said in a statement:

> "Temperature increases over roughly the past half century on the Antarctic Peninsula have had a dramatic effect on moss banks growing in the region. If this continues, and with increasing amounts of ice-free land from continued glacier retreat, the Antarctic Peninsula will be a much greener place in the future."

The evidence for this change has been reported in the journal *Current Biology* (Amesbury et al, 2017) by Amesbury and colleagues, who asserted that until about 50 years ago the two species that monopolized the moss banks on this region grew one millimeter or less a year, on average, and that, since then, the mosses have averaged three or more millimeters a year (Donahue, 2017).

Based on the observed patterns, the researchers deduce that further warming could swiftly tilt the region into a profoundly different ecological landscape - much as how the Arctic region has evolved into a more verdant location, over the last several decades. Dan Charman, co-author of the study upheld that:

> "The sensitivity of moss growth to past temperature rises suggest that ecosystems will alter rapidly under future warming, leading to major changes in the biology and landscape of this iconic region. In short, we could see Antarctic greening parallel to well-established observations in the Arctic."

Similarly, the globe's southernmost continent hasn't always been dominated by ice. As a matter of fact, the discovery of fossil ferns, pines, and ginkgoes from the Cretaceous Era (British Antarctic Survey, 2017) discloses how it was once a warm region, and that flora and fauna used to colonize and thrive very near to the South Pole. This greening rebirth is but a step back in time. As Robin Bell, a geophysical researcher with Columbia University's Lamont-Doherty Earth Observation, affirmed to *National Geographic* (Donahue, 2017):

> "Change is the pulse of our planet. So change is not a surprise. But the change caused by humans and the rate of change are both new."

Few serious scientists impugn the role that humanity has had on the conception of climate change. Be that as it may, the fact remains that many still have a hard time apprehending the full extent of global warming, in some measure as a conducive way of ignoring the destructive impact it is predicted to have (Jacobs, 2017). For this reason, it should be enlightening to expand on the 4ºC warming of the planet map (figure 6.7 above) and how this metamorphosis would impinge on humanity.

Some key points that the reader will soon realize by a quick glance at this map is that, first of all, brown areas symbolize 'Uninhabitable due to floods, drought or extreme weather,' which accounts for a substantial fraction of South America, the Eastern Seaboard of the U.S., along with Mexico and Central America. Moreover, in Africa, Mozambique and Madagascar are abandoned, and not to mention Asia, that surrenders much of the Indian subcontinent, inclusive all of Pakistan. Additionally, Indochina is relinquished, as is most of Indonesia (Jacobs, 2017). As the author and international relations expert Parag Khanna (2016) shows us on the map:

> "The last inhabitants of [the South-west U.S. are] migrating north. The Colorado River is a mere trickle. Deglaciation means [Peru] is dry and uninhabitable. Bangladesh is largely abandoned, as is South India. [In] Pakistan, isolated communities remain in pockets."

Jessica Steward, in the website *My Modern Met* (2018) reflects on the map and explicates that:

> "Most of us would be on the move, with the most populous areas of the map now uninhabitable. As the map shows, deserts engulf the Amazon, South-West United States, Southern Europe, and Australia, pushing populations elsewhere. Islands like Polynesia have vanished altogether, swallowed by the sea, and Southern China is left as a dustbowl."

Coupled with these warmer temperatures there would be major alterations for colder climates, with Khanna pointing out that the melting of the Himalayan glacier would arouse populations to vacate Bangladesh and southern India (Steward, 2018).

Comparatively, orange indicates 'Uninhabitable desert.' That will represent most of the U.S. and the rest of South America, approximately the entirety of Africa and the southern halves of Europe and Asia (Jacobs, 2017). The subtitle reads:

> "Deserts have encroached on [Southern Europe], rivers have dried up and the Alps are now snow-free. Goats and other hardy animals are kept at the fringes."

To say nothing of red which stands for lands engulfed by the rising tide (assuming +4ºC boosts two metres to ocean levels.) These two meters will breach lands where a substantial part of the human population is concentrated. To emphasize, in the U.S, counties directly on the shoreline make up less than 10 percent of the total land area (not including Alaska) but account for 40 percent of the total population (Jacobs, 2017).

Finally, light-green stands for food-growing zones, and condensed high-rise cities. Canada and Siberia will be remodelled into hubs of agriculture, with warmer climates capacitating them to produce much of the world's food supply. "Reliable precipitation and warmer temperatures provide ideal growing conditions for most of the world's subsistence crops," reads the subtitle. Moreover, Antarctica's western coast will be densely populated, receiving people that have migrated from their forsaken landscapes (Steward, 2018). New Zealand, will also be converted into a high-density population centre, and the UK, Scandinavia, Greenland and Northern Russia, will abound and concentrate most of the world's population (Jacobs, 2017).

Parag Khanna speculates: "The entire population of the Arctic region today is less than 4 million. Could it be 400 million within the coming 20 years?" At this point, the reader should be aware of how much ecological damage and speeding of the process of global warming a *new* 'green' overpopulated continent would precipitate.

Climate change is conceivably the world's greatest confrontation to global peace, security, development and human rights in the 21st century (EJF, 2017) (figure 6.8). The expeditive changes to our planet's climate are aggravating natural disasters and water, food, energy and health insecurities; fortifying conditions that can instigate conflict, state instability and failure, strain military readiness, operations and strategy, and make current security threats worse (The Center For Climate and Security, 2018). These changes will involve resource dearth, placing strain on the vital resources that predicate human, national and international security - including food and water. These will, in all probability, magnify the scale of political turmoil, state instability and mass migration in the future, exceptionally in regions or nations with poor governance and existing state fragility (EJF, 2017). As a matter of fact, The World Bank (Adams et al, 2013) cautioned in 2013 that a 4ºC warming by the end of the century is a legitimate concern and urgent risk, while Hsiang and colleagues (Hsiang, Burke & Miguel, 2013) wave a red flag that such a rise could bring about as much as 56 percent increase in the frequency of intergroup conflicts across the world.

After all, the reverberations of climate change (figure 6.8) and the dissolution of the fossil fuel era will impact the world's ability to feed its rapidly spreading population. One can deduce with a high degree of security that these factors will coalesce to manufacture an extremely large-scale famine by the middle of the 21st century if steps are not taken to thwart it. We are already undergoing a crisis from refugees fleeing from famine, rising temperatures, drought and conflicts (more on this in an ensuing segment) (Avery, 2017).

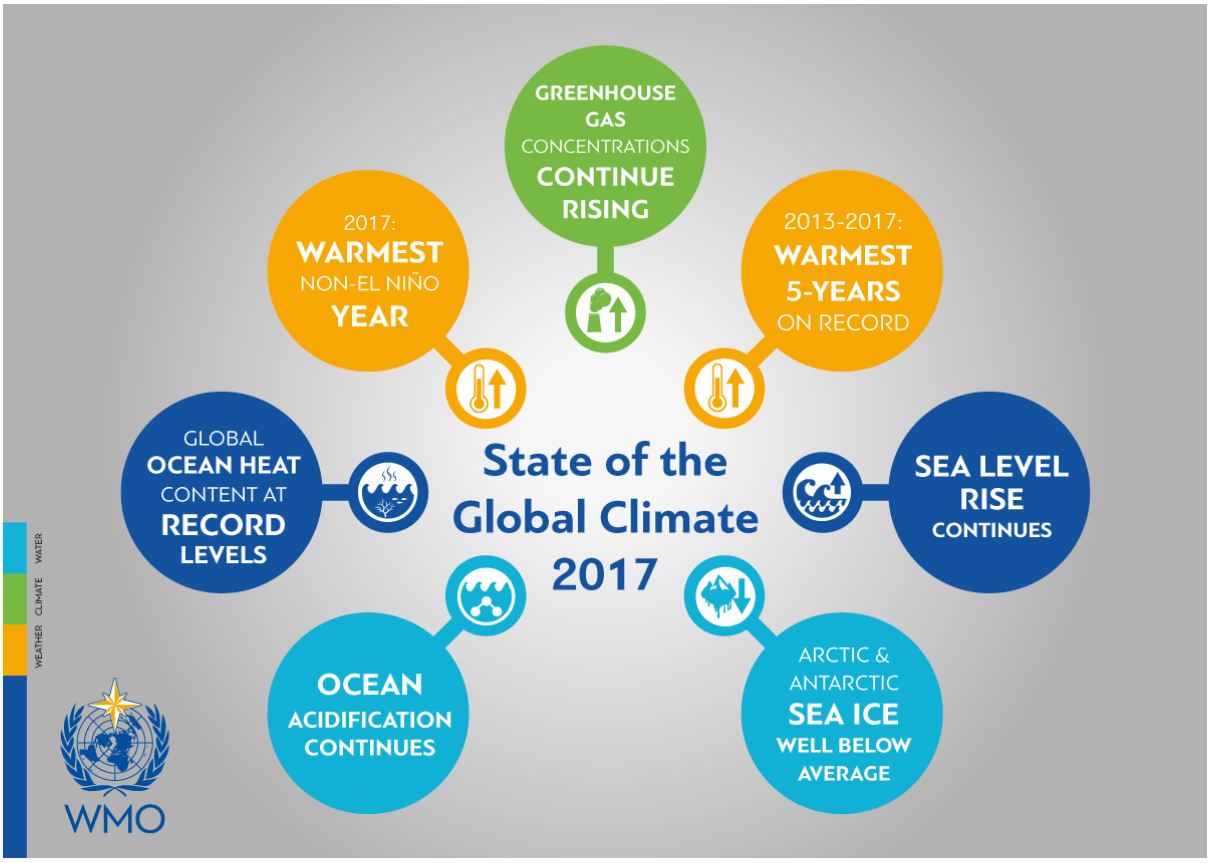


Figure 6.8: State of the Global Climate 2017. What happened in 2017 and what we can expect in future trends regarding Weather, Climate and Water. Retrieved from World Meteorological Organization, 2018.

Unchanged lifestyles and business as usual are not a privilege. Inaction is not a prerogative. Public education is essential. Votes for environmentally friendly politicians are desired. A carbon tax would be a useful first step. Subsidies to fossil fuel giants and the extraction of fossil fuels must cease. Renewable energy infrastructure must be built which will provide unprecedented investment opportunities (Avery, 2017), with the emergence of a new pro-nuclear movement that must arise in tandem with renewable energy, to meet the growing energy demands of this burgenioning population, without entirely sacrificing our climate goals (Shellengerger, 2017).

The points that I have introduced so far, give a distinctive picture of what climate change is and what it could become. Notwithstanding the fact that most likely the projections and computations that try to model future scenarios will not get everything right, due to the sheer complexity of this dynamic system that we call our planet, one thing we can be sure. Humanity has never gone through such an abrupt and extensive alteration in the climate in its recent evolutionary history, and if we, in fact, end up with a planet 4ºC warmer or worse, that will be an unrecognizable world, where it is safe to assume that humanity's almost pandemic geographical range, its density and size of population might simply contract to levels that will allow the maintenance and continuity of the species. Conjectures and thought experiments as they might be at this point, the evidence supports a tremendous shift to our collective civilizational project. So back to the drawing board to examine our best possible solution to avert such a calamity, or at least buy us some time. Putting a stop to population growth.

In the next segment, *The Ship That Sailed by the Water under the Bridge*, I delve into the inertia, otiose and deliquescence demonstrated by governments, nations and collectives in approaching anthropogenic climate change.

The Ship That Sailed By the Water Under the Bridge

- Lost Opportunities to Deal with Climate Change -

"We are running the most dangerous experiment in history right now, which is to see how much carbon dioxide the atmosphere can handle before there is an environmental catastrophe."

- Elon Musk

"Climate change is the single biggest thing that humans have ever done on this planet. The one thing that needs to be bigger is our movement to stop it."

- Bill McKibben

"Today, the greatest threat of extinction we face is not asteroids or climate change or disease or famine. It's society's refusal to heed the warning of scientists."

- Neil deGrasse Tyson

We are presently witnessing the evolvement of a climate emergency. In spite of the high degree of scientific consensus about the causes and repercussions of global warming (Molina et al, 2014; IPCC, 2014a) governments have been found lacking - for over 20 years of negotiations - to step up any relevant and consequential action to demarcate and confine global warming. As a matter of fact, as the scientific evidence piles up, accumulates and becomes more undeniable and incontrovertible, governments have remained polarized and paralyzed, floundering to even truncate the growth of - much less decrease - greenhouse emissions (Smith, 2015). Equally important, in the absence of policies global warming is envisioned to reach 4.1 ºC - 4.8 ºC above pre-industrial temperatures, by the end of the century (Climate Action Tracker, 2017).

Thirty years ago (1988) James Hansen told the American Senate committee that "the greenhouse effect has been detected and is changing our climate now." At that time, Hansen was the head of NASA's Goddard Institute for Space Studies, and even though his deposition was assuredly not the first official forewarning about the "greenhouse effect" - a report to President Lyndon Johnson, in 1965, adumbrated "measurable and perhaps marked changes in climate" in the decades to follow - but it was the first to be subjected to national news coverage. The *Times* ran the feature at the top of the front page, with a graph portraying the long-term rise in average global temperatures (Kolbert, 2018).

In the intervening three decades since Hansen delivered his sworn statement nearly half of the Arctic ice cap has melted down, the oceans have acidified, much of the American West was reduced to ashes, lower Manhattan, South Florida, Houston and New Orleans witnessed the rising of the tide and the *wrath* of the extreme weather events, and average temperatures have never ceased to heighten (Kolbert, 2018).

The years after the landmark climate agreement in Paris (Davenport, 2015) have been accumulating, and humanity still proceeds on a wandering and awry path that deters any amelioration of the more relentless global warming in the decades to come. Under the Paris deal, each nation advanced a framework to curtail its greenhouse-gas emissions until 2030. However, no major industrialized country has yet brought to completion its vow, in consonance with the data from the Climate Action Tracker (2018). Not the European Union. Not Canada. Not Japan. And certainly not the United States, which under the aegis of President Trump intends to relinquish the Paris agreement by 2020 (Plumer, 2017).

Worse still, even if governments were to meet their individual covenants, the planet would still be on route to warm well over the 2 degrees Celsius over pre-industrial levels (3.6 degrees Fahrenheit), the limitation that world leaders consecrated to avoid in Paris, because they conceived it to be unacceptably risky (Plumer & Popovich, 2017). Evidently, a considerable gap remains between what governments have professed to do and the total level of actions they have undertaken to date. Furthermore, both the current policy and pledge projections lie well above emissions pathways compatible with the Paris Agreement long-term temperature goal (Climate Action Tracker, 2017).

Currently, many of the Paris pledges stand reasonably fuliginous, and most nations have been dubious on what specific policies and changes they will adapt to meet them. Since there is no official mechanism for quantifying progress or supervision, countries are not bound by law, but rather by individual nation commitment (Plumer & Popovich, 2017). Not to mention, the Emissions Gap Report 2016 from the United Nations Environment Programme (UNEP, 2016) explicates that even if countries stay true to the commitments - known as Nationally Determined Contributions (NDCs) - that they made in Paris, the world will still warm by 2.9ºC to 3.4ºC. Not to mention, confining warming by 1.5ºC above pre-industrial temperatures by 2100 translates into a mandatory requirement that emissions of GHG need to be curtailed expeditiously in the years and decades, and brought to zero around mid-century (Climate Action Tracker, 2017) (Figure 6.9).

Now to cast an even more ominous and morose prospect of the future of life on this planet, the IPCC's most recent report *Global Warming of 1.5ºC – Summary for Policymakers* (2018) warns that to prevent a 1.5ºC rise, greenhouse pollution must be abated by 45 percent from 2010 levels by 2030, and 100 percent by 2050. The IPCC also stresses that, by 2050, the use of coal as an energy source has to drop from 40 percent today, to between 1 and 7 percent, while renewables would have to surge from about the roughly 20 percent in 2018, to 67 percent (Davenport, 2018).

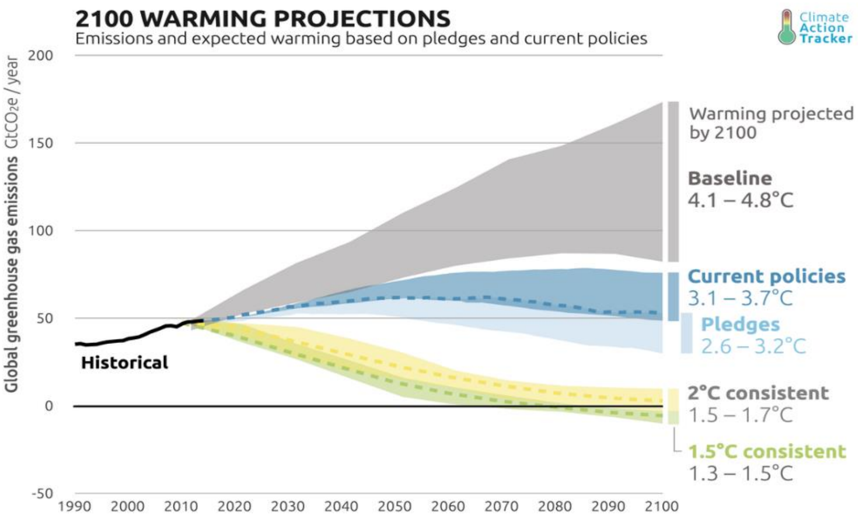


Figure 6.9: 2100 Warming Projections. Emissions and expected warming based on pledges and current policies. Retrieved from Climate Action Tracker, 2017.

This becomes even more relevant when we take into account that humanity's carbon emissions saw a surge of 2 percent in 2017 when we should, by all means, be decreasing them. Scientists with the Global Carbon Project attribute the acceleration to an increased coal consumption in China (Peters et al, 2017; Jackson et al, 2017; Le Quéré et al, 2017) but evidently that the necessity to provide energy, consumer goods, food and shelter, waste treatment etc. for an ever growing and affluent population, obviously cancels out the best intentions of any mitigation strategy set forth at an *almost* planetary level.

The 'unexpected' rise saw an end to a three-year period in which emissions remained flat, undeterred by a growing global economy (Tollefson, 2017). Several factors induced the world's CO_2 emissions to level out from 2014 to 2016 (Weiss, 2015), among other things an economic slowdown in China, the world's largest emitter; a permutation from coal to gas in the United States; and global growth in the use of renewable energies such as solar and wind. By all means, climate scientists and policymakers were looking forward that the pause in emissions growth represented a shift in energy use that would eventually cause global greenhouse-gas emissions to peak - and then decline (Tollefson, 2017).

As Pilita Clark accurately baptizes her piece in the *Financial Times* (2017) *New carbon emissions figures cast a shadow over Paris*, she says, while bringing everyone back to Earth:

> "This had bolstered hopes that the world had finally found a way to "decouple" economic growth from carbon pollution, a goal that had seemed unimaginable only a few years earlier. Either way, it casts an unsettling light on the Paris climate accord."

In the intervening three decades of diplomacy, an international unanimity has emerged, that the rise in temperature must be held down to "well below" 2ºC above pre-industrial times. Be that as it may, emissions have skyrocketed (in 1988, 20bn tons of carbon dioxide/per year had already been emitted (Ritchie & Roser, 2018b) and by 2017 it had escalated to 36bn tons/year, figure 6.10) with pledged reductions defective of the 2ºC goal (Milman, 2018).

Together with this, research published in the journal *Nature Climate Change* indicates that there is only a 5 percent chance that the Earth will bypass this 2ºC warming (Raftery, Zimmer, Frierson, Startz & Liu, 2017) until the end of the century, which paints a grievous and lugubrious picture of the international effort to restrain the rise in emissions. According to the study, global trends in the economy, emissions and population growth make it acutely unlikely that the planet will remain below this limit set out in Paris, 2015. As a matter of fact, the goal to limit warming to 1.5ºC is delineated to have just a 1 percent chance of being successful (Milman, 2017).

Adrian Raftery, from the University of Washington who led the research passed judgment in an interview for *The Guardian* (Milman, 2017):

> "We're closer to the margin than we think. If we want to avoid 2ºC, we have very little time left. The public should be very concerned."

In agreement with the study, there is also a 90 percent likelihood that temperatures will soar between 2ºC and 4.9ºC by 2100. The study examined the previous 50 years of trends in world population, per capita gross domestic product (GDP) and carbon intensity, which represents the amount of carbon dioxide emitted for each dollar of economic activity. The researchers centralize their focus on carbon intensity, which will be a vital factor in future warming, and find that world population will have a relatively smaller role to play because most growth will take place in sub-Saharan Africa (Milman, 2017). As the authors (Raftery et al, 2017) maintain:

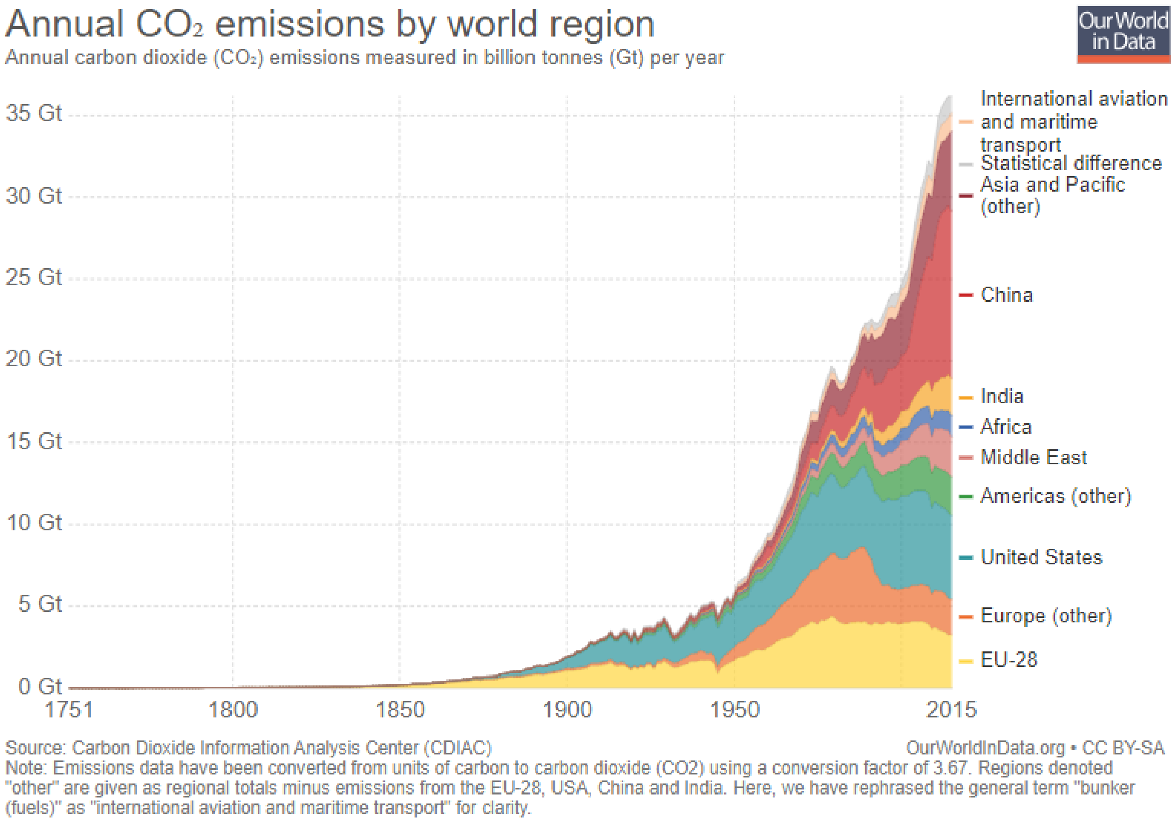


Figure 6.10: Annual CO2 emissions by world region measured in billion tonnes (Gt) per year. Source: Carbon Dioxide Information Analysis Center (CDIAC). Note: Emissions data have been converted from units of carbon to carbon dioxide (CO2) using a conversion factor of 3.67. Regions denoted "other" are given as regional totals minus emissions from the EU-28, USA, China and India. Here, the authors have rephrased the general term "bunker (fuels)" as "international aviation and maritime transport" for clarity. Retrieved from (Ritchie & Roser, 2018b)

> "The median UN population projection is for an increase of 4 billion to 2100 [...] a large portion of that increase is projected to be in Sub-Saharan Africa (SSA), whose population is projected to increase from its current 1 billion to 3.9 billion. Although GDP is projected to rise by around a factor of 21, CO_2 emissions from SSA are projected to be only about 6 percent of the world total at the end of the century. This reflects the very low current economic production in the region, and suggests that population increase will not be a major contributing factor to future increases in emissions this century."

I would agree with the authors to a certain extent. The African continent is most likely the one that will experience climate change in the most unrelenting and implacable way, and as I have previously examined, ecosystems are failing, desertification and soil degradation are rapidly advancing, food security is being compromised, water resources will become scarce, and the land itself is a luxury. These reasons alone would suggest that the billions more that are expected to inhabit the continent will not be bound to it, therefore resorting to immigration, for survival. What the authors overlooked when they constructed their models based on a simplified version of the Kaya Identity (expressed in future emissions levels based on Population, GDP per capita and carbon intensity), was that when humans move from a low emissions country to a high emissions one, they tend to adopt and adapt to the average affluence shared by citizens of that country, increasing their carbon footprint in the process. I will investigate this subject in the coming chapter dedicated to Immigration.

One such other study published in *Nature Geoscience* by Hubertus Fischer and colleagues from 17 countries (Hubertus et al, 2018) alerts that climate models may be underestimating the effects of global temperature rise and sea level rise.

By examining paleoclimate alterations in the previous 3.5 million years, the researchers encountered at least three warm periods in which global temperatures were 0.5-2ºC above pre-industrial temperatures and investigated how the planet responded accordingly. These were the Holocene thermal maximum, which occurred 5,000 to 9,000 years ago; the last interglacial, from 116,000 to 129,000 years ago; and the mid-Pliocene warm period, which took place around 3 to 3.3 million years ago (Cox, 2018).

Correspondingly, in the first two periods surveyed, the climate changes were induced by alterations to earth's orbit, in contrast, the mid-Pliocene event was the outcome of atmospheric carbon dioxide rising to concentrations analogous to our present-day situation. Nevertheless, in each of the cases, the warming that resulted occurred over a much longer time-scale. Furthermore, they unearthed that sustained warming of one or two degrees had coincided with substantial reductions of the Greenland and Antarctic ice sheets and sea level rise of at least six metres - several metres above what current models predict could transpire by 2100 (Cox, 2018).

Katrin Meissner from the University of New South Wales's Climate Change Research Centre and one of the study's lead authors justifies in an interview with *The Guardian* (Cox, 2018):

> "During that time, the temperatures were much warmer than our models are predicting and the sea levels were much higher. Two degrees can seem very benign when you see it on paper but the consequences are quite bad and ecosystems change dramatically."

Prof Alan Mix, of the University of Oregon and co-author of the study adjoined with the following statement:

> "Even with 2ºC of warming - and potentially 1.5ºC - the impacts on the Earth's systems are profound. We can expect an unrivalled rise in the last millennium in sea level, with impact on population, infrastructures and economic activity" (Viegas, 2018).

Meissner also maintains that:

> "Climate models appear to be trustworthy for small changes, such as for low-emission scenarios over short periods, say over the next few decades out to 2100. But as the change gets larger or more persistent… it appears they underestimate climate change" (Cox, 2018).

Similarly, Prof Hubertus Fischer of the University of Bern, and one of the study's lead authors exhorted:

> "Observations of past warming periods suggest that a number of amplifying mechanism, which are poorly represented in climate models, increase long-term warming beyond climate model projections. This suggest the carbon budget to avoid 2ºC of global warming may be far smaller than estimated, leaving very little margin for error to meet the Paris targets" (Cox, 2018).

Regardless of the level of engagement humanity applies on this front, the reverberations of anthropogenic climate change are here. One study published in the journal *Environmental Research Letters* (Jevrejeva, Jackson, Grinsted, Lincke & Marzeion, 2018) estimates that the annual cost of warming above 2ºC could be commensurate to roughly 3 percent of global GDP by 2100. For one thing, these costs are reflective of the damage done to assets prone to flooding and the costs of construction and maintenance of sea defenses. Moreover, the team also investigated what kind of consequences would result from missing the targets, in the matter of sea level rise. They foresee that breaching the 1.5ºC by 2100 would be connected with a median sea level rise of 0.52m, while surpassing the 2ºC would be associated with a rise of 0.63m (Hindson, 2018).

Furthermore, the team indicated that some nations will be more convulsed by this phenomenon, specifically China, due to their long coastline and elevated coastal population. Overall, larger cities, regardless of wealth, are prone to being more prepared to deal with rising sea level due to existing infrastructure, whereas island nations and coastal communities in developing nations will undergo the full frontal attack of the flooding (Hindson, 2018). Notwithstanding, failing to meet those targets will signify that all coastlines will be impacted (Whyte, 2017), and every country will require some sort of adaptation (Hindson, 2018).

In the same fashion, one very important aspect relative to the Paris Climate Accord that needs to be discussed is mitigation strategies, and to that effect, I will resume the press conference from AAAS, where the National Climate Assessment that opened up this chapter was presented, now with the mitigation front in full disclosure. Speaking here is the fourth expert on the panel Ben Anderson (again, to follow the audio follow the link):

> "The report focused on the temperature targets from Paris Agreement, which themselves still represent 2º or 1.5º, a detectable amount of climate change. This is something which will result in sea level rise and a change in extreme temperature frequency, but nevertheless it is a level of an international agreement on desired temperature targets. And so the conclusion of the report was that the only way to achieve these temperature targets is through the rapid reduction of CO_2 emissions.
>
> To hit the 2º target it requires emissions to be cut substantially before 2040 to reach near zero or zero by the latter half of the century, with a likelihood for negative emissions thereafter. And to hit the 1.5º target, in terms of the cumulative emissions that mankind has emitted from the Industrial Revolution until the present day, that means that from this point onwards any CO_2 which is emitted into the atmosphere broadly has to be removed again in order to maintain a 1.5º stable climate.
>
> There is a plausible pathway to achieving the 2º goal if countries of the world in their entirety mange to hit their Nationally Determined Contributions (NDCs) by 2030, but it requires a lot of effort post-2030 if that is all that we do. **And so it would require rapid reductions in emissions after 2030 and then definitely negative emissions for the latter half of the century**. And it has to be remembered that negative emissions and the ability to remove carbon dioxide from the atmosphere is not a technology which is currently available, or not one that can be deployed at scale. And so **the assumption which is implicit in most of the future scenarios that we have that discuss a 2º future or less, assume that carbon dioxide can be removed from the atmosphere in the future, and that is betting on a technology we don't yet have available."**

What we have to realize is that human population growth is central to this debate of warding off the worst anthropogenic climate change, and through the need to feed ourselves and future passengers added to this planet every day, we are completely altering the assailable equilibrium of the Earth. The set of techno-solutions that are reiterated and recapitulated time and time again, instead of addressing the need to stabilize and reduce human numbers are increasingly dominating the narrative, and as Sabine Fuss and colleagues assert in the journal *Nature* (2014):

> "The credibility [of carbon capture and storage] as a climate change mitigation option is unproven and its widespread deployment in climate stabilization scenarios might become a dangerous distraction."

The lengthy list of transgressors for the lassitude and lethargy in meeting the goals and addressing efficient climate responses are both familiar - the execrable lobbying of the fossil fuel industry - and surprising. Even Jerry Brown, the progressive governor of California, and the German chancellor, Angela Merkel, are "both pretending to be solving the problem," James Hansen affirms, while being unassertive and despising low-carbon nuclear power (Milman, 2018, Shellenberger, 2018, Shellenberger, 2017) (I will examine in verbose detail the complete energetic storyline in Energy Bill, in the upcoming volumes).

Hansen also reveals some noteworthy disparagement for former President Barack Obama. In his upcoming book *Sophie's Planet: A Search for Truth About Our Remarkable Home Planet and Its Future* (Hansen, 2020) Hansen recapitulates how the former president "failed miserably" on climate change and shepherd policies that were "late, ineffectual and partisan" (Milman, 2018).

Moreover, Hansen denounces Obama's unwillingness to foil President Donald Trump's extirpation of the US climate action, by refraining to negotiate a lawsuit (Our Children's Trust, 2018) the scientist, his granddaughter and twenty other young people are undertaking against the government, prosecuting it of unconstitutionally inducing endangerment to their living environment (Milman, 2018).

Hansen recalls:

> "Near the end of his administration the US said it would reduce emissions 80 percent by 2050. Our lawsuit demands a reduction of 6 percent a year so I thought, 'That's close enough, let's settle the lawsuit.' We got through to Obama's office but he decided against it. It was a tremendous opportunity. This was after Trump's election, so if we'd settled it quickly the US legally wouldn't be able to do the absurd things Trump is doing now by opening up all sorts of fossil fuel sources."

Hansen points a finger or two to the leaders that allege they are devoting themselves to this matter, and dictates in an interview with *The Guardian* (Milman, 2018) that:

> "All we've done is agree there is a problem. We agreed that in 1992 [at the Earth summit in Rio] and re-agreed it again in Paris [at the 2015 climate accord]. We haven't acknowledged what is required to solve it. Promises like Paris don't mean much, its wishful thinking. It's a hoax that governments have played on us since the 1990s."

David Suzuki, the Canadian academic, science broadcaster and environmental activist also remarked in an interview with *Canada's National Observer* (2018):

> "Paris was an incredible achievement. The Canadian ambassador asked to meet us when they were planning for the conference, I said, 'Look, this is the 21st [climate] conference. What have you accomplished in 21 meetings? If all Paris is going to do is continuing on what was done in Copenhagen and all these other places, forget it!"

When asked by the interviewer if he thinks Canada (one of the countries that proclaims itself to be one of the most environmentally conscious) will abide by Paris targets, Suzuki replied:

> "No, we're not going to make it. [Prime-Minister] Trudeau was like, the sun came out and we praised him to the skies. He was fantastic in Paris. Not only did he say, 'Canada is back,' but he said, 'we aspire to keeping it as close to 1.5 as we can, rather than 2 [degrees]. He set a very hard target. I emailed [P.M Trudeau] after he signed and asked, 'Are you serious about what you just signed?' And he emailed back and said, 'I am very serious.' [...] but the easiest thing to do is sign a document, especially when the end isn't for years and years. He knows bloody well that he's not going to be around in 2030. That's what all politicians do. You can make a flourish and sign and claim but you're not held accountable. And that's a problem. We don't have a way of holding people accountable."

Suzuki recapitulates:

> "So when Trudeau approved the pipelines (De Souza, 2016), I emailed him and said, 'You know, you set a hard target of 1.5 degrees. That's your target. To meet that you know 80 to 85 percent of those reserves have to be left in the ground. We can't burn them. Why the hell are you investing in a project that is going to cost billions of dollars and then, in order to get your return, that it has to be used for 25 to 30 years. You're in a position now to do something that is going to affect the future for your children. You're a father first.' He never answered back."

The United Kingdom is yet another example of a country that is on course to fail its own targets for cutting greenhouse emissions in the 2020s and 2030s. Notwithstanding the fact that the UK has markedly reduced emissions from electricity generation, in the order of 43 percent compared to 1990 levels, still not enough progress has been achieved in transport, farming and buildings, the UK's Climate Change Committee (CCC) reports (Le Page, 2018a).

In 2008, the UK put in law a target of contracting emissions 80 percent by 2050. With that in mind it established the Climate Change Committee to advise and give an account on the status of things, ten years on, the latest report was published and it becomes evident that the government is not doing enough (Le Page, 2018a; UK Climate Change Committee, 2018).

The report calls attention to important issues when combating the rise of emissions and meeting the goals that were set. John Gummer (Lord Deben), chair of the committee catapulted some mordacious criticism to the stagnation made evident by the government, such as on the housing and car industries:

> "The [housing] industry should be ashamed of itself. It is producing homes that cheat the people they are sold to. If new homes are not built to the highest standards, people end up paying higher heating bills for as long as the homes last. As for the car industry, it has shown it cannot be trusted (Heffernan, 2017). So plans to reduce emissions from road vehicles need to be backed by tough regulations and strict enforcement are needed to ensure that vehicles meet standards. The UK has said it plans to stop the sale of petrol and diesel vehicles from 2040, but the deadline needs to be closer to 2030 to meet emission targets" (Le Page, 2018a).

The report also addresses some other focal points and calls for:

- Onshore wind where local communities desire to implement it. This form of renewable energy is the cheapest in the UK but all new projects have been blocked.
- Incentives for better insulation of existing homes. The programs the government had in place for insulation were abandoned and no replacement as yet to emerge.
- More tree planting. The UK is failing to its commitment to planting 11 million trees by 2022. Worse still, and although the report does not include such a fact, UK's policies are prompting deforestation in other countries (Le Page, 2016).

Although all the points brought up in the CCC's report are valid and vital, no mention is made of the contribution of population growth in the UK to the failure in meeting the emission goals aforementioned. As a matter of fact, the Office for National Statistic portends that England's population will expand by 5.5 million until 2030, totaling 60.2 million, 10 percent above the 54.7 million in 2015. Just on the matter of cars that was mentioned in the report, these will rise twice as fast, from 25.8 million to 31.2 million, as householders become more affluent and take possession of more vehicles, according to projections by the charity Population Matters (Webster, 2017).

Chris Packham, environmentalist and patron of Population Matters wrote in *The Times* (2017):

> "We know that every car, truck and train carriage adds to the CO_2 in our atmosphere and makes it harder still to meet climate targets. More congestion also means more pollution - engines have got cleaner but when more are on the roads, we are chasing our tails. And what of the roads we build to ease the crush? When we build them in the country, we squeeze out the natural world. Yet we are entirely dependent on that world, so we simply cannot afford to do so, financially or ecologically."

Alistair Currie, head of campaigns at Population Matters attests:

> "Every commuter knows the strain our transport system is already under, and the last thing our environment needs is more trains, cars, buses and trucks pumping out more pollution" (Webster, 2017).

An even more astonishing, and I would say even really, egregious is the claim that the UK's emissions targets allow for an increase in aviation emissions, therefore justifying projects such as the expansion of London's Heathrow Airport. As investigated in the segment Climate Change Ethics, avoiding air travel is, according to the literature, the second most important and substantial action an individual can take in their life to reduce their carbon footprint. Following that reasoning, it becomes increasingly difficult for countries to accomplish the goals they pledged themselves to in Paris, while at the same time manifesting allegiance to the paradigm of economic growth. We simply cannot have it both ways, and countries need to be held accountable for duplicitous decisions.

Allow me to stay on this example of the Heathrow Airport a bit longer since it is a superb case scenario of a dog chasing its own tail. In 2016, the UK government justified the expansion of the airport capacity generally in terms of economic growth, asserting that it "will better connect the UK to long haul destinations in growing world markets, boosting trade and creating jobs, passengers will benefit from more choice of airlines, destinations and flights." What was evidently left out was the fact that more emissions and a more expeditious climate change will materialize from that prognostication (Population Matters, 2018d).

The Department for Transport (DfT) of the UK (2013) has revealed in their forecasts of demand for air travel, that even without a new runway at Heathrow, airports would serve 445 million passengers per annum (mppa) in 2050. This will translate to more than twice the 211 mppa in 2010. Above all, the DfT asserted that UK aviation emissions, inclusive international flights departing from UK airports, would amount to 47 $MtCO_2e$ (million tonnes of CO_2 equivalent) by 2050 even without the expansion Heathrow. With supplementary runways, passenger numbers can expand to 480 million. The carbon cost of this project is estimated to put aviation emissions in the realm of 51 $MtCO_2e$ in 2050, according to *Carbon Brief* (Evans, 2016).

Correspondingly, this figure amounts to more than two-thirds (71 percent) of the 72 $MtCO_2e$ mid-range carbon budget for 2050 set by the Climate Change Committee to meet the ambitions of the Paris Agreement. It is also roughly a third (32 percent) of the carbon budget for 2ºC (Evans, 2016). Nonetheless, the CCC has called for UK aviation emissions to not surpass the levels of 2005, which would correspond to 37.5 $MtCO_2e$ if the UK is to meet their targets (Yeo, 2015).

For such a scenario to transpire the UK would have to come to grips with its population growth, that stems mainly from immigration (more on Exodus), as well the concomitant rise in affluence of its population, that results in more air travel per capita. Moreover, humanity needs to evaluate its propensity for this narrative of 'perpetual growth' and reform their economic systems. Human civilization as it stands is not compatible with ecological limits and that needs to enter the discussion since a reform on our economic perspectives needs to materialize (In the upcoming Volume II I will examine this subject in Prosperity without Growth).

It would be remiss of me and a major oversight if I didn't include a section on the discussion of the latest report from the IPCC, *Global Warming of 1.5ºC – Summary for Policymakers* (2018), launched in early October. This document has been making waves in the media (Davenport, 2018; McGrath, 2018; Taylor, Weaver & Davidson, 2018; Watts, 2018b) and the reason for it having become controversial is simple. The IPCC appears to be shedding its skin and reputation has being overly conservative in their reports, so as not to alienate governments and nations from enacting policies to deal with climate change.

Hence it seems as though the scientists behind the reports have grown weary of the inaction of governments, and decided to push forward a different strategy, since even with all the promises to cut carbon made by countries that have signed the Paris climate agreement, the planet is still looking at a 3ºC rise in temperature by the end of the century. As a result, many scientists involved say the message is clear, there is not enough time left to take the course of action that would keep the world within an acceptable limit. Professor Arthur Peterson, from University College London and a former IPCC member argues (McGrath, 2018b):

> "If you really look seriously at the feasibility, it looks like it will be very hard to reach the 1.5ºC. I am relatively sceptical that we can meet 1.5ºC, even with an overshoot. Scientists can dream up that is feasible, but it's a pipedream."

On top of the science, there is also politics, and there has been substantial speculation that the scientists are being forced to cushion and moderate the contents of their reports, and tone down their conclusions, with the report mentioned above having been through notable changes. This has induced critics to deduce that crucial aspects are being deemphasized to suit the agendas of countries with major fossil fuel industries, such as the United States, Saudi Arabia and Australia (McGrath, 2018b).

For this reason, members of the IPCC have asserted that they are not allowing their conclusions to be minimized and made light of as Valérie Masson-Delmotte, a co-chair of IPCC has stressed (McGrath, 2018b):

> "What is really important for the work of the IPCC is the respect for the integrity and scientific rigour of the authors – that is at the heart of the work of the author teams. If one can imagine the governments holding the hands of the scientists, this means you don't know how science works!"

But in short, what were the main points to take away from this report? Well, for starters, the scientists stressed that the main climatic implications that were foreseen to occur at a 2ºC, have been extended to the 1.5ºC range. This is to say that inundated coastlines, intensification of droughts, widening human misery, biodiversity loss and a multitude of other catastrophic culminations are now a reality with a 1.5ºC increase in temperature (Davenport, 2018).

Equally important, the scientists have calculated fending off the most serious repercussions of such an existential threat will come at a cost of $54 trillion. Although the scientists assert that this would be technically possible, they are sceptical that there is enough political will to do what is necessary. Under those circumstances, the scientists predict that by 2040, the effects that were only expected by the end of century, will transpire (Davenport, 2018).

To ward off the 1.5ºC of warming, the report warns, greenhouse pollution must be lessened by 45 percent from 2010 levels by 2030, and 100 percent by 2050 (Davenport, 2018). For the reader to get a real sense of what would be necessary please inspect figure I, and figure II to examine how risks increase with each half-degree rise in the Appendix section. In any event, and according to the scientists themselves, already committing ourselves to the target of 1.5ºC will mean "rapid, far-reaching and unprecedented changes in all aspects of society". Prof Jim Skea, who co-chairs the IPCC declared (McGrath, 2018a):

> "The unprecedented nature of the changes that are required if we are to limit to 1.5ºC – changes to energy systems, changes to the way we manage land, changes to the way we move around with transportation."

These changes are connected to not just necessary decreases in the fossil fuels in the transportation sector, but in all the sectors that depend on them. Unfortunately, fossil fuels are the backbone that sustains our current civilization. In the *Washington Post*'s article *Earth's population is skyrocketing. How do you feed 10 billion people sustainably?* Joel Achenbach (2018) assembles considerations from the scientific community regarding the IPCC report. One such is from Katherine Richardson, director of the Sustainable Science Center at the University of Copenhagen in Denmark, who says the following:

> "Everybody knows that energy has something to do with climate – we need to transform our energy system. There's very few people who realize that it's just as, and maybe more, important to transform our food system, which is broken and needs to be fixed if we have any hope of feeding 9 to 10 billion."

James Hansen, the former NASA scientist that started this segment disclosed that both 1.5ºC and 2ºC would propel humanity to uncharted territory because they were both above the Holocene-era range in which human civilization developed. But he also stressed that (Watts, 2018b):

> "1.5ºC gives young people and the next generation a fighting chance of getting back to the Holocene or close to it. That is probably necessary if we want to keep shorelines where they are and preserve our coastal cities."

Regrettably, this isn't the end of this story, much on the contrary. As the dust settles from the announcement of the IPCC report, the scientific and environmental communities have started to respond.

One such comment came from Jamie Henn, co-founder and program director for the international climate group 350-org, who stated in a *tweet* (Henn, 2018) that:

> "The scariest thing about the IPCC Report – it's the watered down, consensus version. The latest science is much, much, much more terrifying."

Henn was focusing on the emerging interpretation that the IPCC report is being considered too "alarmist" in its declarations, to which the Michael Mann, Penn State University climate scientist clearly states (Mann, 2018):

> "If anything it is the opposite. Once again, with their latest report, they have been overly conservative (i.e. erring on the side of understating/underestimating the problem."

One of the reasons for Mann's counterattack stems from a *Nature* article published in late 2017, in which Mann and colleagues argue that the globe has already warmed 1.2ºC relative to preindustrial levels, when a more appropriate baseline is adopted, and criticise the IPCC for using a baseline dating back to the 19th century, when in fact, humanity had already accumulated ~0.2C greenhouse warming by then, that are not being taken into consideration (Schurer, Mann, Hawkins, Tett & Hegerl, 2017; Queally, 2018).

Moreover, one other critique that seems to be gaining ground is the one that recognizes that the report fails to fully concede the role of amplifying feedbacks loops, as Mario Molina, who shared the Nobel Prize in Chemistry in 1995, details (Harvey, 2018):

> "The IPCC understates a key risk: that self-reinforcing feedback loops could push the climate system into chaos before we have time to tame our energy system, and other sources of climate pollution."

In an essay titled *Climate report understates threat*, for the *Bulletin of the Atomic* Scientists, Molina in the company of Veerabhadran Ramanathan, a professor of climate sciences at the University of California, San Diego and Durwood J. Zaelke, president of the Institute for Governance & Sustainable Development in Washington DC, clarify that climate change is not exacerbating in a simple, linear course, but somewhat by compounding and accelerating (Ahmed, 2018a):

> "Adding 50 percent more warming to reach 1.5 degrees won't simply increase impacts by the same percentage – bad as that would be. Instead, it risks setting up feedbacks that could fall like dangerous dominos, fundamentally destabilizing the planet (Molina, Ramanathan & Zaelke, 2018)."

By the same token, the self-reinforcing feedback loop related to the loss of sea ice could lead to an 'Arctic death spiral,' in which the loss of the sea ice expedites the melting of permafrost, inducing large quantities of methane – the greenhouse gas 30 times more potent in driving warming than CO_2 – into the atmosphere (Ahmed, 2013). According to the simulations being run, these imply that toward mid or late century, "the permafrost-carbon feedback should be about equivalent to the second strongest anthropogenic source of greenhouse gases, which is land use change," Katey Walter Anthony, associate professor at the University of Alaska, Fairbanks, asserted in a press release when disclosing the results from a NASA-funded study (Gray, 2018) which found the "abrupt thawing" of permafrost could unleash tremendous amounts of CO_2 and methane via soil microbes "within a few decades" (Ahmed, 2018a).

No wonder Michael Mann is lashing out at the denial and rejection of the science.

And with good reason, a paper published in August 2018 by the *Proceedings of National Academy of Science* (Steffen et al, 2018) established that:

> "Even if the Paris Accord target of a 1.5ºC to 2.0ºC rise in temperature is met, we cannot exclude the risk that a cascade of feedbacks could push the Earth System irreversibly onto a 'Hothouse Earth' pathway."

These disquieting findings continue to substantiate the early warnings of James Hansen and others. One such example came more recently was professed by Hansen and team in their 2008 paper *Target atmospheric CO_2: Where should humanity aim?* In which they address the danger of feedbacks which could trigger "ice sheet disintegration, vegetation migration, and GHG release from soils, tundra, or ocean sediments." Such feedbacks underpin these tipping points, and can induce irrevocable or even runway climate change processes, that have the potential to completely alter the habitability of this planet. Hansen and colleagues argue that the only viable solution is to reduce the level of greenhouse gases back to around 350 ppm, if not lower. According to the most recent measurements (September 2018), these reached 409 ppm (NASA, 2018b; Ahmed, 2018a).

Lastly, the IPCC demonstrates one additional and conspicuous lapse. Their report appears to be filled with uncurbed fervor for geoengineering techniques to sequester carbon from the atmosphere. The report's transition scenario pathways are brimming with mentions of 'negative emissions' technologies designed to absorb carbon emissions. The main technology mentioned goes by the name 'BECCS,' which stands for 'bioenergy with carbon capture and storage.' In short, it is designed to burn biomass for energy, and capturing the carbon emission to be stored underground (Ahmed, 2018a).

Recalling the previous discussion (The Science Show, 2018b) at the American Association for the Advancement of Science tells us, reproduced here again in a shorter form to make the point, Ben Sanderson, one of the authors responsible for the mitigation chapter of the National Climate Assessment, who states:

> "To hit the 2ºC target it requires emissions to be cut substantially before 2040 to reach near zero or zero by the latter half of the century, with a likelihood for negative emissions thereafter […] any CO_2 which is emitted into the atmosphere broadly has to be removed again in order to maintain a 1.5° stable climate […] it requires a lot of effort post-2030 […] rapid reductions in emissions after 2030 and then definitely negative emissions for the latter half of the century. **And it has to be remembered that negative emissions and the ability to remove carbon dioxide from the atmosphere is not a technology which is currently available**, or not one that can be deployed at scale. And so **the assumption which is implicit in most of the future scenarios** […] assume that carbon dioxide can be removed from the atmosphere in future, and that's **betting on a technology we don't yet have available**." (Bold added by author)

Given these points, the authors of a study published in *Nature* (Lawrence et al, 2018) conclude that humanity cannot afford the time to wait for geoengineering apparatus to work their magic:

> "Thus at present, the only reliable way to attain a high probability of achieving the Paris Agreement goals requires considerably increasing mitigation efforts beyond the current plans, including starting extensive emissions reductions much sooner than in the current NDCs [nationally determined contributions—emissions reduction pledges committed to by governments]."

A final note, as the reader might have realized by now, lamentably, the IPCC report and the mainstream media have completely sidestepped action on population. One can surely find in these articles mentions of the empowering decisions of the individual in consuming less meat, choosing public transportation, using video conference, insulating homes, buying locally etc (McGrath, 2018a), while we expect to grow the human collective to 9.9 billion by 2050. Still, the IPCC acknowledged that:

> "Lack of global cooperation, high inequality and/or high population growth that limit the ability to control land use emissions, and rapidly growing resource- intensive consumption are key impediments [to hitting 1.5ºC degree target."

In the face of this unsurprising neglect of the population factor, the director of the NGO Population Matters (2018e), Robin Maynard declared that:

> "Population is identified in the IPCC's report as among the most significant variables in reaching our climate goals. In the face of the crisis so starkly illuminated by the report, it is crazy to stand passively by and see how it pans out. The good news is that addressing population brings multiple other benefits. What we want is more women's empowerment, more modern family planning, more education, and more people moving out of poverty and action taken to encourage and incentivise smaller families. These are voluntary, ethical, effective and pratical solutions which everyone can and should endorse."

In a final analysis, a paper titled *Leading the Public into Emergency Mode: A New Strategy for the Climate Movement* (Salamon, 2017a) – Margaret K. Salamon upholds that while a World War II-style mobilization is mandatory to accomplish the kind of emissions cuts and energy changeovers that science is requiring us to do, acknowledging what is at stake doesn't necessarily mean that we must be incapacitated and enfeebled by this ominous knowledge. In an op-ed for *Common Dreams*, Salomon (2017b) maintains (Queally, 2018):

> "That intense, but not paralyzing, fear combined with maximum hope can actually lead people and groups into a state of peak performace. We can rise to the challenge of our time and dedicate ourselves to become heroic messengers and change-makers."

Before wrapping up this segment, there is one impeccable case scenario, which brings together a multitude of subjects that have been or are still going to be examined, of a country that demands some attention, Germany.

Germany, often regarded as an archetype of how to go green, has declared that it's not going to hit its 2020 emissions-reduction goals, with the government pointing the blame to a meteoric economic growth, increase in vehicles and a "surprising strong population growth," through the reception of massive numbers of individuals through immigration, which have spiked energy consumption in the country. Coupled with these factors, Germany has had a strong anti-nuclear movement to close its facilities, which resulted in a more preeminent dependency on coal and lignite plants, therefore augmenting the carbon footprint of the country (Petzinger, 2018).

One thing becomes clear, if even Germany, which is often held up an example in the transition to "sustainable growth" is failing its commitments, this spells disaster for the entire world. Economic growth and ever-increasing consumption as a result of adding ever more people is incompatible with a healthy environment that will sustain all species, including our own.

Another interesting point emerges from the suggestion that climate change can be entirely resolved through our human ingenuity, which is best reflected in our capitalistic economic system. As Larry Elliott justifies in his *The Guardian* piece *Capitalism can crack climate change. But only if it takes risks* (Elliott, 2018):

> "The struggle to combat climate change brings out the best and worst of capitalism. Decarbonisation of the economy requires alternatives for coal and cars that run on diesel, and that plays to capitalism's strenghs. Innovation is what capitalism is all about, and there has been straggeringly rapid progress in developing clean alternatives to coal, oil and gas. The cost of producing solar – and wind- powered electricity has collapsed. Great advances are also being made in battery technology, which is vital for the new generation of electricity-powered vehicles. Humans are endlessly creative. In the end, they will crack climate change.

To Elliott's credit, he does, in fact, direct our attention to the brewing perils of climate change and the contemporaneous limitations of capitalism:

> "[By the time we crack climate change], it could be too late. Capitalism – especially the dominant Anglo-Saxon variant of capitalism – has trouble thinking beyond the here and now. People running big corporations see their job as maximising profits in the short term, even if that means causing irreparable damage to the world's ecosystem. What's more, they think they should be free to get on with maximising profits without any interference from politicians, even though the fight against climate change can only be won if governments show leadership, individually and collectively."

This brings us back to the IPCC report, previously discussed. One other point present in the document is the intimation that human civilization can continue to grow economically with the prospect of decoupling energy from GDP (the reader might recall the brief discussion of decoupling in Diet, Affluence and China). The following passage is self-explanatory:

> "[E]nergy demand lower than present day, together with strong growth in economic output until the end of the century, is found in scenarios with shifts to more sustainable energy, material, and food consumption patters."

In essence, the message the IPCC tries to transmit is, if we replace energy sources and adopt vegetarian regimes, we can continue to pursue lots of economic growth while using much less energy (Heinberg, 2018). Despite their unfounded optimism, reality does not seem to want to comply, since decoupling energy from GDP has proven illusory and intangible (Hickel, 2018b). In an upcoming volume, I will take the time to dissect the claims of an astounding and prodigious renewable haven in the making, and how humanity can solve all of its environmental and sociological problems, if we just resolve our energetic conumdrum and uphold the promises of Green and Sustainable Growth, in Putting All Our Eggs in The Green Basket.

Given these points, and writing for *Pacific Standard*, Richard Heingerg (2018) weighs in and asks "why all the conjuring and sleight of hand?"

> "Because policymakers have effectively asked scientists to do the impossible. No politician in a wealthy country wants to inform constituents that further economic growth is unachievable. And no international agency would deny hundreds of millions of poor people the hope of bettering their lives through economic growth in the developing world […] to entirely replace fossil fuels with renewables would require a nearly complete transformation in how we use energy (Heinberg & Fridley, 2016) […] Switching to new and relativerly clean energy sources while trying to maintain growth of the overall economy would be a little like redesigning and reconfiguring an airplane while it's in flight (Ahmed, 2018b)."

Heinberg (2018) interconnects by asking “why not landing the airplane, or at least stop trying to gain altitude, while we make the needed upgrades?” That has been exactly the argument proposed by ecological economists, who allude that the one approach that would assuredly work to curtail emissions would be to deflate overall economic activity (Monbiot, 2018), while lessening and eventually stoping population growth (Casey & Galor, 2017).

Nowhere has this chasm between ecology and economics been more flagrant than at the time of the IPCC report announcement, where the main message echoed was “we have 12 years to limit climate change catastrophe,” when also the meeting of the International Monetary Fund was taking place reiterating the directive that the ‘window of opportunity [is] narrowing’ on global growth. Kate Raworth, author of *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist* (2017) said it best (Raworth, 2018):

> “One week, two meetings – a worldview apart. The history books will remember us as The Age of Dissonance, whose international institutions were simply unable to connect ecology and economy.”

But it doesn’t stop there. Ironically, in the same day as the IPCC report made landfall, with all of its prognostications and forewarnings, William Nordhaus reclaimed the Nobel Prize in Economics. Nordhaus is recognized for his work on environmental economics and in detail the economics of climate change. Except, Nordhaus is no climate hero – he has routinely attached little importance to the hazards of climate change as well as berating other scholars for alarmism. Another crucial aspect of Nordhaus’ standpoint relates to his conviction for using high “discount rates” in climate economics, which means that the future should be discounted more heavily – that is, the expenditure of action in the present should be more largely loaded than future benefits (Battistoni, 2018).

As Alyssa Battistoni tries to steel man Nordhaus’ viewpoint in *There’s No Time for Gradualism* (2018):

> “It would be better for everyone, present and future, to gradually impose the costs of climate mitigation and keep growing the economy in the meantime: future generations would be richer, and therefore better able to adapt to climate change. Nordhaus had been making this argument for years […] perfectly in keeping with the principles of mainstream economics. There, a relatively high discount rate reflects the expectation of robust economic growth. Since the economy could be much bigger in 2050, the reasoning goes, it is more expensive to spend on climate action now than it would be then.”

If this discrepancy between the IPCC and the Nobel Committee seems absolutely inconsistent with our ecological reality, it’s because it is. As Battistoni (2018) denotes:

> “Just yesterday [the day before the Nobel Economics Prize] Nordhaus told (Cummings, 2018) his undergraduate economics class, “Don’t let anyone distract you from the work at hand, which is economic growth.””

Then again, Battistoni urges us to focus our attention on other more merited targets:

> “Of course, economists aren’t the real reason why we haven’t taken decisive action on climate change. We can still blame (Aronoff, 2017) fossil-fuel companies, the Republican Party, and Wall Street (i.e., capitalism) for that. And Nordhaus has at least taken environmental harm seriously – for an economist.”

In order to contravene this political and economical circumstance, 94 signatories (Green et al, 2018) backing up the urgency to conceive a plausible plan for the decarbonisation of the economy, and encouraging civil movements such as the 'Extinction Rebellion,' which insists on governments to disclose the hard truths to its citizens in order to foment change. The signatories heavily reprimand their governments in the *Letters* section in *The Guardian*:

> "Our government is complicit in ignoring the precautionary principle, and in failing to acknowledge that infinite economic growth on a planet with finite resources is non-viable. Instead, the government irresponsibly promotes rampant consumerism and free-market fundamentalism, and allows greenhouse gas emissions to rise."

On the whole, and responding to Elliott's piece mentioned above, Richard Vernon writes in the *Letters* section of *The Guardian* in *Capitalism alone cannot reverse climate change* (Vernon, 2018):

> "[Larry Elliott's] suggested solution "that the world needs to wage war against climate change" misses the most important component. Climate change is driven by climate changers: you and me and 7.6 billion fellow humans, increasing by 83 million a year with effects on much more than climate change."

Ultimately, and as Paul Ehrlich says:

> "Whatever your cause, it will be a lost cause without population control."

Howbeit, policymakers are uncooperative and contrary to this pathway. Growth has been elevated to be venerated as a manner of creating jobs, securing returns on investment, and bolstering tax revenues. The truth is that the majority of politicians in almost every part in nearly every nation on the planet wants more of population and economic growth, not less. Changing that approach must be central to us going forward.

To conclude this mostly political chapter, I will reserve my right for skepticism for these claims that countries are committed to the environmental pledges that they have agreed to, until I see, for example, governmental educational programs *really* pushing for its citizens to avoid air travel; adopt car-free lifestyles and plant-based diets alongside recycling and changing light bulbs and saving water as they brush their teeth. Obviously, this would be very disruptive to the social *status quo*, to our economic house-of-cards model, and to what our XXI century civilization has grown accustomed to, overall. It might be hard to grasp a government encouraging its citizens to opt for vacations closer to home, business trips and scientific conventions to be made over video conference, a revolution to our dietary habits and transport preferences as well as a complete make-over of our economic system and way of living, alongside population stabilization and reduction programs as well as the contraction of personal carbon footprints, since our ecological reality is completely insensitive to our whims and vagaries.

Now, this is as much as any sane person should be bombarded with politics, so I propose to shift the conversation and now focusing on the natural world, and what are the repercussions of a more acidic and hotter planet.

Hot on Acid

"I've seen melting ice caps with my own eyes and got very wet in the process, but it is pointless campaigning against climate change or to 'save the Arctic' without addressing the root cause behind it and virtually every other environmental issue we face: our unsustainable numbers on this planet. That is the real 'inconvenient truth'."

- Adrian Hayes, polar explorer & adventure

"Time is the essential ingredient, but in the modern world there is no time."

- Rachel Carson

Since the 1970s, more than 93 percent of overflow heat apprehended by greenhouse gases has been absorbed by the oceans (Laffoley & Baxter, 2016). To get the picture of how much heat that is, contemplate it this way: If the oceans weren't soaking it up, average global temperatures on land would be far higher—around 50ºC, in accordance to researchers on the documentary Chasing Coral (2017). The global average surface temperature right now is 15°C (NOAA, 2017b).

Each of the preceding three decades has been consecutively warmer at the Earth's surface than any antecedent decade since 1850. Equally, the period from 1983 to 2012 was *likely* the warmest 30-year period of the last 1400 years in the Northern Hemisphere, where such evaluation is possible. The globally averaged combined land and ocean surface temperature data demonstrates a warming of 0.85 [0.65 to 1.06] ºC cover the period 1880 to 2012 (figure 6.11a) (IPCC, 2014a).

Coupled with this, on a global scale, the ocean warming is more severe near the surface, to this effect, the upper 75 m warmed by 0.11 [0.09 to 0.13] °C per decade over the period 1971 to 2010. It is virtually undeniable that the upper ocean (0–700 m) warmed from 1971 to 2010, and it likely warmed between the 1870s and 1971 (figure 6.11a).

The thermal inertia of the oceans contributes to the contrasting timescales mentioned above. One of the reasons why the worst effects of climate change will occur in the long-term future is that the oceans warm very slowly. As the oceans slowly warm there will be sea level rise due to thermal expansion of water, and to this will be added the effects of melting ice at the poles (figure 6.11b). Rising ocean levels have already affected island nations such as the Maldives, and coral reefs are already dying (Avery, 2017).

Ocean temperatures are the highest since record-keeping was initiated (figure 6.12), and hundreds of marine species are undergoing life-threatening adversity because of it (NOAA, 2018b). Recent coral bleaching events—prompted by too-hot sea temperatures—have killed off significant portions (Hughes et al, 2017) of the Great Barrier Reef (Cave & Gillis, 2017) and a UN report (UNESCO, 2017) admonished that the world's most significant coral reefs could die out completely by the end of the century, if not sooner (Parker & Welch, 2017). "Warming is projected to exceed the ability of reefs to survive within one to three decades for the majority of the World Heritage sites containing corals reefs," the report stated (UNESCO, 2017).

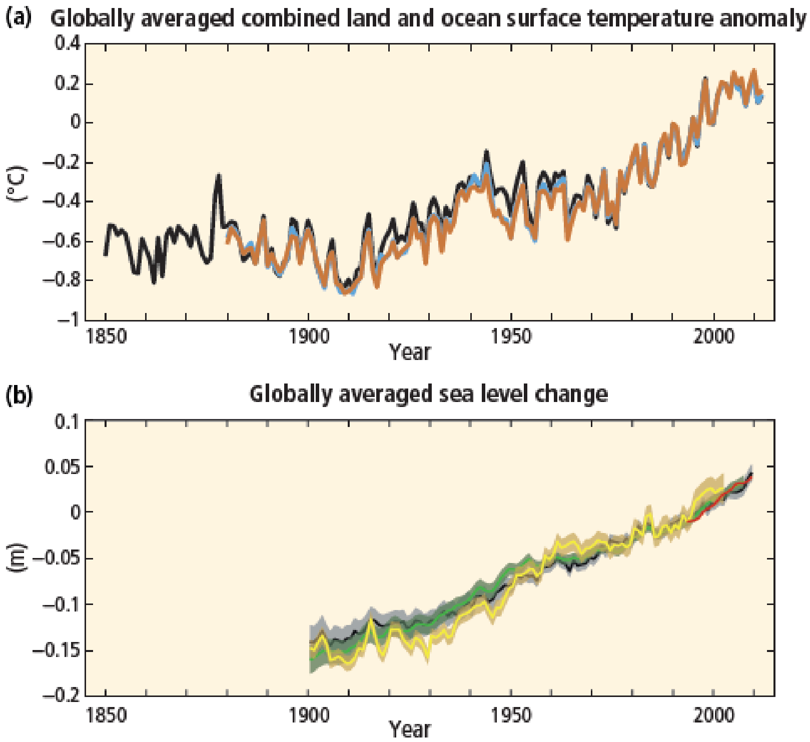


Figure 6.11: (a) Annually and globally averaged combined land and ocean surface temperature anomalies relative to the average over the period 1986 to 2005. Colors indicate different data sets. (b) Annually and globally averaged sea level change relative to the average over the period 1986 to 2005 in the longest-running dataset. Colors indicate different data sets. All datasets are aligned to +have the same value in 1993, the first year of satellite altimetry data (red). Where assessed, uncertainties are indicated by colored shading. Retrieved from (IPCC, 2014a).

The world's tropical reef ecosystems, and the humans who rely on them for subsistence are being increasingly afflicted by anthropogenic climate change (Heron, Maynard, van Hooidonk & Eakin, 2016; Spalding & Brown, 2016; Baker, Glynn & Riegl, 2008; Hughes et al, 2003; Glynn, 1984; Ormond et al, 2016), since in poorer countries hundreds of millions of people acquire their protein primarily from reef fish, and the depletion of that food supply could stir a humanitarian crisis (Cave & Gillis, 2017). Terry P. Hughes, director of a government-funded center for coral reef studies at James Cook University in Australia and the lead author of the *Nature* paper *Global warming and recurrent mass bleaching of corals* (Hughes et al, 2017) stated in an interview for *The New York Times* (Cave & Gillis, 2017):

> "We didn't expect to see this level of destruction to the Great Barrier Reef for another 30 years. In the north, I saw hundreds of reefs - literally two-thirds of the reefs were dying and are now dead."

The impairment to the Great Barrier Reef, one of the world's largest living structures, is part of a global scourge that has matured for roughly two decades while seeming to be aggravating. Correspondingly, the state of coral reefs is a discernible sign of the health of the seas. Their malaise and downfall are yet another indicator of the devastation of global climate change (Cave & Gillis, 2017).

As a matter of fact, reef scientists reprimanded decades ago that the coral reefs would be imperiled if humanity sustained the burning of fossil fuels at an expeditious pace, releasing the GHG that ends up warming the oceans. Emissions of the GHG kept on surging, inducing background ocean temperatures to be high enough so that any minor spike is enough to pose a critical risk to reefs (Cave & Gillis, 2017).

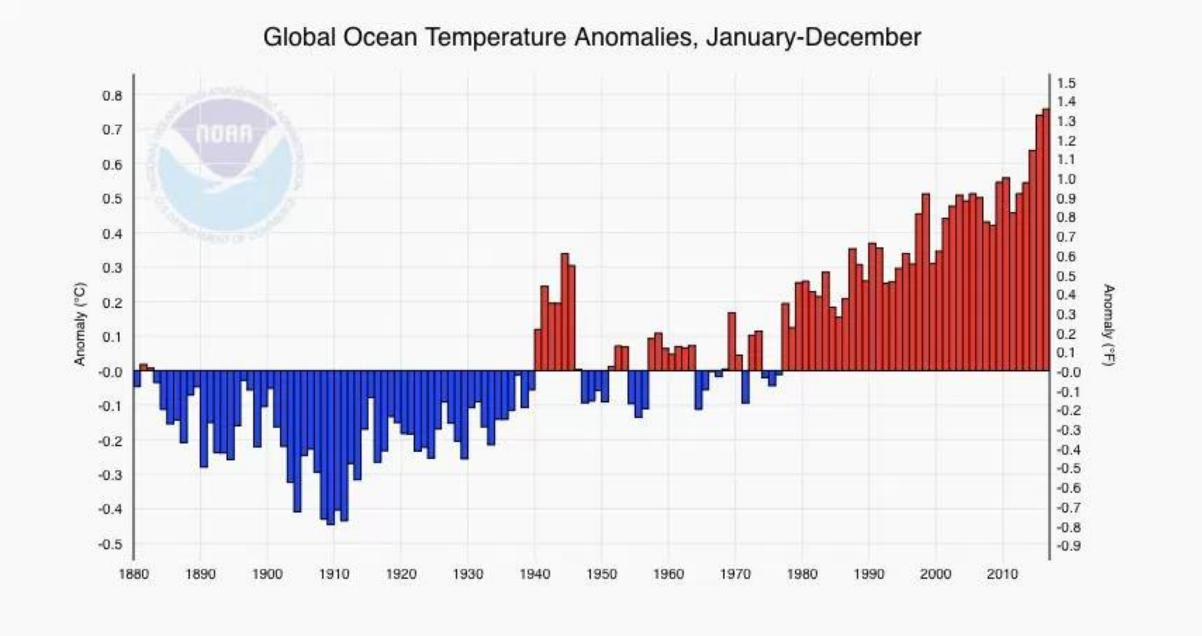


Figure 6.12: Global Ocean Temperature Anomalies from January to December (1880-2017). Source: NOAA National Centers for Environmental Information, Climate at a Glance: Global Time Series (NOAA, 2018b).

Corals demand warm water to thrive, but they are gracefully sensitive to any extra heating. Just two or three degrees Fahrenheit of surplus warming can kill these living beings. To that extent, globally, the ocean has increased in temperature by about 1.5 (figure 6.12) since the late 19th century, by a conservative calculation, and some more in the tropics, home to many reefs. Further heating was provided by an El Niño weather pattern, generating the hottest year in a historical record dating to 1880 (Gills, 2017).

The reasons that lead corals to be so delicate to small rises in heating derives from the fact that each individual coral (polyp) is an animal, and a host for microscopic plants described as zooxanthellae. The zooxanthellae generates carbohydrates, just like farmers harvest corn. Once we have ocean waters rising above a certain threshold - which temperature can vary by location and species - the symbiotic relationship between the corals and their “tenants” falls flat. Owing to this, the zooxanthellae begin to manufacture dangerous concentrations of oxygen radicals causing the polyps to respond by expelling them. Without the zooxanthellae, which are the origin of their dazzling colours, the corals appear to turn white - this is the phenomenon that has been recently dubbed “coral bleaching” (Lough, Anderson & Hughes, 2018). In addition to losing their pigmentation, bleached colonies cease to grow and, if the damage is severe enough, they die (Kolbert, 2014).

With this in mind, it is unavoidable to articulate that there were already major bleaching events in 1998, 2005, 2010 and 2015-2016 and that the intensity of such events is foreseen to augment as global temperatures escalate (Kolbert, 2014). In effect, a study of more than eight hundred reef-building coral species, published in *Science* by Kent E. Carpenter and colleagues (2008), established a third of them to be in peril of annihilation, largely as a result of rising ocean temperatures, elicited by human activity. In view of this reality, the study asserts that stony corals have been upgraded to one of the most endangered species on the planet: the proportion of coral species regarded as “threatened” surpasses “that of most terrestrial animal groups apart from amphibians”(Kolbert, 2014).

Equally important is that the frequency of these large-scale warming events is also on the rise. According to a study published in *Science* by Terry P. Hughes and colleagues (2018), mass coral reef bleaching events have been accepted as routine and commonplace, on a worldwide scale, over the past forty years, with climate change playing a substantial role in that ascension. The most compelling evidence is that in the previous four decades, the scale of bleaching has been rising firmly, with the global proportion of coral being hit per year increasing from 8 percent in the 1980s to 31 percent in 2016 (Dunne, 2018).

These findings are indicative that coral bleaching on this scale is in itself a "modern phenomenon" generated by global warming, the co-author, professor and Royal Society university research fellow and chair in marine ecology at Lancaster University, Nick Graham proclaims in an interview with *Carbon Brief* (Dunne, 2018):

> "All coral reef regions of the world are now experiencing more frequent severe coral bleaching events. Critically, the time between bleaching events is now as short as six years, which is insufficient time for full recovery of coral cover on damaged reefs."

Moreover, the researchers also concluded that the most recent mass bleaching event, from 2015 to 2016, was the most relentless on record (Pidcock, 2016), affecting 75 percent of the reefs examined in the study (Dunne, 2018). Extrapolating on the projections for population and emissions rise in this century, it should be safe to assume that intensity, as well as frequency, are bound to escalate.

Nick Graham again, on the influence of climate change and its association with the El Niño phenomenon:

> "Climate change is causing background sea surface temperatures to rise, such that a smaller and smaller temperature anomaly [rise] is causing corals to become stressed and bleached. El Niño events cause a big temperature anomaly and so, on top of the already warmed seas, the temperature gets far too hot and extensive bleaching occurs. Importantly, other smaller anomalies are now sufficient to cause bleaching, so as climate change continues, coral bleaching events are occurring more and more frequently" (Dunne, 2018).

So what do these findings spell out for a future in which humanity is striving for no more than 1.5ºC above pre-industrial levels as it was proclaimed during the Paris negotiations (as I've shown earlier the probability of remaining below such warming is relatively low, but for the sake of argument I will review the literature that displays the damage to corals with that degree of warming).

According to a study published in the journal *Nature Climate Change* (King, Karoly & Henley, 2017) that examined the repercussions of a global 2ºC rise in global temperatures in the Australian Great Barrier Reef, it concluded that the incalescence could prompt the natural monument to be hit by heat extremes similar to the summer of 2012-2013 and more recently the 2016-17 (that in just 90 days broke more than 205 records (Stock, Steffen & Rice, 2017)), which caused record levels of extensive bleaching, to materialize in almost four out of five years (87 percent of years) (McSweeney, 2017).

Additionally, the study (King et al, 2017) also covers more uncharted territory, in the way that it examines how likely it is under different climate scenarios, that Australia will undergo another summer like 2012-2013. Respectively, under the current climate (defined as the averages across 2006-16), a 44 percent chance of such an event becomes more real; under the projection of 1.5ºC warming that probability expands to 57 percent, and with 2ºC it would get as far as 77 percent. The risk is still respectable at 1.5ºC of warming, as it lowers to less than three out of every five years (McSweeney, 2017).

These results are indicative of the risks of allowing further population growth and emissions discharge into the atmosphere (and indirectly to the ocean). Carl Friedrich Schleussner, a scientific advisor at Climate Analytics in Germany, who led a study (Schleussner et al, 2016) that compared climate change repercussions at a 1.5ºC and 2ºC rise in temperature, affirmed in an interview with *Carbon Brief* (McSweeney, 2017):

> "The impacts of heatwaves in Australia are already very substantial to date and ocean warming has just led to the biggest coral bleaching event at the Great Barrier Reef - one of the world's most precious ecosystems. The reef will be at high risk already at 1.5ºC of global warming and at 2ºC there seems to be little chance of survival."

Equally important stands the testimony from Prof Jean-Pierre Gattuso, from the Institute for Sustainable Development and International Relations (IDDRI), who was not involved in the study and told *Carbon Brief* (Dunne, 2018):

> "The implications of this paper are dreadful: coral reefs as we know them may well vanish in the lifetime of the youngest of us. It is immensely important to make sure that the objectives of the Paris Agreement are met. [Still] another implication is that the Paris Agreement will not be enough to save coral reefs. Other solutions must be identified but none, so far, seem to have the required effectiveness and scalability."

Coupled with this, and seeing that bad news never have good timing, a frightful and unexpected research emerged from the journal *Nature* (Resplandy et al, 2018). Contrary to what was perceived, the world's oceans have been taking in far more excess heat in recent decades than previously assumed by scientists, implying that the Earth could be in a sent down a path where future warming might occur even more abruptly (Mooney & Dennis, 2018).

The research demonstrates that Earth's oceans have absorbed 60 percent more heat each year than assumed, which signifies that more heat is being retained within Earth's climate system, instead of vanishing into space. In a word, more heat in the oceans translates into a more advanced state of global warming and less space for humanity to manage the transitions that have been promised, in the form of our 'carbon budget' (more on the previous segment) (Mooney & Dennis, 2018). Laure Resplandy, lead author of the study and geoscientist at Princeton University lucidly asserts:

> "We thought that we got away with not a lot of warming in both the ocean and the atmosphere for the amount of CO_2 that we emitted. But we were wrong. The planet warmed more than we thought. It was hidden from us just because we didn't sample it right. But it was there. It was in the ocean already."

Besides the tremendous political implications of this study, other far-reaching consequences will take place. In the interest of this segment, rapidly warming oceans portend that seas will rise more expeditiously and more heat will come to critical locations and conveyed to places that already on the brink, such as coral reefs in the tropics and ice sheets of Greenland and Antarctica (Mooney & Dennis, 2018). Besides the reverberations of warmer oceans by taking in more heat, there is also a need to analyse the consequences of soaking up ever more carbon dioxide, present in the atmosphere due to more people doing more consumption.

As Roger Revelle and Hans Seuss delineated out over 50 years ago, humanity is carrying out "the great geophysical experiment" by discharging tremendous quantities of carbon dioxide into the atmosphere (Revelle & Suess, 1957). One consequence of this enterprise is an atmosphere that already harbours more CO_2 than at any time in the last 800,000 years of Earth history (as determined by the analysis of bubbles trapped in Antarctic ice; Lüthi et al, 2008) and presumably more than has occurred in several tens of millions of years (from an array of marine and terrestrial proxies; Royer, 2006; Kump, Bralower & Ridgwell, 2009).

The dissolution of the excess CO_2 that accumulated in the atmosphere is also having a disturbing effect on the ocean, generating what became known as "ocean acidification" (Caldeira & Wickett, 2003; Feely, Doney & Cooley, 2009). Correspondingly, ocean covers seventy percent of the earth's surface, and everywhere there is an interface between water and air, an exchange takes place. Gases from the atmosphere get absorbed by the ocean, and at the same time gases dissipated in the ocean are freed into the atmosphere. When the two are in relative equilibrium, practically the same quantities are being dissolved and liberated. By altering the composition of the atmosphere, as humans have done, the exchange becomes disproportional and irregular: more carbon dioxide enters the water than it is discharged. It is estimated that every year, two and a half billion tons of carbon are absorbed by the ocean alone (Kolbert, 2014).

As a result of all this extra CO_2, the pH of the ocean's surface waters has already dropped from an average 8.2 to 8.1, and under the "business as usual" emissions scenario, surface ocean pH is envisioned to decrease to 8.0 by mid-century and 7.8 by 2100 (Kolbert, 2014). To get a grasp of the scale of conversion of the ocean by human activity, oceanic uptake of CO_2 has spearheaded the pH of ocean surface water deteriorating by 0.1, corresponding to a 26 percent increase in acidity, measured as hydrogen ion concentration (IPCC, 2014a). Moreover, it might be relevant to aim attention to the fact that roughly a third of the CO_2 discharged by burning coal, oil and gas gets absorbed by the oceans, and since the beginning of the industrial era, it has consumed around 525 billion tons of CO_2 (Short, 2018).

Assuming that the burning of fossil fuels will persevere, or that the CO_2 present in the atmosphere will not be removed any time soon, that will translate into the oceans perpetuation of this osmosis process that will lead to further acidification (Kolbert, 2014). According to recent research published in the journal *Earth and Planetary Science Letters* (Sosdian et al, 2018) if the current trends of emissions are to persist the ocean will enter a state of acidification it hasn't undergone in roughly 14 million years, which under the "business-as-usual" scenario will signify atmospheric CO_2 concentrations of roughly 930 parts per million in the year 2100, compared with the 410 in 2018 (Shukla, 2018). Obviously, humanity never inhabited such a world, and it might be possible that they won't be able to or even sustain their populations in such a different reality.

Ocean acidification is often described as global warming's "equally evil twin." No single mechanism or events has fully explained all the mass extinctions on record, and yet, alterations to the ocean chemistry appear to stand as a notable predictor. Ocean acidification played a role in at least two of the Big Five extinctions (the end-Permian and the end-Triassic) and conceivably a crucial factor in a third (the end-Cretaceous) (Hönisch et al, 2012; Clarkson et al, 2015; Veron, 2008). There is even substantial evidence (Mattioli, Pittet, Suan & Mailliot, 2008; Hönisch et al, 2012) that ocean acidification was responsible for a major extinction event called the Toarcian Turnover, which occurred 183 million years ago, in the early Jurassic, to say nothing of the end of the Paleocene (described as the PETM, Paleocene-Eocene Thermal Maximum), 55 million years ago, when a considerable number of marine life forms went through a major crunch (Hönisch et al, 2012; Kolbert, 2014).

So why is there this death record following ocean acidification? That is one tough investigation to close, only due to the long list of reasons that accompany this phenomenon. Depending on how effectively organisms are capable of regulating their internal chemistry, acidification may disturb such fundamental processes such as metabolism, enzyme activity, and protein function. Moreover, on the grounds that it will change the makeup of microbial communities, it will doctor the availability of key nutrients, just like iron and nitrogen. Similarly, it will revamp the amount of light that passes through the water, and for somewhat different reasons, it reshapes the way sound propagates. Equally important, acidification seems inclined to encourage the proliferation of toxic algae and the disruption of photosynthesis as well as alter the compounds assembled by dissolved metals - in particular cases, becoming poisonous (Kolbert, 2014).

Another key point, and probably the most important one involves a group of creatures known as calcifiers (the term includes any organism that builds a shell or external skeleton or, in the case of plants, an internal frame out of the mineral calcium carbonate) (Kolbert, 2014). With the current rate of anthropogenic CO_2 discharges, this generates a surface ocean environment characterized not just by increased dissolved CO_2 and contracted pH (Caldeira & Wickett, 2003) but, critically, decreased saturation with respect to calcium carbonate ($CaCO_3$), a compound that these calcifiers depend on (Hönisch et al, 2012).

From a human perspective, calcification resembles construction work and also something similar to alchemy. To constitute their shells, exoskeletons or calcitic plates, calcifiers must associate calcium ions (Ca^{2+}) and carbonate ions (CO_3^{2-}) to assemble calcium carbonate ($CaCO_3$). Whereas, at the concentrations they are found in common seawater, calcium and carbonate won't combine. Therefore, at the site of calcification, organisms must transform the chemistry of the water to, effectively, enforce a chemistry of their own making (Kolbert, 2014).

The real complication of ocean acidification is that it raises the cost of calcification by diminishing the number of carbonate ions available to begin with. Following the construction metaphor from above, what acidification does is trying to build a house while someone keeps stealing the bricks. Likewise, the more acidified the water, the greater the energy called to complete the indispensable steps. Correspondingly, at a certain point, the water becomes positively corrosive and solid calcium carbonate initiates a decomposition (Kolbert, 2014).

In her book *The Sixth Mass Extinction - An Unnatural History*, the author and staff writer at *The New Yorker,* Elizabeth Kolbert (2014) dedicates two entire chapters to convey a very elucidative image of what ocean acidification is and what it is doing. Brilliantly so, Kolbert interviews biologist Jason Hall-Spencer, lead author of the *Nature* study *Volcanic carbon dioxide vents show ecosystem effects of ocean acidification* (Hall-Spencer et al, 2008) and the following is an excerpt of that interaction:

> "Owing to the CO_2 pouring out of the vents, the waters around Castello Aragonese provide a near-perfect preview of what lies ahead for the oceans generally [...] Hall-Spencer tells me about his first trip to the vents. That was the summer of 2002 [...] at the time, marine biologists were just beginning to recognize the hazards posed by acidification [...] it occurred to Hall-Spencer that the vents could be used for a new and more ambitious sort of study.
>
> At Castello Aragonese, the vents produce a pH gradient. On the eastern edge of the island, the waters are more or less unaffected. This zone might be thought of as the Mediterranean of the present. As you move closer to the vents, the acidity of the water increases and the pH declines. A map of life along this pH gradient, Hall-Spencer reasoned, would represent a map of what lies ahead for the world's oceans. It would be like having access to an underwater time machine.

> [...] Their first task was producing a detailed survey of pH levels around the island. Then they organized a census of what was living in each of the different pH zones [...] in the waters far from the vents Hall-Spencer and his colleagues found a fairly typical assemblage of Mediterranean species. These included: *Agelas oroides*, *Sarpa salpa* and *Arbacia lixula,* as well as *Amphiroa rigida* and *Halimeda tuna* [...] in this vent-free zone, sixty-nine species of animals and fifty-one species of plants were counted.
>
> When Hall-Spencer and his team set up closer to the vents, with a pH of 7.8, which corresponds to the seas of the not-too-distant future, the tally they came up with was very different. *Balanus perforatus,* a grayish barnacle that is common and abundant from West Africa to Wales, was gone. *Mytilus galloprovincialis*, a mussel native to the Mediterranean, that is so adaptable that is has established itself in many parts of the world and considered invasive, it too was missing. Also absent were: *Corallina elongata* and *Corallina officinalis*, a reddish seaweed; *Pomatoceros triqueter*, a kind of keel worm, three species of corals, several species of snails; and *Arca noae*, a mollusk commonly known as Noah's Ark. All told, one-third of the species found in the vent-free zone were no-shows in the pH 7.8 zone.
>
> "Unfortunately, the biggest tipping point, the one at which the ecosystems starts to crash, is mean pH 7.8, which is what we're expecting to happen by 2100. That is rather alarming.""

Ulf Riebesell, a biological oceanographer at the GEOMAR-Helmholtz Centre in Kiel, Germany has also found that the groups that gravitated towards doing better in acidified waters are plankton that are so tiny that they assemble their own food web. Problem is, as their numbers increase, these picoplankton, as they are branded, use up more nutrients, and the larger organisms tend to suffer and decay. Riebesell forewarns:

> "If you ask me what's going to happen in the future, I think the strongest evidence we have is there is going to be a reduction in biodiversity. Some highly tolerant organisms will become more abundant, but overall diversity will be lost. This is what has happened in all these times of major mass extinction" (Kolbert, 2014).

Further experimentation has demonstrated that invertebrates, coral reefs and other calcifiers will be particularly hard-hit by falling ocean pH (Orr et al, 2005; Kurihara, 2008; Andersson, Mackenzie & Bates, 2008; Kroeker, Kordas, Crim & Singh, 2010; Kleypas et al, 2006; Ries, Cohen & McCorkle, 2009) and the list of the ones that left with no trace at Castello Aragonese testifies to this (Hall-Spencer et al, 2008). Correspondingly, in the pH 7.8 zone, three-quarters of the missing species are calcifiers. The list includes species such as the nearly ubiquitous barnacle *Balanus perforatus*, the mussel *Mytilus galloprovincialis,* and the keel worm *Pomatoceros triqueter*. Additional vanished calcifiers are *Lima lima*, a common bivalve; *Jujubinus striatus* and *Serpulorbis arenarius*. Moreover, calcifying seaweed, is altogether absent (Kolbert, 2014).

Approximately one-third of the CO_2 that humanity has discharged into the atmosphere has been absorbed by the oceans. That equals roughly 150 billion metric tons. As it is characteristic of the Anthropocene, though, it isn't just the scale of the transfer that is vital but also the speed at which it is occurring. Evidently that for marine chemistry, it makes a tremendous difference if it the ocean absorbs hundreds of billion metric tons of CO_2 in several million years or just hundreds (Kolbert, 2014). To that effect, Rachel Carson's quote that opened up this segment acquires an emerging meaning:

> "Time is the essential ingredient, but in the modern world there is no time."

In like manner, a group of scientists led by Bärbël Hönisch, of Columbia's Lamont-Doherty Earth Observatory, reviewed the evidence for the mutating CO_2 levels in the geological past (the major extinctions stated earlier) and arrived at the conclusion in the *Science* paper *The Geological Record of Ocean Acidification* (Hönisch et al, 2012), that although there were many ocean acidification episodes in the history of the Earth, "no past events perfectly parallels" what is transpiring in our Anthropocene Era, owing to "the unprecedented rapidity of CO_2 release currently taking place." In like manner, Lee Kump, from the Geoscience department at Penn State, Andy Ridgwell, a climate modeler from the University of Bristol, and Timothy Bralower also from Penn State described in a special issue of the journal *Oceanography* dedicated to acidification (Kump et al, 2015) that:

> "It is the rate of CO_2 release that makes the current great experiment so geologically unusual, and quite probably unprecedented in earth history. [By continuing in this path for much longer] is likely to leave a legacy of the Anthropocene as one of the most notable, if not cataclysmic events in the history of our planet" (Kolbert, 2014).

Bringing us back to the coral reefs that started of this segment, there is still much that needs to be said about these "wonderful objects of the world," as Charles Darwin once put it. As a matter of fact, these organic paradoxes are part animal, part vegetable, and part mineral, as well as brimming with life, and at the same time, mostly dead. Uniquely so, reefs are often equaled to rainforests, and in terms of outright variety of life, the comparison stands its ground, since it is appraised that at least half a million and up to nine million species spend at least a part of their lives on coral reefs (Kolbert, 2014).

Notwithstanding the hazards of acidification that affect beings such as corals being customarily articulated in terms of pH, there is another way to examine the situation that is just as vital - to many organisms probably more crucial still - and this is in terms of a property of seawater described as the "saturation state of calcium carbonate," or alternatively "saturation state with respect to aragonite." (Calcium carbonate originates in two disparate forms, revolving around its crystal structure; aragonite, which is the form that corals assemble, is the more soluble variety.) Essentially, when CO_2 disperses in water, it forms carbonic acid (H_2CO_3), which efficaciously "devours" carbonate ions, thus lowering the saturation state (Kolbert, 2014).

Back at the beginning of the millennium, another team from the University of Columbia Lamont-Doherty Earth Observatory, as well as the BIOSPHERE 2 Center in Arizona, led by Chris Langdon, set out to deeply analyze how saturation affected corals. At that time, the dominant hypothesis among marine biologists was that corals did not perceive saturation as a relevant cause for survival. Langdon demonstrated the opposite. In *Effect of calcium carbonate saturation state of the calcification rate of an experimental coral reef* (2000), Langdon and his team revealed a more or less linear relationship between the growth rate of the corals and the saturation state of the water. That is to say that corals flourished fastest at an aragonite saturation state of five, more reluctant at four, and lethargic at three. Moreover, at a level of two, corals basically cease to assemble, like stonewalled contractors with no machinery to work with (Kolbert, 2014).

Previous to the industrial revolution, all of the world's major reefs were predicated in water with an aragonite saturation state between four and five. In our present day, there are almost no places left on the planet where the saturation state is above four, and following the projections for current emissions trends, by 2060, there will be no place left above 3.5, and by 2100, none will hover above three. Similarly, as saturation levels decrease the energy demanded for calcification will augment, and calcification rates will contract. Eventually, saturation levels may dwindle so low that corals desist on calcifying altogether, which will materialize (or not) in a subsiding of their renewal processes. Then again, long before that corals will give in to other real-world issues like being eaten away by fish and sea urchins and burrowing worms. On top of that, there are also the physical strains of colliding waves and ravaging storms. So, for the purpose of perpetuity, reefs must always continue to flourish and develop or face oblivion (Kolbert, 2014).

Altogether, ocean acidification isn't the only threat that reefs are facing. In fact, in some parts of the world, reefs will not stand the test of time long enough for acidification to finish them off. After all, in an overpopulated world, there is no shortage of hazards coming their way. Overfishing, which promotes the proliferation of algae growth that compete with corals; agricultural runoff, which also leads to algae growth; deforestation, which generates siltation and reduces water clarity; and dynamite fishing, whose lethal and extirpative power should be self-explanatory (Kolbert, 2014).

Before moving on to the next segment, if the reader is someone deeply worried about the state of nature and its non-humans inhabitants and you feel I haven't made justice to that complex issue just yet, you are right. Unfortunately, the theme of planetary climatic mutations is mostly monopolized by its implications on human affairs, so please allow me to quench that fire as much as possible by submitting my intention to organize a proper segment to prospect the scientific literature regarding how these climatic shifts are and will collide with other denizens on this planet, since I was only able to graze it superficially in this segment with acidification and increases in temperature. To be sure, besides these two crucial aspects of anthropogenic climate change there are other pressing and concomitant concerns with the science being clear that to avert further devastation of the natural world humanity needs to prevent temperatures from exceeding the 1.5ºC mark. As the most recent report from the IPCC, *Global Warming of 1.5ºC – Summary for Policymakers* (2018) indicates:

> "Impacts on natural and human systems from global warming have already been observed (*high confidence)*. Many land and ocean ecosystems and some of the services they provide have already changed due to global warming (*high confidence*). Future climate-related risks depend on the rate, peak and duration of warming. In the aggregate they are larger if global warming exceeds 1.5ºC, especially if the peak temperature is high (e.g. about 2ºC) (*high confidence).* Some impacts may be long-lasting or irreversible, such as the loss of some ecosystems (*high confidence).*

By all means, maintaining a lower temperature increase would translate into less risks for a multitude of insect, plant and animal species when equating it with a full 2 degrees of warming (Gramling, 2018a). As a matter of fact, limiting global warming this century to 1.5ºC above preindustrial levels would be not just a moral imperative but an immense benefaction to the planet's biodiversity (Gramling, 2018b). In fact, and according to recent research published in *Science,* lessening our collective emissions of GHG to a level that wouldn't surpass the 1.5ºC threshold, would preserve much larger expanses of the geographic ranges of tens of thousands of land-based species of plants, vertebrates and insects. Indeed, the authors' findings point to contractions of half their ranges in different species, specifically: 18 percent in insect, 16 percent in plants and 8 percent in vertebrates under a 2ºC rise in temperature, with respectively, 49, 44 and 26 percent in case of a 3.2ºC rise by 2100 (Warren, Price, Graham, Forstenhaeusler & VanderWal, 2018).

All in all, I hope to adequately review the literature on the link between population growth, climate change and biodiversity loss and further expand on this momentous issue.

Climate Change Ethics

-The Role of Population in the Climate Predicament and the Need for a New Moral Stance -

"The biggest impact a U.S. citizen can have on global environment problems, such as climate change, is having fewer children."

- David Bielle, in "Human Population Reaches 7 Billion - How Did This Happen, and Can It Go On?" *Scientific American*, October 28, 2011

-

"Population growth is undoubtedly one of the main drivers of GHG emissions at the global level, and thus, climate change."

- Erich Striessnig,*in A Demographic Perspective on Climate Change Mitigation and Adaptation* (2015)

"One hopes that human wisdom and ethics will continue to grow, but indefinite growth of population and industry on a finite earth is a logical impossibility."

- John Scales Avery, *in Population and the Environment* (2018)

The expansion of population is a vital factor behind climate change at our present day. Human-caused climate change is fundamentally an asymmetry of scale, as people unleash heat-trapping gases into Earth's atmosphere faster than the oceans, other carbon sinks and living beings can extract them. This imbalance emerges both from the eruption of technologies made possible through the combustion of fossil fuels since the late 18th century, and the more than sevenfold swell in human numbers since that time (Engelman, 2010). Indeed, there is an almost perfect correlation between population growth and expanding GHG emission in both the US and Europe (Ryerson, 2010).

As Larry LeDoux writes in *Scientific American* (2009)*, Does Population Growth Impact Climate Change?* The answer is surprisingly simple:

> *"*No doubt human population growth is a major contributor to global warming, given that humans use fossil fuels to power their increasingly mechanized lifestyles. More people means more demand for oil, gas, coal and other fuels mined or drilled from below the Earth's surface that, when burned, spew enough carbon (CO_2) into the atmosphere to trap warm air inside like a greenhouse."

LeDoux adjoins:

> "Developed countries consume the lion's share of fossil fuels. The United States, for example, contains just five percent of the world population, yet contributes a quarter of total CO_2 output. But while population growth is stagnant or dropping in most developed countries (except the U.S., due to immigration), it is rising rapidly in quickly industrializing developing nations. According to the United Nations Population Fund, fast-growing developing countries (like China and India) will contribute more than half of global CO_2 emissions by 2050, leading some to wonder if all of the efforts being made to curb emissions in the developed world will be erased by other countries adoption of our long held over-consumptive ways."

For this reason, the Global Population and Environmental Program at the NGO Sierra Club (LeDoux, 2009) attests that:

> "Population, global warming and consumption patterns are inextricably linked in their collective global environmental impact. As developing countries contribution to global emissions grows, population size and growth rates will become significant factors in magnifying the impacts of global warming."

As Ray Wheeler asserts in, *Why population growth matters to climate change* (2013), "the scientific literature supporting the linkage between population growth and climate change is vast and the issue is identified as paramount in countless studies and reports." In figure 6.13, it is conspicuously striking how climate and population are linked. The curves of population growth and carbon dioxide levels in the atmosphere since 1880 essentially follow each other. In effect, one of the more direct consequences of population growth is the automatic expansion of energy consumption, which in turn translates into increased greenhouse gas emissions, declares Prof. Frank Götmark, an ecologist at the University of Gothenburg, Sweden (The Overpopulation Project, 2018a).

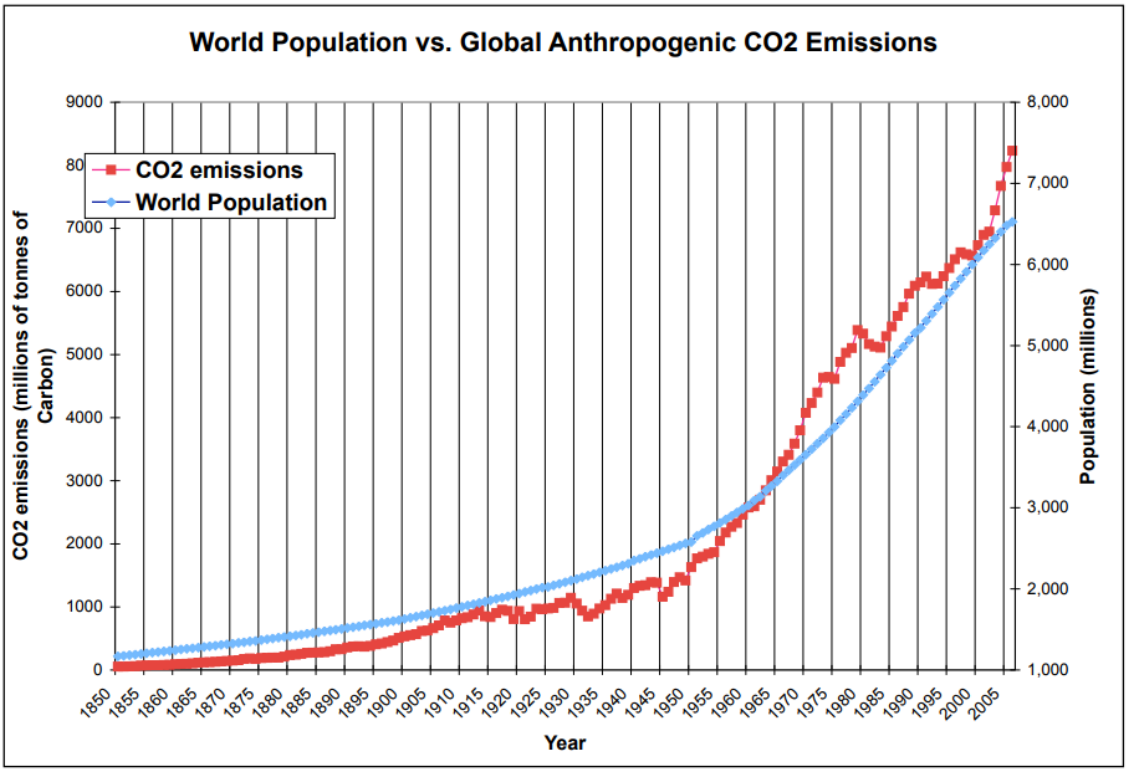


Figure 6.13: Population growth is a threat to the world's climate. The rise in CO_2 levels is directly linked to the expansion of the human population. Retrieved from The Overpopulation Project, 2018a.

Equally important, the size of our contemporary population and its maintained growth also put at risk the social and institutional resilience required to reconcile successfully to the repercussions of climate change, ranging from sea-level rise to more acute weather events (Engelman, 2010). To that effect, fast population growth (figure 6.14) - inflamed by high fertility - cripples the efforts in the reduction of poverty and the achievement of other internationally agreed development goals (Stephenson, Newman, Mayhew, 2010).

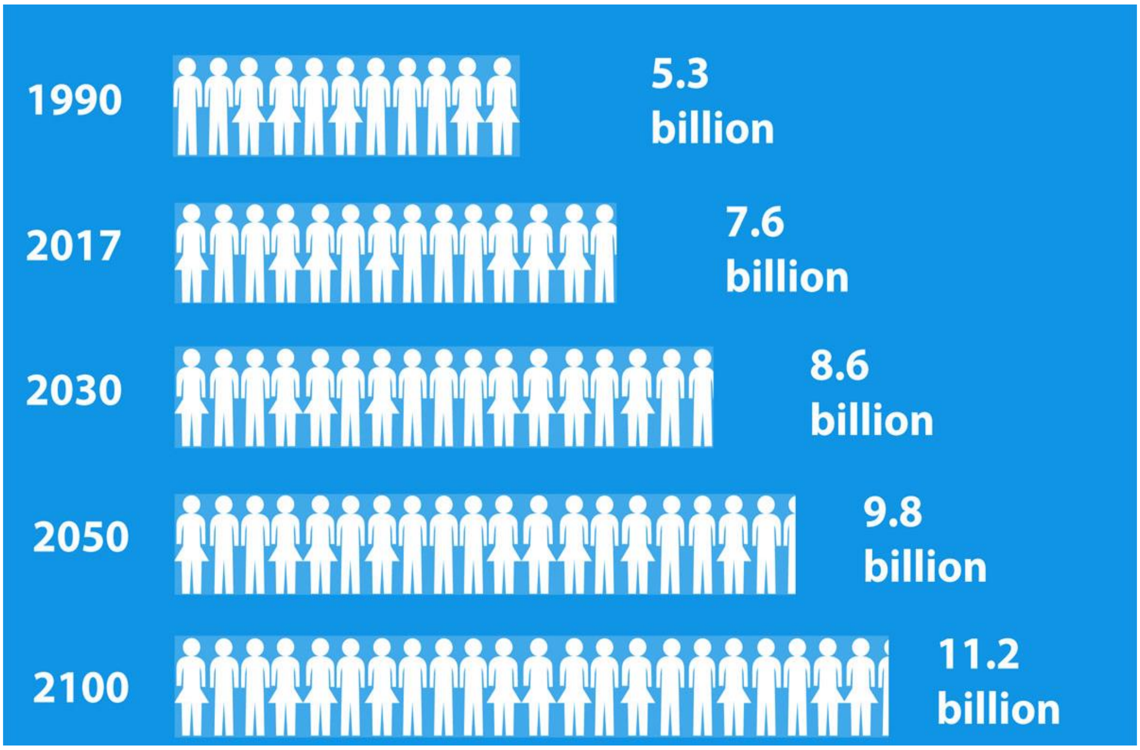


Figure 6.14: World population. Projected world population population by 2100. Source: United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2017 Revision* (UNDESA, 2017). Produced by: United Nations Department of Public Information.

Unfortunately, is is customarily to think that population growth in poor countries is negligible when looking at the whole picture because their emissions per capita are low (The Overpopulation Project, 2018a). While fertility has been descending throughout the developing world since the 1970's, a substantial share of the least developed countries still harbor total fertility rates above 5 children per woman, resulting in the rapid population growth that this world is witnessing, provoking pressure on natural resources, weak infrastructures and the capacity to readjust to the reverberations of climate change. Yet, population is conceivably the most undervalued and disregarded dimension of climate change (Stephenson et al, 2010).

In *Global warming policy: Is population left out in the cold?* Published in *Science,* authors John Bongaarts and Brian O'Neill (2018) denote that UN forecasts point out that the global population will expand from today's roughly 7.6 billion to 11.2 billion by the year 2100 (figure 6.13 above) – and in the worst case, it could reach 13.3 billion. To maintain that this outlandish increase will not impinge on climate dynamics is to be dangerously duplicitous and deceitful while being completely oblivious to reality, according to the researchers (The Overpopulation Project, 2018a). As the authors state:

> "Over the next few decades, overall emissions from low-income countries are likely to rise because of a rise in emissions per capita from rapid industrialization, as well as because of increasing population."

In defiance of its critical augmentation to climate change, population seldom enters the fray in current discussions on how to undertake this laborious and grim quandary, since concerns that policies to hamper population growth might infringe on the right of couples to arbitrate their own family size (this segment will introduce the theoretical ethical concepts and tools to approach this discussion, nevertheless the core of the matter will be argued in the upcoming volume, in the chapter On the Morality of Procreation). By the same token, population is linked with other delicate themes such as sexuality, contraception, abortion, migration and religion. Under these circumstances, the deliberation on climate change tends to concentrate on the role of human technologies and their economic foundations, as a substitute for critical human numbers and behaviors (Engelman, 2010).

Notwithstanding the technical efficiency improvements made, more individuals living more affluently will still translate into heightened emissions in the order of 25 to 90 percent between 2000 and 2030 according to the IPCC's estimates (Metz, Davidson, Bosch, Dave & Meyer, 2007). Allowing this path to materialize will lock humanity in a scenario of above 2ºC rise in global temperature beyond pre-industrial levels, which, by all means would enact a moral calamity as well: the egotistical usurpation and degeneration of key environmental services by the prevalent generations to the disability of future ones, by rich people to the impairment of the poor, and by human beings to the great prejudice of the rest of the living world (Brown, 2013).

Slower population growth has also been expected to reduce climate change risks by extricating resources for adaptation that would otherwise be consumed by an increasing populace (Bongaarts & O'Neill, 2018). Improvements in education and health, which can both evoke and prompt slower population growth, can curtail vulnerability to climate risks (Lutz, Muttarak & Striessnig, 2014).

The IPCC itself has fractionally evaluated this topic, concluding that population growth, urbanization, and transformations in the age structure are crucial drivers of emissions. It has also consummated that demography shapes the exposure and vulnerability of population to climate influences and can confine, or simplify, the ability of societies to adapt to those reverberations. What is still lacking is an accounting of how reductions in population growth might embody full fledged responses to the climate predicament (Bongaarts & O'Neill, 2018).

Climate change is among the most momentous moral problems present-day societies are enduring, in terms of its imperativeness, global spread, and the magnitude of its accompanying impairment. Our blooming numbers play a crucial role in dictating just how dreadful climate change will be, since it impinges on food production, water scarcity, depletion of resources, fluctuations in disease vectors, extreme heat waves, rising sea levels and the escalation and intensity of weather events that result in death, destruction, and challenges to geopolitics and economic systems (Hickey et al, 2016). After all, the bioethicist Travis N. Rieder from John Hopkins University asserts that climate change has the potential to be the biggest moral tragedy in the history of humanity (Rieder, 2016).

Climate change is induced by the accumulation of greenhouse gases (GHG) in the atmosphere, and the emission of these gases is a compound of not only the activity of individuals, but the number of individuals doing the discharging (Rieder, 2016). Correspondingly, one of the more vigorous conclusions among those studying climate change ethics is that atmospheric carbon and other greenhouse gases should not be tolerated to surmount levels that might expedite catastrophic climate change and provoke serious abuse to many innocent people (Cafaro, 2012). As an important *White Paper on the Ethical Dimensions of Climate Change* (Brown, 2013) summarized the matter:

> "All people have a right to be protected from threats to their life, safety, and security caused by others, and [...] existing levels of GHG emissions threaten these rights… So long as atmospheric GHG levels threaten basic human rights, [we] cannot find any respected ethical system that would justify allowing atmospheric levels of GHGs to rise thereby additionally jeopardizing human rights… various ethical systems converge in the conclusion that atmospheric levels of GHGs should be stabilized at the lowest possible levels above existing atmospheric GHG concentrations."

In accordance with the research from Brian C. O'Neill and colleagues (2010) their analysis has demonstrated that:

> "Following a lower population path could reduce emissions 1.4-2.5 GtC/y by 2050, equivalent to 16-29 percent of the emission reductions necessary to achieve these goals… By the end of the century, the effect of slower population growth would be even more significant, reducing total emissions from fossil fuel use by 37-41 percent across the two scenarios."

Another way to put this is by stating that roughly 40 percent of the excessive greenhouse gas emissions envisioned to be discharged over the rest of this century under 'business as usual' will come from population growth alone. The key point is that the potential for emission reduction from human population stabilization or reduction is colossal. Under a non-coercive scenario of population equalization, GHG could be curtailed by 5.1 billion tons per year by 2100 (O'Neill et al, 2010). In contrast, *total* current yearly emissions are in the vicinity of 30 billion tons of CO_2 (CO2.earth, 2018). To that effect, 5.1 billion tons per year is more than *five times* the annual emissions savings humanity would carry out in 50 years by doubling the fuel efficiency of the world auto fleet, or by halving the average kilometers traveled per car, or by tripling the number of nuclear reactors currently catering our energy demands, or by augmenting current wind energy capacity 50 times, or by ceasing *all* deforestation *everywhere* around the world (Pacala & Socolow, 2004). **Reducing population growth could grant more emissions reduction than all five of these other methods put together** (Cafaro, 2012).

Many in the climate policy community are presently focusing on achieving substantial emission reduction in the near future. Granted that, a slowed population growth would contribute only in a modest manner in the *short term*, its cumulative outcome during the 21st century would be considerable. A slowed population growth would reduce emissions and enable a contraction in the demand for energy that would have to be satisfied with low- or zero-carbon sources (Bongaarts & O'Neill, 2018).

Although, some climate ethicists and policy analysts might discredit stabilization at "the lowest possible levels" as too demanding and due to disparities regarding the exact amount of tolerable climate change, a broad consensus appears to condense among climate ethicists that the nations of the world should take combative and assertive steps to confine greenhouse gas emissions, so as to bypass the engendering of grave harms to fall on large numbers of people (Cafaro, 2012).

Just as the traditional measures to expand solar and wind power, cut back on automobile use, or slash deforestation should be embraced wherever they are enacted, as helping meet the global challenge of climate change, so measures that reduce human numbers in a humane manner are welcome wherever they transpire and should be reinforced and reassured universally. To repudiate this is commensurate with selecting for a future in which humanity tries to provide for ever more people in comfort and security while generating ever fewer greenhouse gas emissions. Such a future is highly implausible and unconvincing (Cafaro, 2012).

Likewise, pending the glaring disinclination of most governments to address the other main driver besides population growth: increased *per capita* wealth, this in turn, adds to the fact that every additional human being makes *some* demands on the environment and *some* contribution to global climate change, and this contribution cannot be driven down to zero, therefore we arrive at the conclusion that creating more human beings is not an inherent inconsequential action (Rieder, 2016).

Adding insult to injury, in 2008, a biologist named Frederick Meyerson (2008) determined that if we deemed necessary to hold steady the total global emissions at (then) current levels, while keeping pace with the population growth, a contraction of 1.2 percent of global *per capita* emissions would need to occur every year. Moreover, this 1.2 percent number does not encompass the expansion in the per capita affluence that humans crave to consummate, as more people climb in the hierarchy of consumption, and it only refers to a sustainment of *current levels of emissions,* and although a 1.2 percent reduction might seem sober and pragmatic, to the degree of Meyerson's calculations, we have not been able to reduce *per capita* emissions by even 1 percent over the course of the previous 38 years. Thus, to give credence to the conviction that we can act so as to mitigate climate change by altering only our carbon-emitting behaviors requires the fictitious conjecture that we can do more to scale down emissions every year than we have been able to attain in the past four decades (Rieder, 2016).

Furthermore, recalling that most affluent human beings have proven selfish and short-sighted in taking meaningful action regarding climate change (activities with substantial impact that would reduce one's carbon footprint such as avoiding air travel; living car-free; having a plant based diet, or the much needed reform of our economic systems that would ditch this paradigm of incessant growth and profit above all else), hesitating and vacillating for several decades now in the face of definite evidence of climate change, there is every reason to assume that our collective riposte will progress to be incompetent and inadequate to what is truly required and that every extra human being makes this predicament worse (Cafaro, 2012). For the most part, we can't count on future people to be able to curtail consumption when we haven't so far been capable to do that ourselves. And in the long run, unhampered growth would sooner or later have the same repercussions, even if we cut back substantially on our rates of consumption and pollution. There is just a limit to how many of us the planet can shoulder, even if we were to cut back - as the evidence suggests we won't (Conly 2016).

To demonstrate this, an article entitled *Many Indians are deciding not to bring children into this overpopulated, unkind world* written by Reem Khokhar (2018) which delineated that:

> "The decision to have a child is primarily an emotional one and often in India, a cultural pressure to which most people succumb. But as our resources are being stretched to breaking point, it is evident that the uncomfortable truth associated with overpopulation is crossing people's minds and motivating some to not contribute further to the problems. Whether environmental concerns will motivate more people to be child-free is still to be seen. However, allowing people to make a choice about having children, and celebrating all types of families, is a way to help many consider that parenthood does not have to be a part of their life's journey, unless they really want it."

Under these circumstances, Philip Cafaro, philosopher and professor at Colorado State University submits the following pronouncement: "***the consensus regarding acceptable limits to global climate change demands, at a minimum, that we take steps to end human population growth"***. Undeniably, taking such limits earnestly, in all probability substantiates a significant *reduction* in the size of the current global human population. Given the role population growth has and will endorse in advancing climate change under business as usual, no less than prudent policies would appear to pass as ethically acceptable. Therefore, humanity should promote and bolster policies that limit human numbers, not just in the poor countries that are customarily recognized to be overpopulated, but in rich ones, where each additional person begets much larger volumes of greenhouse gases (Cafaro, 2012).

To this end, an unforeseen and surprising perspective is beginning to draw sober examination in both academic and popular discussions of climate change ethics. In consonance with this view, having a child is a major contributor to climate change. The logical result here is that everyone on Earth ought to contemplate having fewer children (Rieder, 2017).

The criticalness of climate change vindicates this uneasy conversation. In this case, this means humanity needs to stop pretending that the decision to have children doesn't have environmental and ethical consequences. In this view of responsibility, one can admit that having many children is wrong, or at least morally suspect, for standard environmental reasons. Having a child imposes high emissions on the world, while the parents get the benefit. So like with any high-cost luxury, we should limit our indulgence (Rieder, 2017).

In the seminal work *Reproduction and the carbon legacies of individuals* (2009) Paul Murtaugh and Michael Schlax examine the relationship between population growth and global warming, and determined that the "carbon legacy" of just one child can generate 20 times more greenhouse gas than a person will spare by driving a high-mileage car, recycling, using energy-efficient appliances, and light bulbs, etc. To this effect, each child born in the United States will charge up about 9,441 metric tons of carbon dioxide to the carbon legacy of an average parent (Center for Biological Diversity, 2010). Ultimately, the study (2009) concludes, "Clearly, the potential savings from reduced reproduction are huge compared to the saving that can be achieved by changes in lifestyle."

Commenting on their work (Center for Biological Diversity, 2010), Paul Murtaugh, co-author of the study reveals that:

> "In discussions about climate change, we tend to focus on the carbon emissions of an individual over his or her lifetime. Those are important issues and it's essential that they should be considered. But an added challenge facing us is continuing population growth and increasing global consumption of resources. . . . Future growth amplifies the consequences of people's reproductive choices today, the same way that compound interest amplifies a bank balance."

Reporting on the study, *The New York Times* (Galbraith, 2009) advances a theoretical but very real thought experiment:

> "Take for example, a hypothetical American woman who switches to a more fuel-efficient car, drives less, recycles, installs more efficient light bulbs, and replaces her refrigerator and windows with energy-saving models. If she has two children, the researchers found, her carbon legacy would eventually rise to nearly forty times what she had saved by those actions."

Procreation, nonetheless, isn't quite like all the other gratuitous and inessential carbon-emitting activities that most of us undertake, such as driving for pleasure, taking vacations, using electricity to watch television or charging our tech equipment. Conceiving another person has instantaneous, high-emissions ramifications – like buying diapers, furniture, wash extra clothes, sometimes moving to a bigger house, buying a larger car, purchasing more food, etc. – moreover, procreating has a *carbon legacy,* in that there is now a new person, who will become a consumer and emitter in his or her own right, and conceivably beget more people (Rieder, 2016).

This wisdom ushered Paul Murtaugh and Michael Schlax to elaborate on the basic proposition that a person is accountable for the carbon emissions of his or her descendants. Their simple equation goes as follow:

$\mathbf{(1/2)^n}$, where *n* represents the number of generations from the individual in question.

To put it another way, a mother and father are each constrained by one-half of the emissions of their offspring $(1/2)^1$, and ¼ of the emissions of their grandchildren $(1/2)^2$ etc (Murtaugh & Schlax, 2009). With access to the fertility rate of a given country and its per-capita rate of carbon emissions at a time *t,* it is possible to gauge the total carbon emissions for which one ancestor is "responsible" (Rieder, 2016).

Murtaugh and Schlax appraised the average carbon legacies with medium-variant fertility rates for the constant-emission scenario and a vertical line connecting the estimates for the optimistic and pessimistic emission scenarios (figure 6.15). Each legacy was the sum of the 2005 fertility rate, plus the weighted emissions of her descendants, assuming all future reproduction remained the same (Rieder, 2016). The range of values was tremendous: under the constant-emission scenario, the legacy of a United States female (18,500 t) is two orders of magnitude more ponderous than that of a female from Bangladesh (136 t) (Murtaugh & Schlax, 2009).

Finally, Murtaugh and Schlax (2009) appraised the carbon legacy of procreation and their calculations demonstrate that, on the constant-emissions scenario, each child than an individual has figures in about 9441 metric tons of carbon dioxide to the parent's carbon footprint, which is 5.7 times the lifetime average emissions of an American's non-procreative activities (Rieder, 2016).

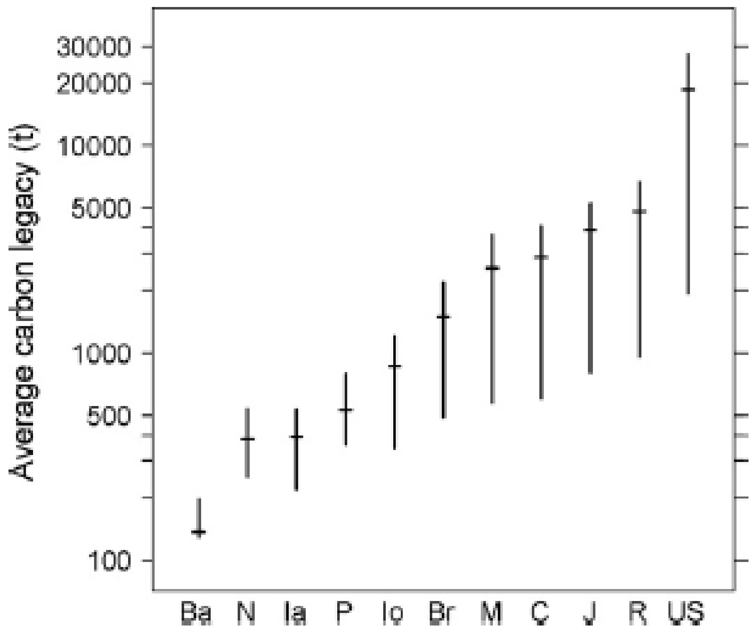


Figure 6.15: Average carbon legacies (log scale) with medium-variant fertility rates for the constant-emission scenario (+), with a vertical line connecting the estimates for the optimistic and pessimistic emission scenarios. The number of children borne by the ancestral female follows the 2005 fertility rate in her home country. Retrieved from Murtaugh & Schlax, 2009.

Most people are shocked and appalled by these numbers, but on contemplation, they shouldn't be. Humans are GHG emitters and until the economy is completely decarbonized we can foresee this trend to extend into the future. So while a trans-Atlantic flight has negative repercussions for the environment, these are one-time costs. Rieder concludes: “When I procreate, I stand on top of an iceberg of future emissions as my family tree branches into the future” (Rieder, 2016).

Succeeding Murtaugh and Schlax’s research, Seth Wynes and Kimberly A. Nicholas (2017) have clearly determined that the greatest impact an individual can have in battling the advances of climate change is by having one fewer child (Carrington, 2017b). Figure 6.16 illustrates the implications of their findings, and the overall discrepancy in the different behaviours one can conduct throughout one’s life (as I had previously given some context and examined these matters in the segments A Good Life for All? and The Ship that Sailed by the Water Under the Bridge), the authors highlight that **per capita emissions must reach the 2.1tCO_2e** by 2050 under the Paris Climate Accord, if warming of the planet is to be kept below 2ºC (Girod, van Vuuren & Hertwich, 2013). As previously examined, per capita carbon emissions are in the order of 16 tonnes in the US and Australia, and around 7 in the UK. Kimberly Nicholas, from Lund University in Sweden and co-author of the research, said in an interview for *The Guardian* (Carrington, 2017b):

> “That’s obviously a really big change and we wanted to show that individuals have an opportunity to be a part of that.”

Their findings surmise that an individual who lives car-free will save roughly 2.4 tonnes a year, bypassing a transatlantic flight amounts to another 1.6 tonnes, while becoming vegetarian economizes about 0.8 tonnes (Carrington, 2017b). Evidently, if one spends the entire year recycling, riding a bike, having a vegetarian diet, and buying green energy, but then takes one intercontinental vacation, that individual will exhaust their personal carbon budget, without accounting for any other emissions.

Wynes and Nicholas emphasize the relevance of focusing our efforts on the high-impact actions such as living car-free (1000-5300 tCO_2e/year), avoiding lengthy air travel (700-2800 tCO_2e/year), buying green energy (<100-2500 tCO_2e/year), buying a more efficient car (1190 tCO_2e/year), eating a plant-based diet (300-1600 tCO_2e/year) and having one fewer child (23700-117700 tCO_2e/year) (Wynes & Nicholas, 2017). It is pertinent to point out that the values in figure 6.16 are the median of the ones presented just now, which shows the spectrum of *per capita* consumption depending on the country analyzed. The immense interval of the carbon footprint of *having one fewer child,* that goes from 23700 to 117700 tCO_2e/year shows just how much the wealth of an individual can alter his/her carbon footprint.

Nicholas still argues for the continuation of low-impact actions, such as recycling:

> “All of those are good things to do. But they are more of a beginning than an end. They are certainly not sufficient to tackle the scale of the climate challenge that we face” (Carrington, 2017b).

In his book, *Toward a Small Family Ethic - How Overpopulation and Climate Change are Affecting the Morality of Procreation* (2016)*,* Travis Rieder expounds the moral rationale behind the relevance and weight of an ethic to attenuate one’s carbon footprint even if the act itself does not have a *significant difference.* Rieder clarifies:

> *“*We are sometimes obligated to refrain from an act that doesn’t significantly cause the likely harms of everyone’s performing that act, the *relative* contribution that one’s act makes to those harms may yet strengthen or weaken the obligation. If I am obligated to minimize my carbon footprint, then I have a stronger obligation not to fly across the Atlantic for a weekend than to unplug my television when I’m not using it.”

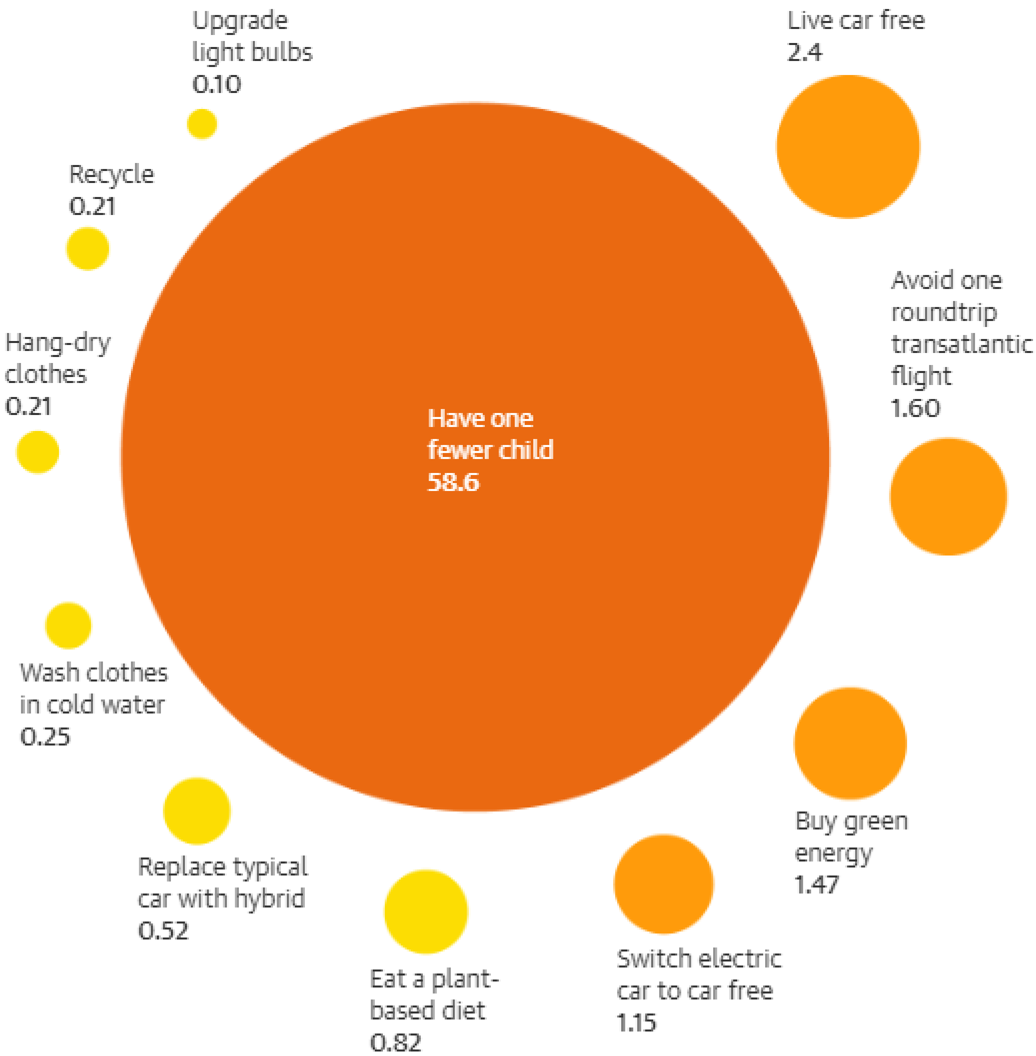


Figure 6.16: CO_2 saving through a range of different actions. Having one fewer child will save 58.6 tonnes of CO_2-equivalent per year. Source: Wynes & Nicholas, 2017, Environmental Research Letters. Retrieved from Carrington, 2017.

He completes his premise with the relevance that the proclivity for human begetting acquires in the climate change debate:

> "Since procreation is likely the most carbon-intensive activity that most of us could engage, as a result, if there are any individual moral obligations due to climate change, these would likely include procreation-limiting obligations."

When scrutinizing the scale of the challenge these 9441 metric tons of CO_2 per child of carbon legacy or the 23700-117700 tCO_2e/year (±58.6) are part of the global emissions of humanity each year, roughly 30 billion tons of CO_2 (Co2.earth, 2018), considering further still the all-time anthropogenic carbon budget – the volume that humanity can emit before raising the global average temperature by 2ºC – is about a trillion tons, and we have already run through about 60 percent (Trillionth Tonne, 2018), and that recent models foresee that levels of GHG will reach concentration of 450 ppm (about the same as the trillion tons) will be reached in 2030 under business as usual scenarios (IPCC, 2014a), our predicament suddenly acquires a very dire and critical status (Hickey et al, 2016).

By allowing such a scenario to materialize, its not just humans that will take a toll from temperature alterations. If the global temperature exceeds 3.5ºC and locks us in a calamitous scenario of roughly 4ºC (prediction under 'business as usual' by the IPCC, 2007), between 40 and 70 percent of all Earth's species may be driven to annihilation by the end of the century.

The new geological epoch: the Anthropocene, that has been marked by the increased demand and impacts on the planet concocted by a rise in numbers and affluence of the human species (Zalasiewicz, Williams, Steffen & Crutzen, 2010) has permitted a self-indulgent and pernicious confiscation of the resources of the Earth that has resulted in what can only be represented as interspecies genocide (Gottlieb, 2003). It is past time to recognize the massive transgression toward other species represented by climate change and other human onslaughts on the biosphere and to reform our environmental ethics and behavior accordingly (Foreman, 2011).

As Paul Ehrlich (2017) asserts:

> "The more people there are, the more products of nature they demand to meet their needs and wants: timber, seafood, meat, gas, oil, metal ores, rare earths and rare animals to eat or to use for medicinal purposes. Human demands cause both habitat destruction and outright extermination of wildlife. So when you watch the expansion of the human enterprise; when you see buildings springing up; when you settle down to dinner at home or in a restaurant; you are observing (and often participating in) the sixth mass extinction"

Given these points when considering the billions of humans on the planet, the broadening affluence of many, and the scale of the harms to humans (millions – perhaps billions will be tarnished by climate change), and to non-human life, procreation habits also rise to a status of paramount pertinency due to the fact that there is no single act that one can refrain from that will have such a high environmental impact as abstaining from having a child, which means that procreation is environmentally *significant* (Hickey et al, 2016).

Equally so, the inflictions of climate change are the outcome of a massive assemblage of unassociated acts by uncoordinated individuals, so in the framework of a gargantuan composite action that harms, we might assume that our duty is not to make a significant difference (Rieder, 2016).

In other words, with the intricacy of the climate system, and the way in which our minuscule, individual contributions of GHG get scattered throughout an extensive system, it purports that they may end up in a natural carbon sink, just through sheer circumstance, in which case personal emissions don't get to causally redound the harms of climate change (since one's emissions aren't warming the atmosphere). Still and all, even if one is fortuitous, and their emissions get subtracted out of the atmosphere by a natural carbon sink such as a forest or the world's oceans, the emissions have just used a small fraction of the earth's available carbon sinks, forcing out other emissions into the atmosphere. Correspondingly, not all ways of withdrawing carbon from the atmosphere are equal: the forest that consumes CO_2 is a somewhat short-term carbon sink, by way that the death of the trees in the future will vent the gas back into the atmosphere; and the ocean is becoming more acidic as it sponges up more carbon dioxide (Rieder, 2016).

By and large, the richest 10 percent of people generating half of Earth's climate-harming fossil-fuel emissions, the underprivileged and destitute half supplement a mere 10 percent (figure 6.17), British charity Oxfam contends in their report (Oxfam International, 2015). The report also avouches than an average person among the richest one percent originates 175 times more carbon than his or her equivalent among the bottom 10 percent. Tim Gore, climate policy head of Oxfam upholds:

"Rich, high emitters should be held accountable for their emissions, no matter where they live" (AFP, 2015).

This not only speaks about inequality but also about something even harder to address, which is the fact of existence that in a world in which everyone is presumed to aspire to high incomes, can we avoid turning the Earth, on which all prosperity is contingent on, into a dust ball? (Monbiot, 2017a).

On the other hand, and despite the fact that it is often asserted that the expanding GHG emissions are caused by the disproportionate superfluous consumption of the developing world, population forecasts indicate that the net production of GHG could become equivalent between the developed world, due to the immense consumption of the former and the Brobdingnagian population of the latter (Mora, 2014; Bongaarts, 1992).

But despite their personal or collective contributions, another essential dictum that all climate change ethicists seem to recognize is that the indigent of the world should not be harmed: either by sanctioning too much climate change, or by immorally encumbering them in the attempt to mitigate climate change (Cafaro, 2012).

Simon Caney articulates this consensus view in a palpable way, in the language of human rights. According to Caney (2010):

"Human rights specify minimum moral thresholds to which all individuals are entitled, simply by virtue of their humanity, and which override all other moral [and other] values."

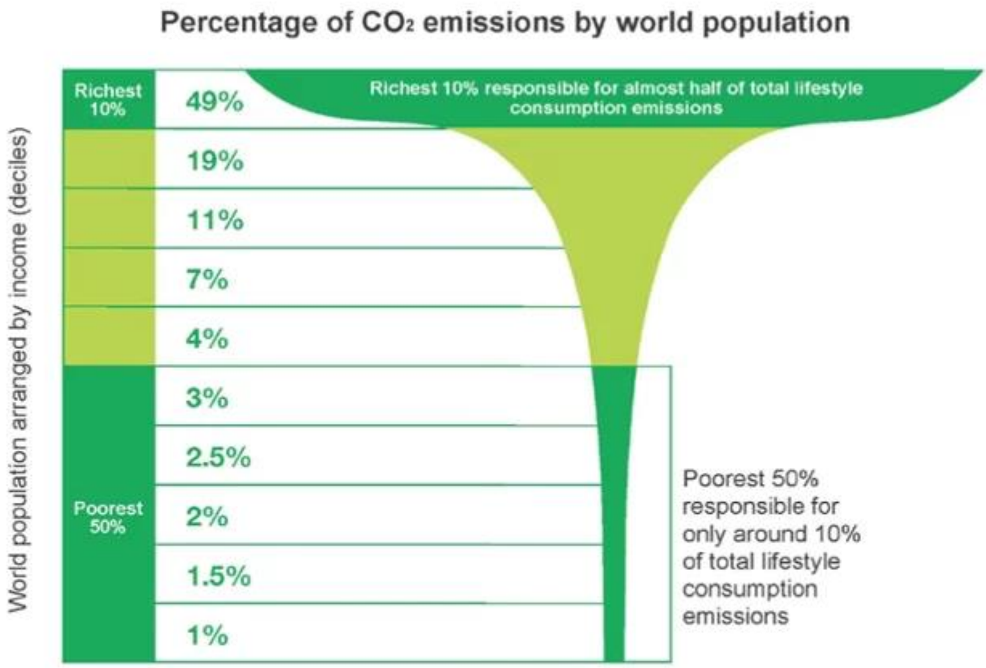


Figure 6.17: Global income deciles and associated lifestyle consumption emissions. Photograph (Oxfam International, 2015). Source: (AFP, 2015).

Among the most fundamental and sacrosanct human rights are the right to life, the right to health (inferred as a right not to have one's health sabotaged and impaired by the avoidable and avertible actions of others) and the right to subsistence. However, as climate change advances, it jeopardizes the life, health and subsistence of many people globally, notably among the poor (Cafaro, 2012). Owing to this, individual actions and governmental policies today which strengthen climate change, or cripple endeavours to fulfill the confrontation, are morally unpalatable and reprehensible, as being conducive to human rights violations (Caney, 2010).

With this intention, Cafaro's second substantive pronouncement goes as follow: "***This moral consensus regarding the need to avoid the massive human rights violations threatened by catastrophic climate change necessarily demands serious efforts to reverse human population growth***." Granted that the rights to life, health and subsistence legitimize telling individuals not to drive high-consumption and polluting automobiles, take superfluous plane trips, build colossal houses and spend outrageous amounts of energy to cool and warm them, or broadly generate excessive greenhouse gas emissions, they also vindicate admonish individuals not to have six children - wherever they live, in the developed or the developing worlds. If these rights concede us to expound in an assured manner that governments should institute carbon taxes, fund alternative energy consumption and contract greenhouse gas emissions, then they also legitimize instructing governments that they should introduce family planning programs, reform tax policies to dissuade large families, and legalize abortion, for strictly the same reason. In pursuance of the guardianship of human rights to life, health and subsistence in the congested world we have concocted, we must circumscribe redundant and superfluous consumption *as well as* unbounded and intemperate procreation. Both steps are paramount, since one without the other cannot disentangle the problem of growing emissions and the plethora of repercussions that takes place alongside it (Cafaro, 2012).

To put this pronouncement in another light, the crucial point is that people who are over procreating, *wherever they live,* are jeopardizing the human rights of future people. Countries with fertility rates far exceeding replacement are over procreators begetting people who are reasoned to experience extreme weather events, droughts, and lack of food in the decades to come (Cafaro, 2012).

In the *Peak Prosperity's* podcast (Martenson, 2018), Bill Ryerson, president of the Population Institute asserts that:

> "A new Egypt is added to the world's population every year (roughly 83 million people) and all of those people have needs for food, shelter, housing and clothing and when you look at their environmental impact the number of new people is a major driver of loss of biodiversity and it is a significant factor in climate change. Now, I have heard a lot of environmentalists say that population doesn't matter, because the real culprits are the high consumers of the West to which everyone has a huge carbon footprint. But in fact, if you take the median projection by the UN Population Division, from now to 2050, an additional 2.5 billion and multiply that times, admittedly low per capita carbon emissions of a citizen in the developing world, it is the climate equivalent of adding two United States to the planet."

Ultimately, until the world's population ceases to grow, there will be no stop to the need to squeeze individual's consumption of fossil fuels and other natural resources, which indulges this anthropogenic climate change. In the event that the low-consuming billions of the developing world acquire the consumption levels of Americans, Australians, South Koreans or Europeans, for example, with similar apathy for the environment - as they have as much right to do so, in a humanist sense, probably not so much in an ecological ethical sense (to clarify, in that regard nobody would). These facts imply that the advancing ecological catastrophe will be of a scale that will put to the test the much-acclaimed ingenuity of Man, and it will most likely not be enough (Engelman, 2009).

The reality that we as a species need to grapple with it that population growth constantly pressures the sequela of any level of individual consumption to a higher plateau since reductions in individual consumption can always be overwhelmed by an augmentation in population. Ultimately, we have to get a grip and immediately introduce action on both fronts, since that might be our best and crucial key to long-term environmental sustainability (Engelman, 2009).

As I have attempted to demonstrate throughout this work, anthropogenic climate change is a predicament of our own making. It is the culmination of every individual's presence and activities on this planet, even though the share of implication is ostensibly pending to the richest nations. Notwithstanding, that does not stand as a viable rationalization and legitimacy for the less developed nations to maintain high fertility rates. From what has been uttered and articulated until this point in the Atlas, my analysis stands as following:

1. Over-developed nations are condemned (rapidly developing ones such as India, for example, are usually not included) for their proclivity to generate and exudate colossal volumes of CO_2 and other greenhouse gases (GHG's) that have wide-reaching and perversive effects. Identically, the tremendous ecological footprints practised in these nations are directly linked to the most substantial apportionment of anthropogenic activity responsible for climate change. Equally important, these nations are also disparaged for their own economical conduct that converges upon extractive capitalism and the cult of perpetual economic growth, which is centered on the notion of always increasing per capita income and nation-wide GDP. This system is what is driving much of the relentless and ravenous consumption patterns of the increasingly affluent human population. Moreover, individuals in the developing world aspire to acquire the same wealth and material abundance. At this point, we can safely infer that raising the number of individuals with high purchasing capability will excessively impair humanity's effort to contain the advances of climate change. These scenarios account for a substantial share of our anthropogenic climate change as well as the calamity inflicted on our ecosystems and the whole of biodiversity.
2. Developing nations are reprehended for their towering fertility rates, which ultimately perpetuate conditions of poverty, misery, and regional and local ecological devastation, by surpassing carrying capacity quotas of available resources and preventing human flourishing. Although a plethora of international commitments, pledges and assurances have been sworn by developing countries to curb their emissions, as they attempt their metamorphosis into developed status, no global action has been taken to pressure countries to regulate their procreative behaviors. If the dominant narrative stems from rich countries being responsible for actions that transcend their own national confines (e.g. greenhouse gases), so too, developing nations must be held morally, environmentally and socially accountable by actions that have consequences not delimited by their own frontiers. In other words, by our own nature, humans are intrinsically programmed to relinquish a given territory to seek distant shores that might provide for a better condition in life, and it is hardly possible to find a justifiable line of reasoning to deny that human personal thriving. What this means is that nations with high fertility rates are not being held liable for begetting new humans, which might migrate due to an amalgamation of reasons, to a developed country and adopt the average lifestyle in the process, therefore reinforcing the blameworthiness and answerability of the developed world, with no recrimination and implication of their own.

3. All things considered, when we have to weigh in on the accountability of anthropogenic climate matters between the developed nations and the developing countries, we can point to their conspicuous discrepancies. The developed world has low fertility rates but an extensive record of GHG emissions. On the other hand, the developing world, in general, has a much higher fertility rate - as well as an overall bigger share of population - and minuscule background and *direct* (inside borders activity, without accounting for migration of individuals to the developed world) GHG contribution. Under these circumstances, if we had to compare the 'sins' of both sides, we would have GHG emissions on one side and the unchecked human proliferation on the other. The real problem lies in the fact, that only the latter have human rights, aspirations, ambitions, aims and whims that need to be safeguarded and assured. So in reality, I would argue, this is really an asymmetrical dilemma. While all eyes are set on the much-needed metamorphosis of the biggest GHG polluters, nations marked by elevated fertility/population size have yet to be held responsible by the international community and continue uncontested, and under no contractual or statutory obligation to alter their internal population dynamics.

Finally, and equally important, there is a need to stress that there is no such thing as poverty being intrinsically associated with "environmentally friendly" habits. In much of the world, those who are wrestling to find opportunities in the formal economy will turn to extractivist activities to make a living for themselves and their families (Harrison, 2011; Duffy & St John, 2013) (an example of this is delineated in No Sanctuary, where the hunt for bushmeat and illegal market of species is instigating the extinction of species), often with calamitous results: empty forests where most wildlife has been eradicated (Pfaff et al, 2008); unchecked deforestation for wood fuel and growing food (McCarthy, 2011; Hosonuma et al, 2012); and overfished rivers and bays (Stobutzki, Silvestre & Garces, 2006; Keskar, Raghavan, Kumkar, Padhye, Dahanukar, 2017). Moreover, it is evident that some environments are better able to provide for larger human populations than others. Poverty-stricken, rapidly swelling populations are too often found in drought-prone, resource-poor, infirm environments such as the Sahel and the Horn of Africa. In such areas, mere subsistence activities are enough to overexploit natural resources, prompting desertification and worsening the already chronic food insecurity (United Nations Economic Commission for Africa, 2007; Lifland, 2012).

Under these circumstances, the only humane way of pragmatically dealing with the devastating and ruinous repercussions of climate change and all that is linked with human existence is by excluding such an existence to begin with. By decreasing fertility rates worldwide we can compassionately reduce the number of passengers on this planet, preventing their needs from ever existing, focusing our efforts on the humans already here and in the restoration of the natural world.

One way of achieving such a goal has taken the form of a proposal to the United Nations, so as to lay the foundations for a Framework Convention on Population Growth. So far, over 30 organizations in conjunction with hundreds of invididuals – scientists, academics, activists, and other attentive citizens – speaking for 15 countries across 5 continents have articulated their approval for this initiative (Harding, 2018). The reader can find more information including the solutions proposed and why such a treaty is required through the United Nations, here.

Up next, I turn the page from this much-needed discussion of population and climate ethics, and resume the analysis of climate change repercussions, this time aiming attention at the most conspicuous of symptoms: extreme weather events.

In Extremis

- Escalation and Intensification of Natural Phenomena -

"When it comes to tackling climate change and extreme weather, we ignore population at our peril."

- Emma Woods, Royal Society's Head of Policy

"Climate change is a global problem. The planet is warming because of the growing level of greenhouse gas emissions from human activity. If this trend continues, truly catastrophic consequences are likely to ensue from rising sea levels, to reduced water availability, to more heat waves and fires."

- Malcolm Turnbull

"Who is afraid of the big bad wolf?" the little pigs sing in the Disney classic (1933), as the carnivorous *Canis lupus* blows their houses with winds unrivalled even by Category 5 hurricanes. In the end, the piglets find shelter in a house made of bricks and the wolf is forced to forfeit its tempestuous strategy while either exercising its choice for less industrious and laborious pigs or going vegan and probably perishing prematurely. In either case, this children's fable is meant to depict how a concoction of ingenuity, hard work, resourcefulness and lots of singing will keep any villainous character or situation at bay. While that might have been the case almost a hundred years ago, evolution has run its course and endowed the once-defeat wolf with the potency and intensity to not just bulldoze the brick house, but flatten out entire cities. In an unfortunate turn of events, the wolf still misses another protein meal, as the landscape is denuded and devoid of most of its life, after such a sudden and excessive manifestation.

As the reader might have guessed by now, the wolf in this parable is anthropogenic climate change, and the brick house symbolizes not just human cleverness and inventiveness but also the reliance that our species has devoted to technological resolutions. Correspondingly, in the original narrative, the first two pigs entrusted their safety to straw and stick houses that ended up collapsing in the face of an event that they did not fully understand or envisaged. That is our contemporaneous plight, to keep charging up the intensity and frequency of extreme weather events through our Brobdingnagian numbers and carbon-imbued lifestyles, only to find out that our houses are no match for heavy rainfall, storms, cyclones and floods, as well as heat waves, extreme droughts, sand and dust storms, desertification and the loss of productive farmland. The snow and ice that melt at expeditious rhythms, glaciers that are retreating, permafrost that is evanescing, sea levels are that are rising and wildfires that are becoming more regular and more extreme. The pigs were the lucky ones.

Climate change can crystallize itself in slow-onset environmental deterioration, such as the melting of polar ice caps and rising sea levels, heightened salinization of groundwater and soil, droughts and desertification from modernized and reconditioned precipitation levels. It can also assume a pattern of sudden-onset disasters including storms and floods, heat waves, wildfires, windstorms, tropical cyclones, storm surges, extreme temperatures and landslides, or by health epidemics and insect outbreaks, directly associated to meteorological and hydrological circumstances (Guha-Sapir, Hoyois, Wallemacq & Below, 2017; WMO, CRED & UCL, 2014).

The first thing to remember is that the number of weather-related natural disasters has risen on all continents since 1980 (Heim, 2015). From 1970 to 2012 there were 8,835 disasters related to climate, of which 3496 took place between 2001 and 2010. All of them put together caused the deaths of 1.94 million lives and economic losses of US$ 2.4 trillion. Specifically, storms and floods justify 79 percent of the total number of disasters due to weather, water and climate extremes and precipitated 54 percent of deaths and 84 percent of economic losses. Moreover, droughts, provoked 35 percent of deaths, mainly on the grounds of the severe African droughts of 1975, 1983 and 1984 (WMO et al, 2014).

And then there was 2016. The extreme weather events that were imprinted on that year set several records on the entire globe, such as the record global heat, the heat across Asia as well as the marine heat wave across the coast of Alaska, among others. But while those results were novel, they were not unanticipated and unforeseen. Climate scientists have been adumbrating that in the course of time, anthropogenic influence would become extensive and imbued enough on this planet to the point that it would push events beyond the bounds of natural variability alone (Herring et al, 2018).

In the preceding six years to the 2018-edition of the annual special edition of the *Bulletin of the American Meteorological Society* (BAMS), over 130 peer-reviewed papers evaluating the potential connection between extreme weather had been presented. Somewhere around 89 papers recognized that climate change had shifted the odds of an event materializing. Prior to the 2018-issue, however, none had singled out that human pressure and significance was a vital factor in the occurrence of the event. That changed in the 2018-issue when the report encompassed three lines of research that consummate that the extreme magnitude of a specific weather event was not conceivable without the ascendancy of human-caused climate change (Herring et al, 2018):

- A paper examining the 2016 global heat record by NOAA scientist Thomas Knutson and colleagues (Knutson, Kam, Zeng & Wittenberg, 2018) brought down the curtain that record global warmth “was only possible due to substantial centennial-scale human-caused warming.”
- Likewise, a study of the record heat over Asia persuaded Yukiko Imada of the Japanese Meteorological Agency and colleagues (Imada et al, 2018) that the extreme warmth across Asia in 2016 “would not have been possible without climate change.”
- Coupled with these two papers, a team led by John Walsh (Walsh et al, 2018) of the University of Alaska ascertained that a large, incessant area of incongruous warm ocean water off the coast of Alaska (usually referenced as “the Blob”) established “no instances of 2016-like anomalies in the preindustrial climate” for sea surface temperatures in the Bering Sea.

Comparatively, in the special annual edition of the *Bulletin of the American Meteorological Society* (Herring et al, 2018), the report claimed that some weather events would have been downright inconceivable without the warming pressure of humanity’s greenhouse-gas emissions (Nature, 2017). The research focused on 2016, the hottest year on record, so far. The first study mentioned above, led by scientists at the US National Oceanic and Atmospheric

Administration (NOAA), matched the temperature record to a simulated baseline climate without human greenhouse-gas emissions (Knutson et al, 2018). In baseline simulations of some 24,000 years of weather from seven climate models, nothing like the record warmth of 2016 ever transpired. Greenhouse-gas emissions, essentially those from fossil-fuel use, are imperative for this kind of heat. Not to mention, the paper demonstrates that greenhouse gases began to thrust the climate outside the realm of natural variability around 1980 (Nature, 2017).

From what has been perceived throughout this chapter, the planet has gone through drastic changes during its existence. Similarly, models prognosticating future changes have divergent levels of climate diversity. For this reason, the IPCC has conceived scenarios for the magnitude of climate change based on distinctive levels of atmospheric greenhouse gases. These scenarios fluctuate conspicuously, gauging an upsurge in global mean temperature from 0.3ºC to 4.8ºC by 2100. Without resolutions, complex international networks and institutions that can follow up and supervise progress as well as dictating and prescribing actions and accountability for nations to that fail to live up to the required pledges to mitigate climate change, it is estimated that the global mean temperature rise could be between 2.5ºC and 7.8ºC (IPCC, 2014a).

These scenarios consolidate a far-reaching range of different factors, including feedback processes triggered by warming. Largely, this progression will persist and climate extremes and disasters will become more frequent and more forceful, which translates into a considerable rise in temperature extremes, a surge in maximum wind speed of tropical cyclones, an accretion in heavy precipitation, augmentation in extreme coastal high-water levels and amplification and persistence of droughts (IPCC, 2012; Thompson, 2011).

Crucial reverberations of global warming can translate in disturbances into precipitation patterns and divergences in the hydrological systems, resulting in both more rain and more drought. For example, one foreseeable effect of climate change will be in precipitation intensity: a larger volume of rain will fall in a shorter amount of time (Van der Wiel et al, 2017). This is mainly caused due to the lower atmosphere becoming warmer, evaporation rates augmenting, culminating in the circulation of more moisture throughout the troposphere (lower atmosphere), that ends up in increased precipitation events mainly over land areas. Moreover, due to a rise in temperatures, more precipitation falls in the form of rain instead of snow. These changes are represented in figure 6.18 (NASA Earth Observatory, 2010).

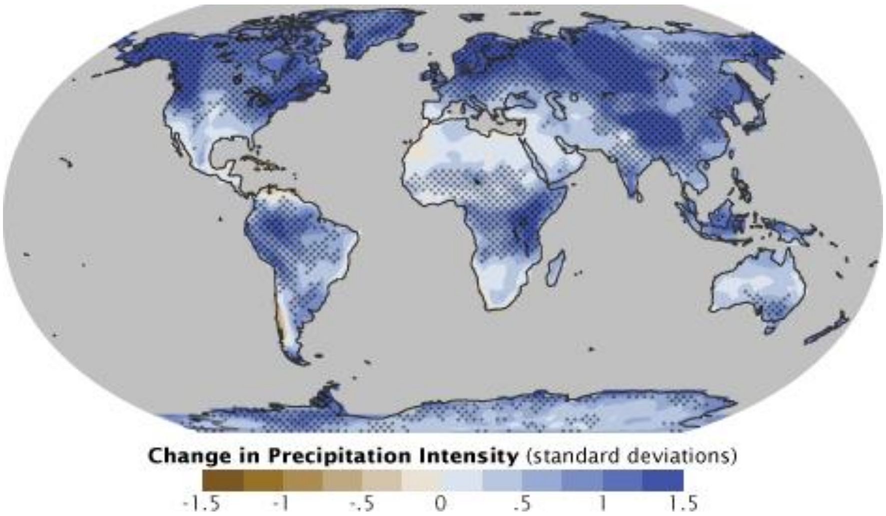


Figure 6.18: Change in precipitation intensity. Map adapted from the IPCC Fourth Assessment Report. Retrieved from NASA Earth Observatory, 2010

As an illustration, in mid-August 2016, a slow-moving storm released more than two feet of rain in parts of southern Louisiana (Liberto, 2016a). An analysis (Liberto, 2016b) found that the statistical return period for extreme rain events of that magnitude had contracted from an average of 50 years to 30 years due to global warming from greenhouse gases. Additionally, the amount of rain that would have fallen during a typical 30-year event in 1900 would have been 10 percent less than an analogous today (Figure 6.19) (Lindsey, 2016). But by and large, it has been much more strenuous for scientists to identify anthropogenic influence in the attribution of precipitation, due to shorter spatial scales compared with extreme temperature events, for example (WMO, 2018a).

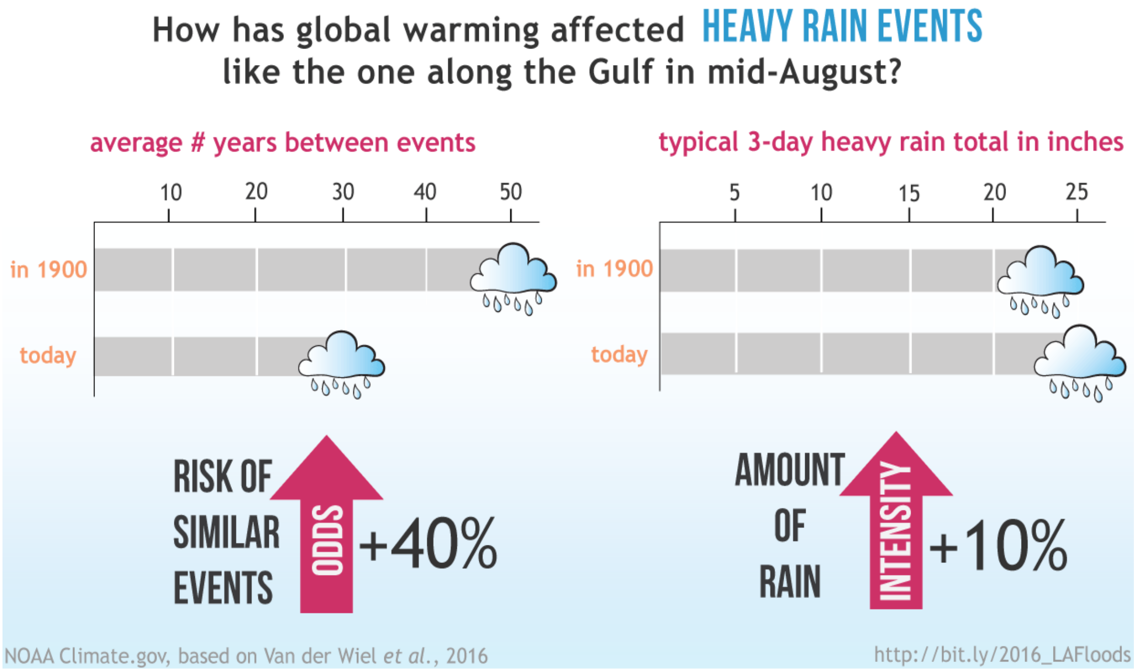


Figure 6.19: Global warming effects on increased probability of extreme weather events, average years between events, and intensity (amount of rain). Source: Climate.gov, based on Van der Wiel et al, 2016. Retrieved from (Lindsey, 2016)

Another very important issue that concerns geodemographics and the intensification and escalation of natural phenomena is linked to the propensity of humans to densely inhabit coastal areas. As a matter of fact, population density is substantially augmented in coastal than in non-coastal areas (Balk et al, 2009; Small & Nicholls, 2003), explaining the apparent reality of having roughly 10 percent of humanity occupying coastal areas with elevations less than 10 m above mean sea level, in spite of these accounting only for 2 percent of the Earth's surface (McGranahan, Balk & Anderson, 2007; Neumann, Vafeidis, Zimmermann & Nicholls, 2015). Moreover, coastal population growth and urbanisation rates are surpassing the demographic development of the interior or backcountry, driven by rapid economic growth and coastward migration (Smith, 2011; McGranahan et al, 2007), which will translate into ever more movement into coastal zones.

Equally important is the fact that most world's megacities are situated in these coastal zones (Brown et al, 2013). The increased interest in coastal zones will most likely continue to materialize into rapid population growth in these areas, with research deducing that by 2030 the global human population inhabiting a Low Elevation Coastal Zone (LECZ) could expand to 880 million (figure 6.20), whereas by 2060 it could reach more than 1.3 billion, what would signify an enlargement of 763 million additional people compared to the situation in 2000 (Neumann et al, 2015).

To point out, the UN's World Cities Report (2016) accounted 1700 cities with at least 300,000 people in them, and 56 percent of these cities were at high risk of exposure to at least of six types of natural disasters: cyclones, droughts, floods, earthquakes, landslides and volcanic eruptions. In a nutshell, this signifies about one in five people on the planet, 1.4 billion people [at current rates]. By following that line of thought, in the World Population Podcast, episode *Tap Dancing Around Overpopulation* (2017) Alan Ware comments:

> "As we continue to grow at 83 million people per year, and over 40 percent of the planet's population lives within 100 km of the coast (Ciesin, 2006) and with a projected sea-level rise of 28-98 cm by 2100 (IPCC, 2014b), that means a lot of people are in danger, especially to sea level rise, hurricanes and as they will become climate refugees, that will have domino effects on the inland cities and towns. When we add that these natural disasters are predicted to be altered by climate change and become more frequent that has all types of more knock-on effects, as we have more densely populated and complex cities, we rely on food from elsewhere and manufactured goods from elsewhere, our global civilization becomes more fragile and less resilient, and adding population to that will only make the problems worse."

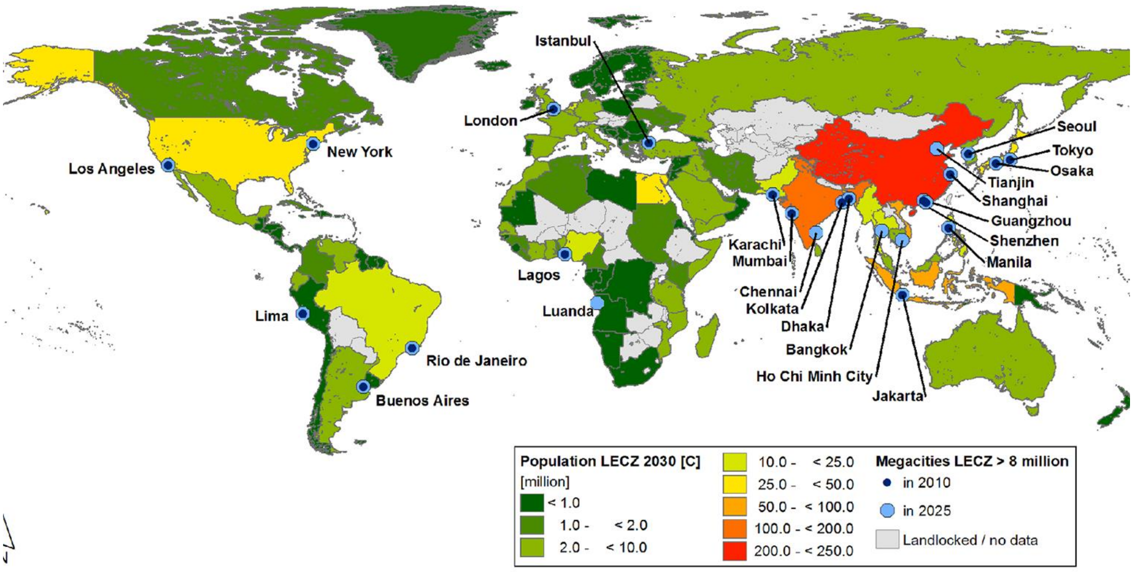


Figure 6.20: LECZ Population in the year 2030 per country for a scenario of 8.7 billion people in 2030. Population estimates (year 2010) and projections (year 2025) for selected megacities (> 8 million people) located in the LECZ were derived from the UN's World Urbanization Prospects: The 2009 Revision. Retrieved from Neumann et al, 2015.

Hurricane Harvey, which flagellated the USA's southern states in August 2017 was the most forceful storm in over a decade (WMO, 2017). It trounced Texas and Louisiana with 27 trillion gallons of rain in only six days (Zarracina & Resnick, 2017). It broke rainfall records (Ryan, 2017), left an estimated 82 people dead (Moravec, 2017) and affected as many as 13 million people (Ryan, 2017). The foreseen economic loss due to Harvey stands at US$75 billion (Sullivan & Gilblom, 2017; Oyedele, 2017).

A study published in the journal *Environmental Research Letters* by Geert Jan van Oldenborgh and colleagues (van Oldenborgh et al, 2018) claimed that Harvey would have released 15 percent less water in the form of precipitation if not for the influence of climate change, and historical rains are now three times more common in the Gulf of Mexico than they used to be a century ago. Moreover, the Expert Team on Climate Impacts on Tropical Cyclones from the World Meteorological Organization (WMO) concurs that rainfall rates linked with Harvey were in all probability made more intense by anthropogenic climate change. Demonstrably, it is due to the water vapor that is held in the atmosphere as a consequence of climate warming (about 7 percent more water vapor per degree Celsius sea surface temperature) (Knutson et al, 2017).

As Kevin Trenberth and colleagues vindicate in *Hurricane Harvey Links to Ocean Heat Content and Climate Change Adaptation* published in the journal *Earth's Future* (Trenberth, Cheng, Jacobs, Zhang and Fasullo, 2018):

> "The relentless increases in global OHC (Ocean Heat Content) that have made 2017 the warmest year on record for the global ocean have consequences for the atmosphere and climate [...] this is especially relevant for hurricanes which feed off of the warm tropical waters and drive strong air-sea interaction that involve the ocean subsurface. Indeed, it can be argued that a role of hurricanes in the climate system is to increase the evaporative cooling of the ocean, thereby acting as a cooling valve for the tropical oceans by means of the strong winds and an order of magnitude in evaporation. That moistens the atmosphere, and the convergence of moisture into a storm not only leads to higher precipitation but also, for certain storms, greater intensity and growth [...] Climate change is expected to increase the activity [of hurricanes] [...] and the risk is clear."

Conclusively, two separate research efforts, the first published in *Geophysical Research Letters* by Mark Risser and Michael Wehner (Risser & Wehner, 2017) and the second by Geert Jan van Oldenborgh and colleagues (van Oldenborgh et al, 2017) in *Environmental Research Letters,* respectively determine that human-induced climate change to all appearances increased Harvey's total rainfall around Houston by at least 19 percent, with the best appraisal of 37 percent; and that climate change increased flooding by roughly 15 percent as well as increasing the odds of witnessing such an extreme event from 1.5 to 5 times, with the baseline being pre-industrial times (Irfan & Resnick, 2018).

Besides Harvey, Hurricane Irma made landfall in the Caribbean just one week later. With winds of up to 185 mph continuing for 37 hours, Irma became the longest-lasting cyclone of such intensity ever (WMO, 2017b). Irma took a toll on an approximated 1.2 million people in the Caribbean before re-intensifying and moving north to the US mainland (BBC News, 2017a). Barbuda in the Caribbean, one of the islands hit the hardest by Irma, experienced 95 percent of its structures damaged and 60 percent of its population made homeless (Humanity Road, 2017). As with Harvey, scientists are resolutely embracing the link of causality between the intensification of Irma and anthropogenic climate change (Shankleman & Nicola, 2017). Anders Levermann, a climate scientist at the Potsdam Institute for Climate Impact Research pointed out in an interview with *Bloomberg*:

> "Unfortunately, the physicality is very clear: Hurricanes get their destructive energy from the warmth of the ocean, and the region's water temperatures are super elevated. Burning coal, oil and gas warms our planet and that way supplies energy for the build-up of ever more powerful tropical storms"(Shankleman & Nicola, 2017).

This occurrence has marked the first time that two category 4 storms have made landfall in the United States in one year (Borenstein, 2017). Hurricanes Harvey and Irma are the reflections of a climate that is changing in an expeditious stretch of time, geologically speaking that is. As previously described, with more heat content on the ocean and with every degree Celsius that the temperature rises, the air can hold 7 percent more water (Knutson et al, 2017). In effect, the global average temperature over land and sea surfaces in July 2017 was the second highest for the month of July in the NOAA global temperature record (NOAA, 2017c). Consequently, there is now at least 4 percent more water vapour in the air than a century ago, forging larger storms than ever before, that prompt higher rainfall rates in hurricanes (Roston, 2017).

Besides the connection from human overpopulation and continuous population growth on the supplement of anthropogenic climate change (Climate Change Ethics), the sheer aggregate of human life and urban development that has surged in Houston, the country's fourth largest city and also the fastest-growing city in the United States with its 2.3 million residents (US Census Bureau, 2017) - 6.5 million, when taking into account the greater Houston metropolitan area (Houston Facts, 2016) - set the city on a collision course with a disaster with much higher consequences (human and economic) than it would have otherwise had (Starkey, 2017).

On this account, Samuel David Brody, director of the Center for Texas Beaches and Shores at Texas A&M Galveston assesses the state of affairs impacting Houston:

> "Houston has a large amount of pavement - impervious surface - put down in a very low-lying, flat area that experiences heavy rainfall events. I tell my students that the problem is complicated; there are lots of underlying factors. There are physical conditions. There's environmental change increasing these heavy rainfall events. There's sea level rise and changing temperatures. All of those small, slow-moving gears are part of this overall problem. The bigger gear moving much faster is human development - the built environment. Houston added 100,000 people last year alone. That sets us up for this potential catastrophe" (Starkey, 2017).

Fortunately, it seems some media outlets quickly realized the link between overpopulated and overdeveloped cities and the reverberations from extreme weather events made worse by climate change. *The New York Times* also weighed in on the necessity to face ecological limits in the piece *A Storm Forces Houston, the Limitless City, to Consider Its Limits* (Fernandez & Fausset, 2017):

> "Though its breakneck development culture and lax regulatory environment have been lauded for giving working people affordable housing - and thus a shot at the American dream - many experts and residents say that the developers' encroachment into the wetlands and prairies that used to serve Houston as natural sponges has inevitably exacerbated the misery that the city is suffering today [...] The post-Harvey rebuilding drama here is bound to unfold as a frontier nation increasingly faces up to limits - as southern and western cities mature, as resources are strained by a growing population, and as climate change, exacerbated by Houston's signature industry, threatens bigger, wetter, ever-more-dangerous storms [...] Harris County, which includes Houston, experienced the highest annual population growth of any county in the United States in eight of the last nine years, according to census data (US Census Bureau, 2017)."

The *Washington Post's Houston's 'Wild West' growth* (Boburg & Reinhard, 2017) and *Bloomberg's Houston Will Recover. But Will it Change?* (Sen, 2017) also subscribed and endorsed the immense population factor, respectively writing:

> "As the population grew, the city expanded, covering fallow land that had served as a natural sponge. Between 1992 and 2010, 30 percent of the surrounding county's coastal prairie wetlands were paved over, according to a 2010 report from Texas A&M (Jacob, Pandian, Lopez & Biggs, 2015). Projects to widen the bayous and build thousands of retention ponds for excess water have not kept pace with the new rooftops, roadways and parking lots needed to accommodate about 150,000 new residents a year, experts say.

> The most recent urban devastation that comes to mind would be Hurricane Katrina. But the growth trajectory of New Orleans in 2005 is not a model for Houston in 2017. The population peak of New Orleans was in 1960, 45 years before Katrina. New Orleans is an important, iconic city for a variety of cultural and industry-related reasons, but it never adopted the model practiced in Houston, Dallas, Atlanta and other Sun Belt metro areas: sprawling, cheap housing and fast population growth. As New Orleans rebuilt, its task was primarily about fixing what had been broken rather than planning for endless population growth."

With population projections indicating at least an addition of at least 4 billion people on this planet until the end of this century, with each one begetting some augmentation to global climate change, we can anticipate that first, there will a breaching of the Paris Climate Accord Goal of keeping global temperatures "well below" 1.5ºC compared with industrial levels; forthwith, sea levels will continue to move upward and invade further; inland storms will have shorter periods and be more devastating, and increased development and population density in coastal and disaster-prone areas, will lead to millions, if not billions of people on the move. Immigration propelled by climate change will be the theme of the last segment of this chapter, which will pave the way for the Exodus chapter, which focuses entirely on immigration.

But before that, there is still more to be said about extreme weather events and climate anomalies, since I have only scratched the surface by examining hurricanes and heavy precipitation occurrences. For the reader to grasp how the globe is changing, it might be informative to run through some of the major phenomenon that took place between 2016 and 2017 (figures 6.21 and 6.22):

- California was saturated in the wettest winter on record (Lin II, 2017), ending years of drought (Lin II & St. John, 2017).
- California's most destructive and largest wildfire season ever, the Tubbs Fire, in Northern California took the lives of 22 people and wrecked more than 5,600 structures (White, 2017; Cal Fire, 2017).
- San Francisco withstood its hottest temperature ever, 106 degrees Fahrenheit (Samenow, 2017), while other parts of the country set records for high-temperature streaks (Masters, 2017).
- 14 places across Oklahoma, Missouri, and Arkansas underwent record-high water levels during floods in April and May (Erdman, 2017) (figure 6.21).
- Hurricane Maria struck Puerto Rico and launched the country in the longest blackout (more than 43 percent of Puerto Ricans didn't have electrical power even after 100 days) (Irfan, 2018). More than 1,000 are likely to have fallen victim to the destructive power of this natural phenomenon (Mazzei, 2017) with a study inflating that number up to 4,645 (Emery, 2018). Moreover, *Maria* also unleashed an extensive ecological debacle with the normalized difference vegetation index (NDVI) - used to portray the scope of vegetation destruction and provide damage severity - depicting a reduction from 0.75 (prior to the hurricane) to 0.56 in Puerto Rico; and in Dominica from 0.91 to 0.70. Values started to increase after about 1.5 months, but were still lower than in previous years, suggesting that full recovery might not happen in a short period of time (Hu & Smith, 2018). Besides impairment to the integrity of the landscape, which directly affects habitat and nurture for non-human species, an array of environmental issues also arises from the occupation of land by humanity and our development. Problems such as polluted drinking water from dead animals and human sewage, closed roads, landslides

that can also pollute water courses, waste disposal and overflowing landfills, mountains of untreated coal-ash (Newkirk II, 2017).

Still, in North America, the Canadian province of British Columbia endured the loss of almost 900,000 hectares - its worst-ever wildfire season in 2017. The unparalleled year has seen 1,029 fires across the province, costing C$315.7 millions to date (Yuzda, 2017).

All things considered, 2017 became the most expensive disaster year in US history, costing nearly $400 billion in reparation and amends (Lowrey, 2017).

In Central America, in September 2016, Hurricane Matthew caused at least 400 deaths and 438 persons were injured in Haiti (Reliefweb, 2016a; BBC News, 2016). After crossing Haiti, Matthew trailed north and went on to wreak havoc in Cuba and the Bahamas, before tracking along the east coast of the United States and making landfall in South Carolina, causing major flooding (WMO, 2016). In 2016, Mexico had its warmest year on record (Meyer, 2017) and then warmer-than-average circumstances overwhelmed much of Mexico throughout the year 2017. Each month from January through October had a temperature deviance greater than +1.0ºC and ranked among the five highest on record (the highest Jan-Oct period since 1971) (NOAA, 2018c).

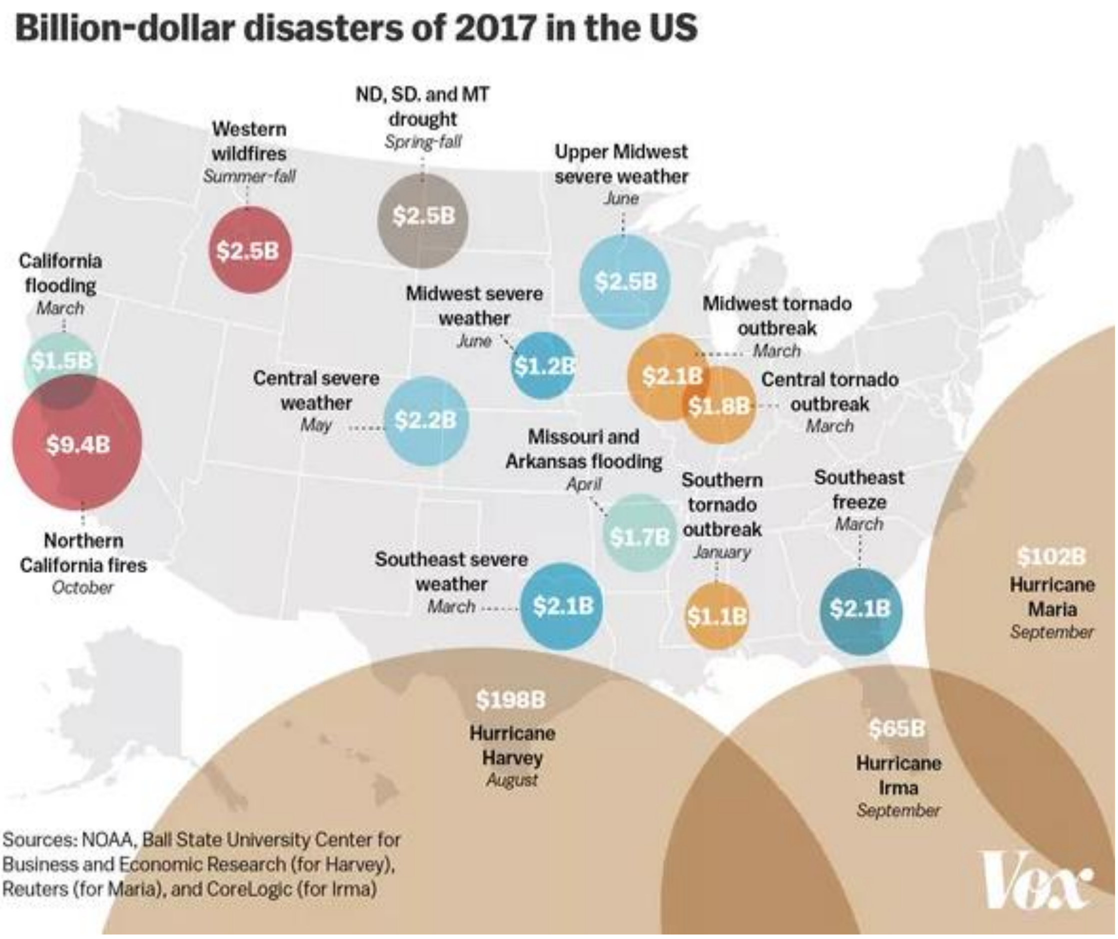


Figure 6.21: Billion-dollar disasters in the US in 2017. The Tubbs Fire in California was not included in this map. Source: NOAA, Ball State University Center for Business and Economic Research (for Harvey, 2017), Reuters (Graham & Respaut, 2017) (for Maria) and CoreLogic (Hussain, Cohn & Merriman, 2017) (for Irma). Retrieved from Irfan & Resnick 2018.

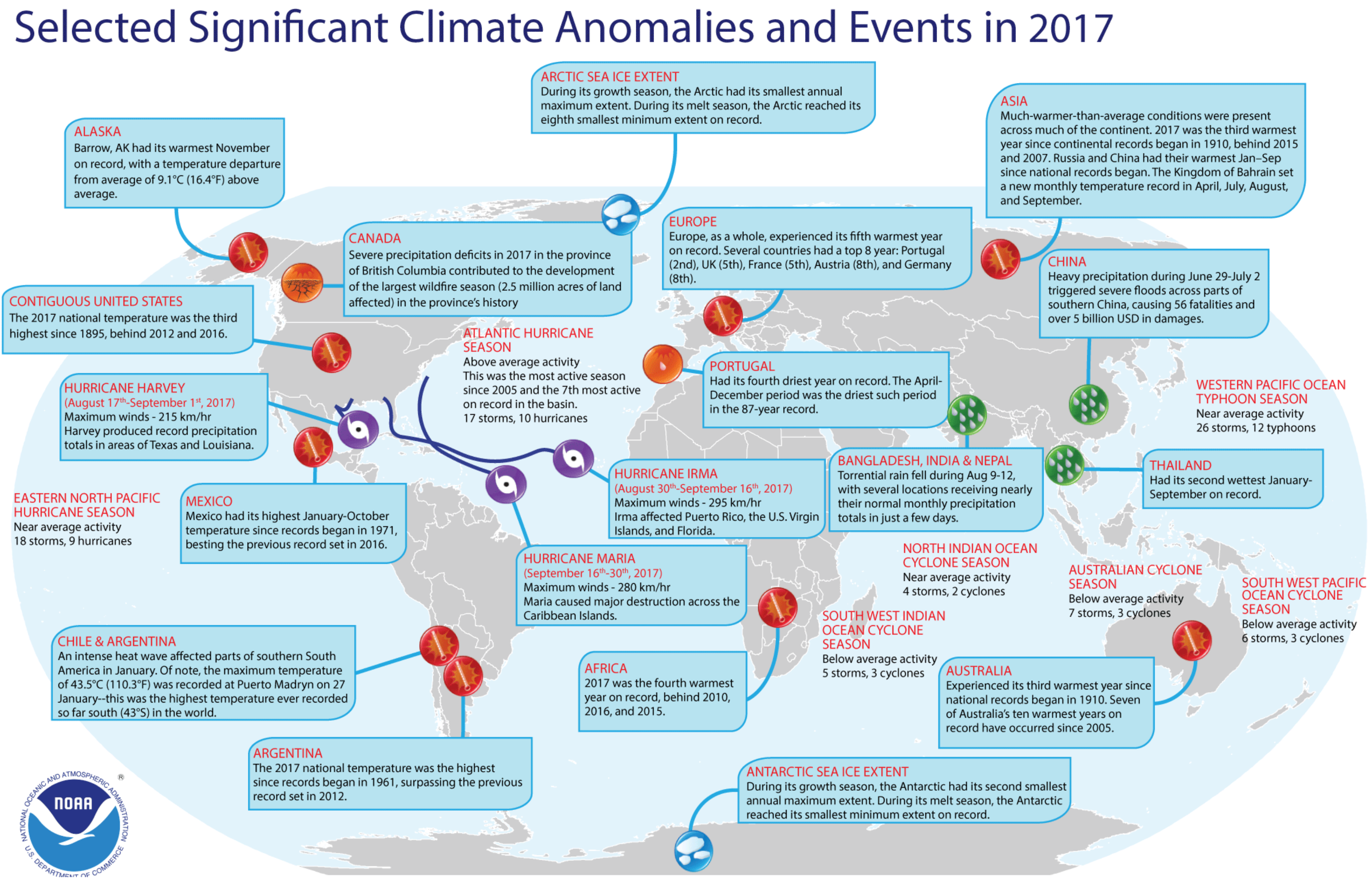


Figure 6.22: Significant Climate Anomalies and Events in 2017. Retrieved from NOAA's National Centers for Environmental Information State of the Climate Reports and the WMO Provisional Status of the Climate in 2017 (NOAA, 2018c)

South America had its second warmest year on record, creeping behind 2015 by 0.16ºC. Additionally, and in accordance to Argentina's Servicio Nacional de Meteorologia (2018), the country underwent an intense heatwave and reached the highest values on record since 1961 at +0.66ºC above average. The value outcompeted the previous record set in 2012 by +0.03ºC.

Similarly, Chile experienced its second warmest summer (December 2016 - February 2017) since records were initiated in 1964, with a deviance in temperature of + 1.02ºC. The month of January was overwhelmingly warm, with a 3.2ºC above the 1981-2010 average, resulting in the warmest January since 1950 (Vicencio et al, 2018).

In Europe, in 2017, cold temperatures plunged Austria into one of its coldest January since 1987, with the Netherlands convulsed by the coldest January since 2010. Then warmer temperatures engulfed the region throughout the rest of the year, with overall, Europe having its fifth highest temperature on record (NOAA, 2018c). To that extent, parts of Southern Europe underwent severe drought, with the situation in Corsica reaching near-record precipitation deficits. The rainfall deficit was conducive to the grim wildfires across the region at the end of July (WMO, 2017c). Identically, Portugal had its second warmest year on record, with a national temperature departure from the average of +1.1ºC, behind the year of 1997, which stands as the nation's record. Moreover, the annual nation maximum temperature was +2.4ºC above the 1971-2000 average and the highest annual maximum temperature since 1931 (NOAA, 2018c).

Important to realize is that 2016 was the hottest year ever measured, following 2014 and 2015, with 2017 ranked as the second warmest since 1880. Presently, as this work is being written, the first drafts of 2018's average monthly temperatures are being released. Globally, the past four years have been the hottest four years on record, and 2018 is until now (July 2018) ascending to stand as the fourth hottest year (Climate Central, 2018) (Figure 6.23). The National Oceanic and Atmospheric Administration (NOAA) concluded that 2017 was the third-warmest year on record (without accounting 2018). The contrasting results stem from different methods of analysis, nevertheless, both agencies concur that the five warmest years on record all have taken place since 2010 (NASA, 2018c).

According to Michael E. Mann and colleagues in the research paper *Record temperatures streak bears anthropogenic fingerprint* (2017) in the journal *Geophysical Research Letters*, the chances of this kind of streak of record high temperatures *without* some kind of anthropogenic contribution to global warming is now less than 0.03 percent. In contrast, if global heating is taken into account, the probability that these events continue to materialize escalates to between 30 and 50 percent (Meyer, 2017). Furthermore, a *Nature Climate Change* paper (Christidis, Jones & Stott, 2014) forecasts that extremities regarding hot summers, that would have occurred twice a century in the early 2000s are now expected to take place twice in a decade.

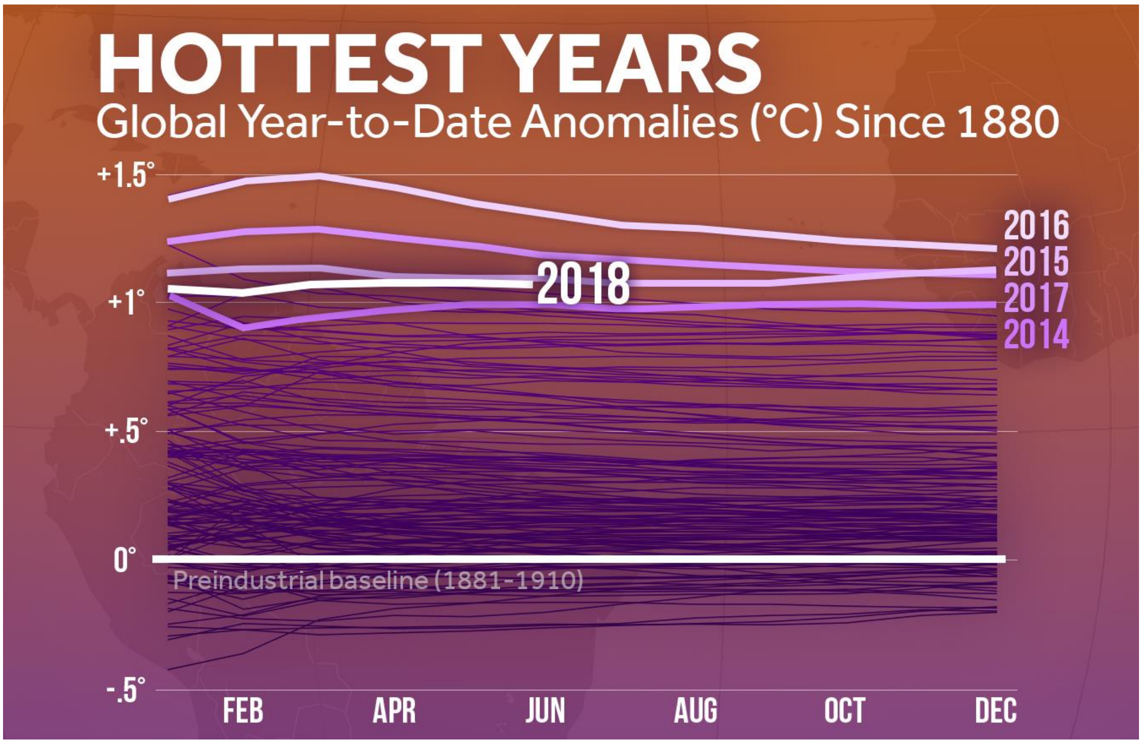


Figure 6.23: Hottest Years. Global Year-to-Date Anomalies (ºC) since 1880, global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910). Data as of 18/07/2018. Source: NASA GISS & NOAA NCEI. Retrieved from Climate Central, 2018.

The increasing frequency and intensity of heat waves stands as the most glaring and self-evident well-documented repercussion of climate change (Committee on Extreme Weather Events and Climate Change Attribution, 2016). Globally, the Intergovernmental Panel on Climate Change wrote in the Fifth Assessment Report (2014a) that:

> "A large amount of evidence continues to support the conclusion that most global land areas analysed have experienced significant warming of both maximum and minimum temperature extremes since about 1950."

Concluding that:

> "It is very *likely* that human influence has contributed to observed global scale changes in the frequency and intensity of daily extremes since the mid-20th century, and *likely* that human influence has more than doubled the probability of occurrence of heat waves in some locations."

Coupled with this, Stanford University climate scientist Noah Diffenbaugh and colleagues published their research on the journal *Proceedings of the National Academy of Sciences* (PNAS) under the title *Quantifying the influence of global warming on unprecedented extreme climate events* (Diffenbaugh et al, 2017) in which they reveal how a relatively small shift in the global average surface temperature of just 1ºC in the past century has fiercely augmented the odds of extreme heat events (Burt, 2018).

One such outcome of an increase in temperatures is translated in droughts that potentiate ever more vicious and fierce wildfire seasons. That was the outcome of Portugal, my home country that underwent its most ravaging, severe and savage wildfire season in recorded history, as the nation resembled a Viking Pire when observed by satellite imaging. By comparison, 2016 was already a very grave example since of the entire 536,200 acres that burned in the EU, 286,600 burned in Portugal (Jenner, 2017). Whereas in 2017, the number of forest fires in the EU had more than doubled, according to the European Forest Fire Information System (EFFIS), impinging on an area twice the size of Luxembourg. To emphasize, and as figure 6.24 portrays, more than 2200 fire occurrences were reported in 2017 - a tremendous increase on the 639 average the bloc endured annually, over the previous eight years (Harris, 2017).

In Portugal alone that represented roughly 560,000 hectares of burned forest, which amounts to 60 percent of Europe's wildfire total, for a country that makes up just 2 percent of the continent's landmass (Wildfire Today, 2017). As a matter of fact, while this document was emerging and taking form, the most deadliest and tempestuous fire in Portugal's memory, that took the lives of 64 people and injured 130 (BBC News, 2017b; Jones, 2017a; 2017b) ravaged and desolated the land, just a few dozen kilometers from my window. As previously mentioned, Portugal underwent a very dry season with off the charts temperatures, which according to the scientific community also extended the "wildfire season" from two to five months (BBC News, 2017b). Demonstrably, in October firefighters were still combating the advance of the blazing fires (Minder, 2017a; 2017b).

Without going into much detail, since the reader can explore the provided links and examine some of the factors that are not directly connected to anthropogenic climate change, but that nevertheless potentiate the occurrence and intensity of the forest fires, three other major chain links are worth mentioning: Those are forest ownership - the majority of woodland, 85 percent, is privately owned and highly fragmented; the emergence of monocultural forests, dominated by eucalyptus, an Australian species introduced in the 18th century and that was adopted by private owners who saw an economic opportunity due to the rise of paper industries in Portugal; and an ineffective fire prevention strategy (BBC News, 2017b) with the addition of the abandonment of private terrains in the interior of the country, when individuals move to coastal areas looking for economic opportunities.

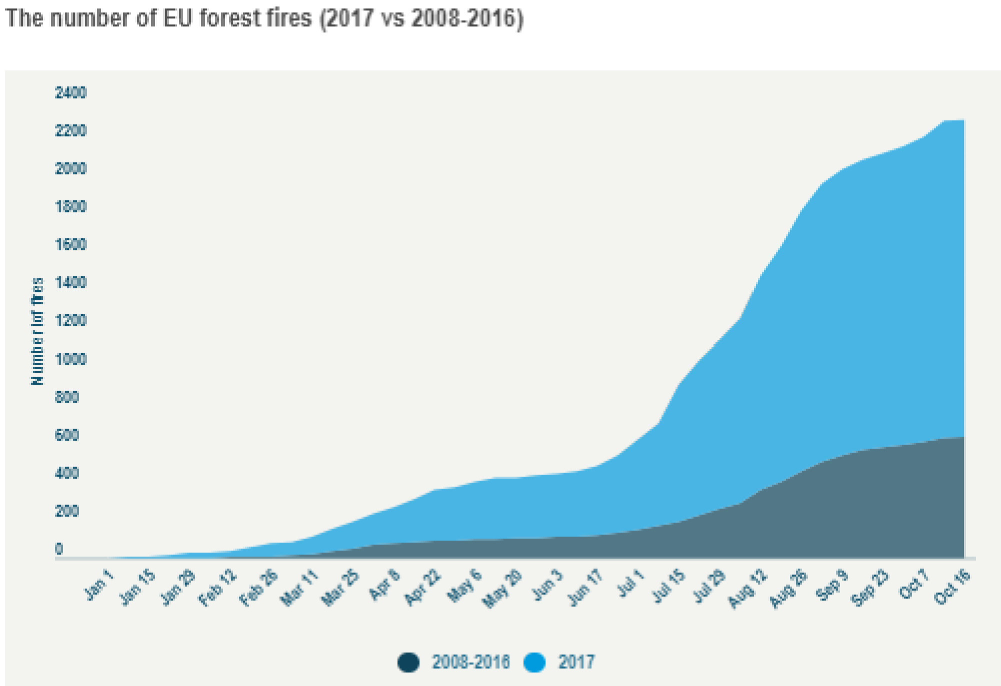


Figure 6.24: The number of EU forest fires (2017 vs 2008-2016). Source: European Forest Fire Information System (EFFIS). Retrieved from (Harris, 2017).

Back to the significant anomalies and events that took place in 2016-2017 in the rest of the world (some can be followed in figure 6.22, above). Still, in Europe, several countries underwent annual above average temperatures worth mentioning. As an illustration, Germany reported an annual value 0.7ºC above average, which was considered to be among the eight warmest years since national records began in 1881. Similarly, the United Kingdom also experienced a 0.7ºC excess above average, with the country enduring its fifth warmest year since record keeping was initiated in 1910. France on the other hand, went through temperature deviations from average on the order of +2.0ºC in the months of February, March and June, whereas the annual deviation was on the order of 0.8ºC above the 1981-2010 average. This was France's fifth highest yearly temperature record. Also worth pointing out, were the periods of March-May and June-August that ranked as the second warmest since 1900. Finally, Austria, which initiated the year with the coldest January in three decades, was superseded by uncommon warm months, specifically the warmest March and the second warmest June on record. Coupled with this their June-August period was the third warmest on record. On balance, 2017 was 0.9ºC above the 1981-2010 average - the eight warmest years since records began in 1768 (NOAA, 2018c).

In the case of Africa, the continent had its fourth most elevated temperature on record, with 2010, 2016 and 2015 taking the lead (NOAA, 2018c). Not to mention the dreadful landslides in Sierra Leone, near the capital Freetown in 2017, because of the increasing rainfall in August, which was over 300 percent of normal (WMO, 2017c). Identically, in July 2016, Mali sustained high rainfall that inundated the Niger River basin, with the river stretching to its highest levels in about 50 years in the country. This prompted 12 dead and almost 10,000 left temporarily homeless (Reliefweb, 2016b). Moreover, Southern Africa, kicked off 2016 with an extreme heat wave, aggravating the ongoing drought, which has not abated, as described in Watermark. Because of it, a 9.3 million tonne shortfall in regional maize production was brought about (UNOCHA, 2016a). Comparatively, all-time heat records were attained in January: in Pretoria, 42.7ºC, and Johannesburg, 38.9ºC (WMO, 2016). Finally, in the Greater Horn of Africa, in

2016/2017, extreme droughts desolated the region, with up to 24 million people facing critical food insecurity (UNOCHA, 2017b).

Asia's 2017 regional temperature stood as the third most elevated in the 108-year record, behind 2015 (highest) and 2007 (second highest) (NOAA, 2018c). Additionally, in Asia, tropical Cyclone Hato brought high winds and rain to Hong Kong and Macau on 23 August 2017, prompting devastation in Macau in particular (WMO, 2017c). In 2016, the Yangtze basin in China had its most symbolic summer floods since 1999 (WMO, 2016), with the rainfall over the middle and lower Yangtze region being 140 percent of average in April to July (NOAA, 2017b). Owing to these floods, 310 people lost their lives and an economic damage estimated to be roughly US$14 billion was generated (WMO, 2016). Moreover, in Bangladesh, Cyclone Mora precipitated appreciable damage and some casualties. This was followed throughout June by heavy monsoon rainfall, which induced severe flooding and was conducive to deadly mudslides. Nearly 900,000 people were affected by floods as of 5 July 2017 (WMO, 2017d). Together with this, in India, as of 24 August 2017, 32.1 million people had been afflicted by flooding across Assam, Bihar, Uttar Pradesh, and West Bengal. More than 600 people are known to have died (WMO, 2017c). Likewise, Sri Lanka was also overwhelmed in 2016 by flooding and landslides, motivated by Tropical Storm Roanu (UN News Centre, 2016), that left more than 200 people dead or missing, and uprooted several hundred thousand (WMO, 2016). Furthermore, in August 2016 North Korea was hit by Typhoon Lionrock which produced destructive flooding in the country (WMO, 2016). It is appraised that more than 130 people died and at least 100,000 were displaced (United Nations, 2016). Finally, in 2017, the tropical Storm Nanmadol was linked with torrential rainfall in southern Japan. The city of Hamada in Shimane, endured hourly precipitation of over 80mm on July 6; leading to an advisory evacuation of nearly 60,000 residents in affected areas (WMO, 2017d).

Ultimately, the second study in the *BAMS* mentioned at the start of the segment pinpointed global warming as the transgressor behind heat waves that gripped much of the southeast Asia in 2016 (Imada et al, 2018). In India, the heat deprived at least 580 people of existence from March to May. Thailand recorded its highest temperature ever - 44.6ºC - on 28 April, and energy consumption across the region surged to record levels as people turned on air conditioners for relief. El Niño might have aggravated the plight, says the study, but the temperatures "would never have happened without the anthropogenic warming" (Nature, 2017).

In Oceania, for starters, temperatures were elevated to the point that 2017 was considered to be the sixth warmest year since records have been kept, in 1910. In particular, in 2017 New Zealand sustained its fifth warmest year and Australia had its third warmest year with an average of 0.95ºC above the 1961-1990 average (NOAA, 2018c). Specifically, Australia had the second driest June on record, with rainfall 62 percent below average for the country as a whole, in 2017 (WMO, 2017d). The Great Barrier Reef withstood abnormal temperatures in 2016, which assisted in a coral mortality of up to 50 percent in some of its parts (WMO, 2016). Not only did the continent experience warmer temperatures but it was also struck by other natural phenomena. Fiji was battered by Cyclone Winston in 2016, which was the most relentless tropical cyclone to affect the country (WMO, 2016). More than 56,000 people - an equivalent of 40 percent of Fiji's population - lost their homes and were forced to live in rudimentary, temporary shelters (Reliefweb, 2016c).

To put 2017 to rest, sea ice in the Arctic was 16.1 percent below the 1981-2010 average - the fifth lowest July sea ice extent since satellite records began in 1979 (NOAA, 2017c). Researchers came to the same conclusion in the third *BAMS* study mentioned at the beginning of this segment, which focused on marine warming in the Gulf of Alaska and the Bering Sea that began in 2014 and climaxed in 2016-2017 (Walsh et al, 2018). El Niño might have been implicated in the action, but global heating set the stage, with sweeping after effects. For instance, ice on Alaskan rivers broke up earlier than ever; a lack of sea ice impinged on fishing, and toxic plankton blooms contracted shellfish harvests. Tens of thousands of seabirds were found dead, probably starved (Nature, 2017*)*.

Conclusively, figure 6.25 accurately sums up what has been described and portrayed in this work.

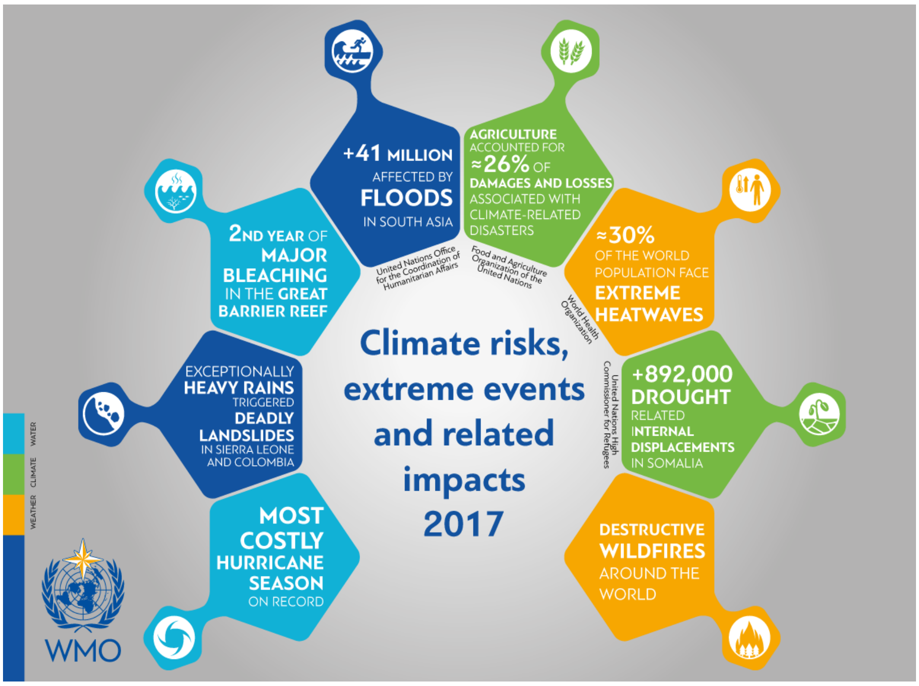


Figure 6.25: Climate risks, extreme events and related impacts in 2017. Retrieved from World Meteorological Organization, 2018b.

As previously mentioned, 2018 has been shaping out to be the fourth hottest year on record (figure 6.23) and so far, some worth mentioning records have already been breached, according to a few stats compiled by Weather Underground (Burt, 2018):

- Glasgow, Scotland sustained its hottest day on record, reaching 31.66ºC on June 28.
- Norway, Sweden, Finland, Denmark, Estonia, Latvia, Lithuania, Belarus, Netherlands, Poland*, Germany*, Czech Republic*, Slovakia experienced their warmest May on record. Those with an (*) also sustained their warmest April. Helsinki withstood a local record of 29.6ºC, on May 15; and Kevo also in Finland endured a record of 33.4ºC. A record of 33.5ºC in Badufoss, Norway on 17 July was also gauged (WMO, 2018c). These temperatures have led to the emergence of forest fires throughout Scandinavia and the Baltic region, with Sweden reporting about 50 fires burning in mid-July (Copernicus, 2018a).
- Montreal, Canada set a new record, withstanding 36.66 ºC on June 29.
- Southern California experienced an all-time record with an official 48.9ºC observed at Chino on July 6th.
- Ouargla, Algeria was subject to what is considered to be the highest reliable temperature EVER recorded in Africa, reaching 51.1ºC on July 5 (Masters, 2018).
- Tianxiang, Taiwan endured the hottest temperature on record, reaching 40.5ºC.

- New Zealand surveyed their hottest summer on record, with January being the single warmest of any month on record.
- Pakistan, with the hottest temperature for the month of April ever determined on the entire planet, 50.2ºC at Nawabshah on April 30.
- In Mexico, some sites at astonishing high elevations produced all-time heat records, including Durango (elevation 1900 meters) with a 41.6ºC temperature on May 29; Guadalajara with 39.2ºC on May 31 and Torreon with a shocking 44.8ºC, also on May 31.
- In the Middle East and the Caspian Sea Regions between 3 and 4 of July: Kirkuk, Kurdistan with 50.0ºC, an all-time record for this major city in Iraq. Tbilisi, Georgia pinpointed 40.5ºC, another all-time record for the capital. Yerevan, Armenia with 42.0ºC on July 2nd encompasses an all-time record for the capital, then ten days later that record was beaten with 42.4ºC. Baku, Azerbaijan accounted 42.7ºC on the first of July, with an all time record. Other meaningful all-time records were set on Turkmenbashi, Turkmenistan on July 1 with 45.6ºC, Kucubej, Russia with 41.6ºC, and on July 2 at Novyj Ushtogan, Kazakhstan, with 44.8ºC.
- The United Arab Emirates on July 10th, with an all-time record of 51.4ºC at Saih al Salem.
- Ahvaz, Saudi Arabia sustained the highest observed temperature on Earth so far this year (as of July 12) with a temperature of 53.0ºC on July 2nd.

Besides the extreme heat, the World Meteorological Organization (WMO, 2018c) reports that drought and disastrous precipitation have marked the first half of summer in the northern hemisphere. To that effect, Japan has endured the worst flooding and landslides in decades, breaching several daily rainfall records. In agreement with officials from the government, more than 200 people lost their lives, and around 10,000 houses have been wrecked, with roughly 4,500 people still living in temporary shelters (Rich, 2018). After the downpour wore down and tested Japan's climate change resilience, an intense heatwave hit Japan, with maximum temperatures exceeding 35ºC in 200 of the 927 stations deployed around the nation (WMO, 2018c).

Notably, on July 23rd 2018, a city on the outskirts of Tokyo, Japan hit a record high of 41.1ºC. The heatwave had by that date claimed the lives of 40 people, and thousands had been hospitalized due to symptoms of insolation in the nation. Correspondingly, in South Korea temperatures have not yet broken records, but people are still languishing and perishing from above-average temperatures. It is worth mentioning that between 20th May 2017 and 21st July 2018 there was a rise of 61 percent of people falling ill to heatstroke in South Korea (Rich, 2018; Público, 2018).

Globally, June 2018 was the second warmest on record, following the statement from the European Centre for Medium Range Weather Forecasts Copernicus Climate Change Service (2018b), and the year so far, has been the hottest La Niña on record (WMO, 2018c) with present La Niña years persistently warmer than El Niño years from 30 years ago (Climate Central, 2015; 2018). Uniquely, the heatwave that epitomized the month with blazing temperatures over much of Europe (Coghlan, 2018), breaching several records above 30ºC (New Scientist, 2018), with Michael Le Page from *New Scientist* rightly branding the title of his piece *Record heatwaves are here to stay - welcome to our warming world* (Le Page, 2018b).

Temperatures were so above average and conditions were so abnormal that wildfires ravaged through Sweden's and UK's landscape and into the Arctic Circle (Irfan, 2018; BBC News, 2018a), at an almost dystopian scenario, where the Portuguese government moved to send help to fight the devastating fires in Sweden (TPN/LUSA, 2018). According to a preliminary analysis (not yet peer-reviewed) from the team at World Weather Attribution (WWA) (2018) the heatwave was made twice as likely by climate change.

The team reports to *New Scientist* (Marshall, 2018):

> "We estimate that the probability to have such a heat or higher is generally more than two times higher today than if human activities had not altered climate. [The team] can conclude that anthropogenic climate change increased the odds of a heat wave as observed in 2018 in Scandinavia but we cannot quantify by how much."

Gareth Redmond-King, a climate change specialist at WWF, also contended with *New Scientist* (Marshall, 2018):

> "This analysis confirms what we already know - that we are suffering an extreme weather events caused by climate change. World leading academics are warning us that, like a disaster movie, this is going to get worse and we know this will impact our nature, wildlife, people and food supplies. We urgently need ambitious action to cut our emissions and to build a cleaner, greener economy to tackle climate change before we pass the point of no return that we are so very near."

The team also prognosticated that comparable heatwaves will start to become more likely (WWA, 2018) and this was supported by a paper published in the journal *Scientific Reports* by Michael E. Mann and colleagues (Mann et al, 2017), in which he grounded what he had to say to *Scientific American* (Marshall, 2018):

> "Events like the massive wildfires breaking out around the Arctic Circle really have no precedent in modern history and they are consequently very difficult to anticipate in advance. It is a reminder that there are many surprises lurking in the greenhouse and they are unlikely to be welcome surprises."

Besides all the environmental, ecological and human health implications from these extreme events, there is also another more obscure side that generally does not get much attention. With that being said, *Bloomberg* perfectly encapsulated the economic perspective in the piece *The Global Heatwave Is About to Hit Your Wallet* (Morison, Perez & Larkin, 2018).

The rise in temperatures and drought conditions felt all over the world in the summer of 2018, but particularly in the Northern Hemisphere have prompted spikes in the prices of anything from wheat to electricity. It is a stark reminder of the susceptibility of global commodity prices to the whims of a changing climate. As stated in the article:

> "Cotton plants are stunted in parched Texas fields; the Russian wheat crop is faltering; French rivers are too warm to effectively cool nuclear reactors; the hot-weather has forced a German coal-fired plant to curb operations, as well as reducing the availability of some plants in Britain fired by natural gas; the sultry conditions are leaving wind turbines virtually at a standstill; windmills are also becalmed in Spain, Italy, the U.K., Denmark and Sweden. Solar operators are enjoying the weather, but they can't fill the gap left by wind and demand for natural gas is rising."

On top of these events a general agreement is brewing in the thick of the scientific community that a new El Niño will form before the end of the year, which will, in all likelihood, make 2018 finish as one of the hottest 10 years on record (International Research Institute for Climate and Society, 2018).

WMO Secretary-General Petteri Taalas instructs in the WMO Statement on the State of the Global Climate in 2017 (WMO, 2018b) that:

> "The start of 2018 has continued where 2017 left off - with extreme weather claiming lives and destroying livelihoods. The Arctic experienced unusually high temperatures, whilst densely populated areas in the northern hemisphere were gripped by bitter cold and damaging winter storms. Australia and Argentina suffered extreme heat waves, whilst drought continued in Kenya and Somalia, and the South African city of Cape Town struggled with acute water shortages."

Mr Taalas adjoined:

> "In the past quarter of a century, atmospheric concentrations of carbon dioxide have risen from 360 parts per million to more than 400 ppm. They will remain above that level for generations to come, committing our planet to a warmer future, with more weather, climate and water extremes."

Despite the fact that it is not congruent to attribute the individual extreme events of June and July 2018 to climate change, they are nevertheless consistent with the general long-term trend of rising concentration of GHGs (WMO, 2018b). As a matter of fact, a new study published in *Science Advances* (Mann et al, 2018) connects the GHG accumulation with the disruption of the jet stream - a potent river of winds that conducts weather systems in the Northern Hemisphere – that is, invariably, augmenting the rate of droughts, floods and wildfires. Also according to the research, summers like that of 2018, when the jet stream engendered extreme or unprecedented weather across the Northern Hemisphere, will become around 50 percent more frequent by the end of the century, if carbon emissions are not reduced (Berwyn, 2018). By all means, as stated in beginning of this segment an array of recent studies established that the probability of an extreme event being influenced by human activity stood at a significant probability of 65 percent, among the studies reviewed (Herring et al, 2018).

The reader might be wondering why I chose to examine this lengthy list of anomalies and natural phenomena, instead of just finding the evidence in broad strokes to the tempering of the Earth's climate. The explanation is quite simple really. First of all my aim was to provide the reader with the necessary body of evidence demonstrating that this planet is in fact changing and that everything we hold as perpetual in its essence and existence can, abruptly, vacillate and be reconditioned. This world has undergone major makeovers throughout the ages, and one thing that has been constant ever since life evolved on Earth, was the need to acclimate, adapt and if necessity required, to migrate. In the last stretch of this segment, I will analyze the link between food security and the escalation and intensity of natural phenomena that is potentiated by anthropogenic climate change, creating immense human suffering and misery and now more than ever, pushing people to abandon and relinquish their *places* and material wealth.

Following from this, rising temperatures and changing rainfall patterns will have epidemic, ponderous negative reverberations on food production and food security. Demonstrably, between 1985 and 2007, droughts instigated a 13.7 percent loss in cereal production, compared to just 6.7 percent in losses between 1964 and 1984 (Lesk, Rowhani & Ramankutty, 2016). Drought in one of the vital factors for agricultural breakdown and it is foreseeable that the escalation in intensity, frequency and duration of such droughts - all consequences of climate breakdown - will engender consequential downturns to crop yields (Gitz, Meybeck, Lipper, De Young & Braatz, 2015). By all means, as it was possible to decipher from the chapter Hunger

Games, this annexation of further menaces to an already strained and vulnerable state of affairs, can only be a recipe for disaster.

Released in 2017, the FAO's *Crop Prospects and Food Situation* report encompasses educated guesses that 37 countries currently necessitate external assistance for food: 28 are in Africa and are driven by El Niño-triggered droughts and irresponsible or nonexistent family planning policies. At the time of writing, the food security situation is 'of grave concern' in northern Nigeria, Somalia, South Sudan and Yemen, where over 20 million people are facing severe food insecurity due to long-standing conflicts, compounded by drought (FAO, 2017c). In 2011, the UN's International Fund for Agricultural Development (2011) wrote:

> "Drought in this part of the continent is not unknown and has been an increasingly frequent occurrence. Datelines change but the stories of unimaginable hardship, death and deprivation, while differing in magnitude from one drought to the next, remain much the same. Drought never only has localized consequences. Its effects cascade through countries in the form of higher food and fodder prices, civil unrest and diminished social services as governments redeploy budgets to meet the most pressing needs of their citizens."

It must be remembered that the open-ended drought in East Africa is allied to the manifestation of a "super" El Niño in 2015 and the fact that 2016 became the hottest year since record-keeping began. As previously mentioned, El Niño results from a strong and scopious synergy between oceans and the atmosphere: variations in the sea-surface temperature of the tropical Pacific Ocean discombobulates normal weather patterns, bringing heavy rains and drought to different parts of the world. El Niño is supplanted by La Niña and together the cycling is called is the El Niño Southern Oscillation (ENSO) (NOAA, 2018d).

The absence of long-term observational data makes it exceedingly strenuous to arbitrate how climate change is partly responsible for El Niño's reshaped rain patterns and how this will be subject to alterations in the future, owing to this, climate models give mixed, and at times, paradoxical and incompatible results. However, a 2014 study published in *Nature* points in the direction that the incidence of 'super' El Niño extreme weather events could double in the future: arising roughly every 10 years instead of every 20 (Cai et al, 2014). Given the calamitous and overwhelming effects on food production, ecosystems, health, energy demand, air quality and the escalation in the risks of wildfires around the globe, it is indispensable that the intricate interplays between climate change and El Niño are given the consideration that they deserve (EJF, 2017). In an interview with *Reuters* (Miles, 2015), Michel Jarraud, former Secretary-General of the World Meteorological Organization had the following to say on the matter:

> "So this naturally occurring El Niño event and human-induced climate change may interact and modify each other in ways we have never before experienced. Even before the onset of El Niño, global average surface temperatures had reached new records. El Niño is turning up the heat even further."

By all means, and to enumerate, over the previous decade or so, East Africa has undergone a number of particularly severe droughts - in 2005, 2006, 2008, 2011, 2015, 2016 and 2017 (Wainaina, 2017). Researchers appraising the East African drought in 2011 established that there was evidence to demonstrate that anthropogenic climate change heightened the probability of a diminution in rain in the region (Lott, Christidis & Stott, 2013). Along with an elevated frequency, the severity of droughts and the influence on human populations have also been exacerbated. Demonstrably, the drought that lasted from July 2011 to mid-2012 was the region's worst in 60 years (BBC News, 2011). But while that crisis impaired over 12 million people, the drought that commenced in 2016 has immeasurably raised the number of people languishing from food insecurity and malnutrition (UNOCHA, 2017a). To emphasize, in August 2016, 24 million people - twice as many as in 2015 (PENHA, 2017) - were facing critical food insecurity. According to UNICEF, by early 2017, more than 880,000 children were markedly malnourished and 5.5 million children in danger of falling into the same circumstance (UNICEF, 2017). Owing to the debilitated status of the populations, the drought has been instrumental to the outbreaks of yellow fever, malaria, cholera and measles that have afflicted the region (UNOCHA, 2017b).

Ethiopia, Kenya and Somalia have been relentlessly hit by large-scale and all-encompassing crop failures and livestock deaths (UNOCHA, 2017b), but other countries, including Burundi, Uganda, Djibouti, Rwanda, Sudan, South Sudan and the Democratic Republic of Congo have also been badly affected (UNOCHA 2017b). For instance, in South Sudan, the drought - coupled with ongoing armed conflict - has pushed the country into a dire situation (FAO, 2017d). In February 2017, the UN announced famine in parts of South Sudan (UN News Centre, 2017), where 100,000 people face starvation and around one million people are classified as being on the brink of famine; one in seven people have been forced to surrender their homes and decamp (Messengers of Humanity, 2017) through combined impacts of conflict and drought. When coupled with merciless and ruthless ongoing conflicts, drought, food scarcity and spiralling food prices prompt massive migration across borders, as well as internal displacement. According to the UN, there were 4.4 million refugees and asylum seekers and a supplementary 3 million internally displaced across the East African region in July 2017 (UNOCHA, 2017c).

The prognosis is austere for the region. The UN Regional Outlook for the Horn of Africa and Great Lakes Region anticipates that the drought will enhance even further, that food prices will carry forward and rise, that there is a risk of further escalation of violence in South Sudan and that the humanitarian situation in many of the countries will retrogress (UNOCHA, 2017c). Distinctively, northern and eastern Tanzania, much of Kenya, southern and north-western Somalia, much of Djibouti, south-eastern Eritrea, north-eastern, eastern and southern Ethiopia, south-eastern parts of South Sudan, north-eastern Uganda and southern parts of Sudan are facing an augmented prospect of below-normal to near-normal rainfall. These regions will, with great plausibility, face poor harvests and water shortages (Karanja, 2017).

The accumulation of scientific results implies that we may need to reevaluate how we contemplate extreme events. The epic El Niño warming event in the eastern tropical Pacific Ocean in 2015-16, for example, might have propelled global temperatures to record levels, but only because it was inflated by more than a century of greenhouse-gas emissions. From this perspective, global warming might also be answerable for many of the repercussions that we regularly ascribe to El Niño itself, which roils weather patterns across the globe (Nature, 2017).

In conclusion, extreme weather events would be counted from time to time, in spite of global warming. In fact, of the 131 papers inspecting extreme events that *BAMS* has published over the past 6 years, 35 percent found that global warming played no discernible part. Nevertheless, the latest results illustrated and portrayed throughout this segment insinuate that the climate is entering uncharted territory, and that would mean that weather will increasingly fall outside the historical norm (Nature, 2017). As climate change scientist Michael C. Mann argued in an interview with *The Guardian* (Carrington, 2018e):

> “This is the face of climate change. The impacts are no longer subtle. We are seeing them play out in real time and what is happening this summer [2018] is a perfect example of that. We are seeing our predictions come true. As a scientists that is reassuring, but as a citizen of planet Earth, it is very distressing to see that as it means we have not taken the necessary action.”

Climate Change as the Precursor for Migration and Conflict

"If global warming is not contained, the West will face a choice of a refugee crisis of unimaginable proportions, or direct complicity in crimes against humanity"

- George Monbiot

Each of the previous three decades has been successively warmer than any antecedent decade since 1850 (IPCC, 2014a), and in 2015 temperature rise surpassed 1.0ºC, compared to pre-industrial times, for the first time (Blunden et al, 2016). These changes are having and will continue to exert escalating, negative impacts on our environment, economies, livelihoods and security, on a global scale. Those reverberations will immoderately affect the most vulnerable groups in society, and those who have been the least conducive and instrumental to the onslaught of climate change will be the first and the ones most distressed by it (Oppenheimer et al, 2014). It is for this reason that the Pentagon calls climate change a "threat multiplier" (The White House, 2015).

One of the archetypal symptoms of our time is the increscent flow of internally displaced people and environmental/climate refugees: people banished by rising seas, more ruinous storms, broadening deserts, water deficiency, and alarmingly high levels of toxic pollutants in the local environment. Over the long-term, rising-sea refugees will likely eclipse all others in the flow of environmental refugees. The forecast for this century is a rise in sea level of up to six feet. Then again, a three-foot rise would inundate parts of many low-lying cities, major river deltas, and low-lying island countries (Brown, 2011). Among the more premature refugees will be millions of rice-farming families from Asia's low-lying river deltas, those who will watch their fields sink below the rising sea (Pfeffer, Harper & O'Neel 2008). Generally speaking, the effusion of rising-sea refugees will come primarily from coastal cities and among those most directly overwhelmed are London, New York, Washington, Miami, Shanghai, Kolkata, Cairo, and Tokyo, to name a few (Brown, 2011).

Indeed, the more in disrepair the climate becomes, the more people will be forced to relinquish their homes. As the world warms and sea levels expand inland, the predicament of enforced migration is envisioned to become far worse (Markham, 2018). The *Global Report on Internal Displacement* (IDMC, 2017) by the Internal Displacement Monitoring Centre (IDMC) appraises that in 2016 alone, 31.1 million people were uprooted due to conflict, violence and disasters, with extreme weather-related disasters displacing around 24.2 million people (IDMC, 2017), with another 6.9 million connected to a rise in conflict. This does not encompass the people coerced to decamp and abscond, leaving their homes as a consequence of slow-onset environmental degradation, such as droughts (EJF, 2017).

In reality, there is no explicit global dataset on displacement due to slow-onset climate extremes such as sea level rise and desertification; often this migration is branded as economic or other planned migration, overlooking or neglecting to endorse fully the 'push' arising from climate change repercussions (EJF, 2017). According to a recent study *Impediments to inland* *resettlement under conditions of accelerated sea level rise* (Geisler & Currens, 2017), 1.4 billion people could be facing imminent threats to leave their homes by 2060 and this number could rise to two billion by 2100 (Hadlock, 2017). This assessment is built on mixed forecasts of population growth, submerging coastal zones, dissipated natural resources, drained net primary production, desertification and urban sprawl (EJF, 2017).

Nonetheless, from 2008 to 2016, roughly 227.6 million people were displaced by environmental hazards (IDMC, 2017), which were most likely intensified and made more frequent due to anthropogenic climate change. Evidently, climate change is not at the root of every displacement since the reasons that lead people to relinquish their homes and *places* are complex and deeply interwoven. Notwithstanding, this segment will examine the link between climate change, and the global diaspora (figure 6.24) that has ensued because of it. Worth noting is that not every Internally Displaced Person (IDP) is a climate refugee, although it puts people one step closer to abandoning their nations and looking for a better life in some other country.

Climate change is resulting in the eradication of livelihoods, infrastructure and communities and - without further action - will doubtlessly compel people to leave their homes and drive forced migration (IPCC, 2014a). Climate change is by the time mentioned, reshaping weather patterns and ecological processes in ways that are momentous for human populations, directly impinging on their health (Barrett, Charles & Temte, 2015). Underdeveloped societies face additional challenges. First of, they tend to rely and depend more on local and regional environmental stability and integrity for their livelihoods, and second, they can commit fewer resources to climate change resilience, which, ultimately will result in these societies being more inclined to vacate and forsake the affected areas (Reuveny, 2007). To this effect, an abundance of research has come to demonstrate how climate variability substantially prompts migration in Indonesia (Bohra-Mishra, Oppenheimer & Hsiang, 2014), Mexico (Feng, Krueger & Oppenheimer, 2010), South Africa (Mastrorillo et al, 2016), Bangladesh (Davis, Bhattachan, D'Odorico & Suweis, 2018; Gray & Mueller, 2012), Pakistan (Mueller, Gray & Kosec, 2014) among many other countries (e.g. [Marchiori, Maystadt & Schumacher, 2012; Gray & Wise, 2016]). But notwithstanding the current agreement of climate change acting as a catalyst for migration and displacement worldwide, the magnitude of the population movements are still widely contested (Ionesco, Mokhnacheva & Gemenne, 2016; The Government Office for Science, 2011; Foresight, 2011).

Correspondingly, many international initiatives now perceive the association between climate change and migration, one that will *prima facie* widen and become more distinct, given the deterioration and degeneration of ecosystem services, snowballing constraints on natural resources, and affiliated socioeconomic and geopolitical encumbrances under climate change (Vitousek, Mooney, Lubchenco & Melillo, 1997; Vörösmarty, Green, Salisbury & Lammers, 2000; Raudsepp-Hearne et al, 2010). Given the amplified sensibility of the link between climate change and migration, it is paramount to understand that this bond is strongly heterogeneous (Hunter, Luna & Norton, 2015). The climate-migration relationship relies on the contrasting vulnerability of places and populations to climate change, which, in turn, is a function of their unique exposure, sensitivity, and adaptive capacity (McLeman, 2013; McCubbin, Smit & Pearce, 2015; Grecequet, DeWaard, Hellmann & Abel, 2017).

Environmental change can be contemplated to mobilize conflicts over land or resources, which in turn can bring about the displacement of people. Forced migration can be provoked by environmental conflicts, but involuntary migration due to the scarcity of food or extreme weather events can also in itself trigger conflicts (Kolmannskog, 2008). The synergy between different social, economic and political variables - as well as environmental ingredients - are effective influencers of wars and armed conflicts in vulnerable countries (Burke, Hsiang & Miguel, 2015; IPCC 2014a; Scheffran, Brzoska, Brauch, Link & Schilling, 2012). The convergence of risks around water scarcity, climate change, extreme weather events and involuntary migration linger on as a potent cocktail and a 'risk multiplier', especially in the world economy's more fracturable environmental and political contexts (World Economic Forum, 2017).

Brigadier General Gerald Galloway from the United States Army (Ret.) avouches in the *Beyond Borders* Report from the *Environmental Justice Foundation* (EJF, 2017) that:

> "Climate change certainly has national security implications [...] it is a source of instability, it creates the conditions under which wars are fought or tensions increase."

A 2013 report (Harris, Keen & Mitchell, 2013) by the Overseas Development Institute (ODI), intimates that disaster and government missteps to react to climate change can deepen existing societal tensions, while disruption presents economic opportunities for criminal activities. Overall the report portends that natural disasters aggravate pre-existing conflicts. A research paper titled *Armed-conflict risks enhanced by climate-related disasters in ethnically fractionalized countries* (Schleussner, Donges, Donner & Schellnhuber, 2016) established an eventuality rate of 9 percent between armed conflict and disasters - such as heat waves and drought - between 1980 and 2010, however, this figure was far higher - 23 percent - in ethnically fractionalized countries.

In addition to this, further implications of the onset of climate change for human migration crystallize in the spawning of focal points of violent conflict that materialize in a range of activities, such as, appropriation, insurgency, skirmishes and interstate or intrastate wars (Reuveny, 2007). Gleditsch, Nordås and Salehyan (2007) denote that climate change-induced migration surges in many climate change-to-violence scenarios, and they reason that their materialization is dependent on the scope of degradation and the extent to which it instigates migration decisions (Reuveny, 2007).

One such reason at the core of this rise in conflict is that the arrival of environmental migrants and refugees can encumber the economic and resource base of the receiving area, stimulating native-migrant contest over resources. The surplus in demand of resources may also prompt lateral pressure, which might unfold as expansions of economic and political activities beyond the bounds of the region's or state's borders, in order to amass resources, leading to an upsurge in risk of conflict (Reuveny, 2007). As stated in the GRID (IDMC, 2017), 6.9 million people were internally displaced on the grounds of a surge in violent conflict in 2016, and although not every incidence can be connected to climate change, it is safe to ratiocinate that some fraction is linked to it (figure 6.26).

Since conflict is a major catalyst for migration and displacement these observations have determining ramifications for future security policies - geopolitics and geodemographics acquire a crucial status of relevance. Several of the world's most conflict-prone regions (figure 6.26), in addition to North and Central Africa and Asia are not only vulnerable to climate change burdens

(Adams et al, 2013; IPCC, 2007) but are also marked by deep ethnic, religious and other social divisions. In these areas, climate-induced disasters might well act as a threat multiplier that evokes conflict within or between nations (EJF, 2017).

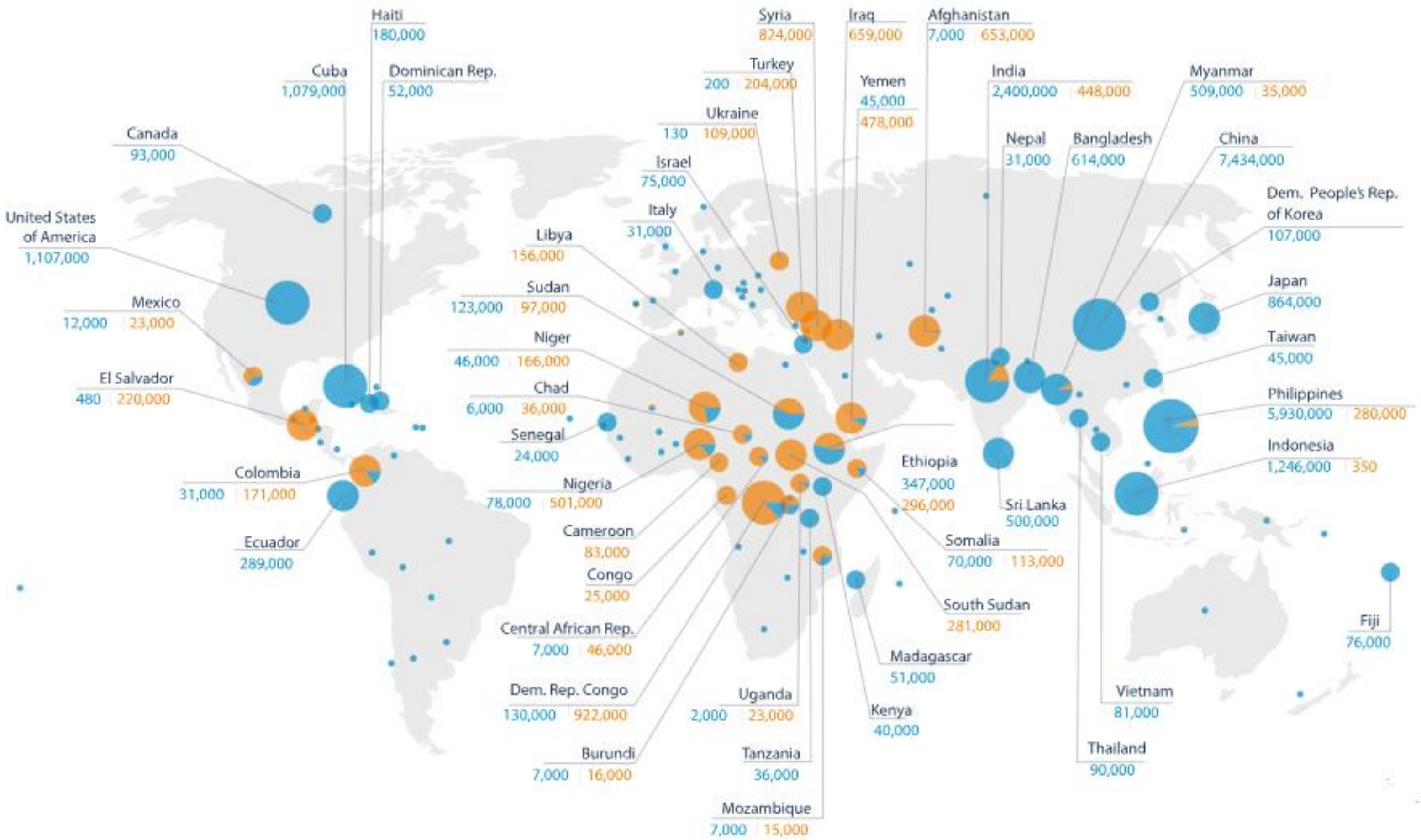


Figure 6.26: New displacements by conflict and disasters in 2016. Orange indicates Displacement by Conflict and Blue by Disasters. The country name and the figure are shown only when the value exceeds 20,000 people displaced. Retrieved from Global Report on Internal Displacement (GRID, 2017).

Correspondingly, a research paper branded *Warming increases the risk of civil war in Africa* (Burke, Miguel, Satyanath, Dykema & Lobell, 2009) delved into the inherent rebounds of global climate change on armed conflict in sub-Saharan Africa, and substantiated strong historical linkages between civil war and temperature, with warmer years breeding a considerably heightened tendency of war. The research cautions of roughly a 54 percent increment in armed conflict incidences by 2030, or an additional 393,000 battle deaths if future wars are as deadly as recent wars. Another study, *Come rain or shine: An analysis of conflict and climate variability in East Africa* (Raleigh & Kniveton, 2012) aimed attention to the situation in East Africa and demonstrated that:

> "Higher rates of rebel conflict will be exhibited in anomalously dry conditions, while higher rates of communal conflict are expected in increasingly anomalous wet conditions."

Finally, another study published in the *Journal of Economic Geography* titled *Local warming and violent conflict in North and South Sudan* (Maystadt, Calderone & You, 2015) exhibited how local seasonal migrations, which are motivated by rainfall, are also correlated with the risks of violence. For this reason, anomalies in temperature have been settled to impinge on the level of conflict, through the accentuated competition for resources, specifically water.

One such example takes shape in Yemen. Considered to be among the most water-stressed countries in the world (recall Watermark): water scarcity has manifested itself to be an integral factor underlying the country's instability, which catalyzed the spark of the conflict that began in 2015. By January 2017, the United Nations Refugee Agency (UNHCR) reported that more than 11 percent of Yemen's population, some three million people, had been compelled to flee their homes (UNHCR, 2017), while 17 million people or two-thirds of the population are conjectured to be food insecure (FAO, 2017c). A World Bank report (2014) underlined that:

> "Yemen today is a glimpse of what's in store for other parts of the Middle East and North Africa (MENA) as climate change and rapid population growth combine to put more and more pressure on the resources essential to human life, like water."

One other crucial link in the migration-climate change model is the health of individuals who are faced with emerging new challenges. Therefore, improving the health of migrants and decreasing adverse health repercussions connected to migration is also a growing concern. Demonstrably, current crises related to migration and uprooting, whether in the Horn of Africa, the Mediterranean or in Burma with the Rohingya people, for example, highlight the contrasting challenges related to migrant's health, particularly in humanitarian crisis (Schütte, Gemenne, Zaman, Flahault & Depoux, 2018).

Planetary health, as figure 6.27 depicts, is a newfangled discipline, which was devised to ensure and secure human health in the Anthropocene epoch (Horton et al, 2014). Planetary health directs attention to two dimensions: the first being human health within human systems, examining the threats experienced by our species such as pandemics or climate change; the second revolving around the natural systems within which *Homo sapiens* evolved and analyzes the integrity and diversity of the biosphere (Horton & Lo, 2015; Schütte et al, 2018).

By directing attention to figure 6.27, the reader will perceive how the chapter Hunger Games and this chapter concentrated on the link between climate change and human health **[A],** so that subject has already been fairly scrutinized and I will avoid repetition in this segment, and limit myself to pinpoint the major transgressors, such as indirect exposures to heatwaves or extreme weather events, even though less direct byproducts emerge from disruptions to environmental, ecological and social systems. Other issues such as the propagation of new and *old* pathogens - global warming causing ice to melt and exposing carcasses that have been buried for centuries or millennia that might be harboring diseases that humans had no prior contact with and therefore no resistance (Fox-Skelly, 2017; Goudarzi, 2016; Bearak, 2016; Luhn, 2016). And indirect after effects from changes in food yields, freshwater availability, air quality, social cohesion and subsistence livelihoods (Schütte et al, 2018).

The **[B]** link, climate change-migration is, manifestly, the dominant subject addressed here, leaving the **[C]** link health-migration, considerably underrepresented. On that regard, if the reader is enticed by the theme, I would suggest further investigation with the recent paper published in the prestigious journal *Lancet,* titled *Connecting planetary health, climate change, and migration* (Schütte et al, 2018).

Coming back to the **[B]** link, indeed, climate change can jeopardize food security through contractions in agricultural and fishery yields. This reverberation is especially disquieting in regions that are already withstanding food insecurity such as sub-Saharan Africa and South Asia

(Lobel et al, 2008). In like manner, the manifestation of flooding or drought cycles, as well as hotter summer in some regions, will presumably, heighten the risks to agricultural productivity, seeing that environmental problems are closely linked with migration (Foresight, 2011), such as extreme weather events, sea-level rise, soil degradation, and food and water scarcity. In detail, extreme weather events tend to be distinct and restricted to a particular geographical region, while other problems comprehend slower incremental changes, such as rising sea levels, land degradation, and diminishing freshwater resources, which are predisposed to exert more permanent and radiated effects (Reuveny, 2007; Schütte et al, 2018).

Important to realize is that in some cases migration will be a procedure of last resort, when people left with no other choice as a consequence of loss of habitable land, extreme health risks, or crumbling livelihoods. This is a conceivable scenario where the **[C]** link can be applied, where the uprooting might augment the risks of adverse health outcomes, specifically for vulnerable groups such as children and the elderly, as well as those already languishing from (chronic) illnesses (Schütte et al, 2018).

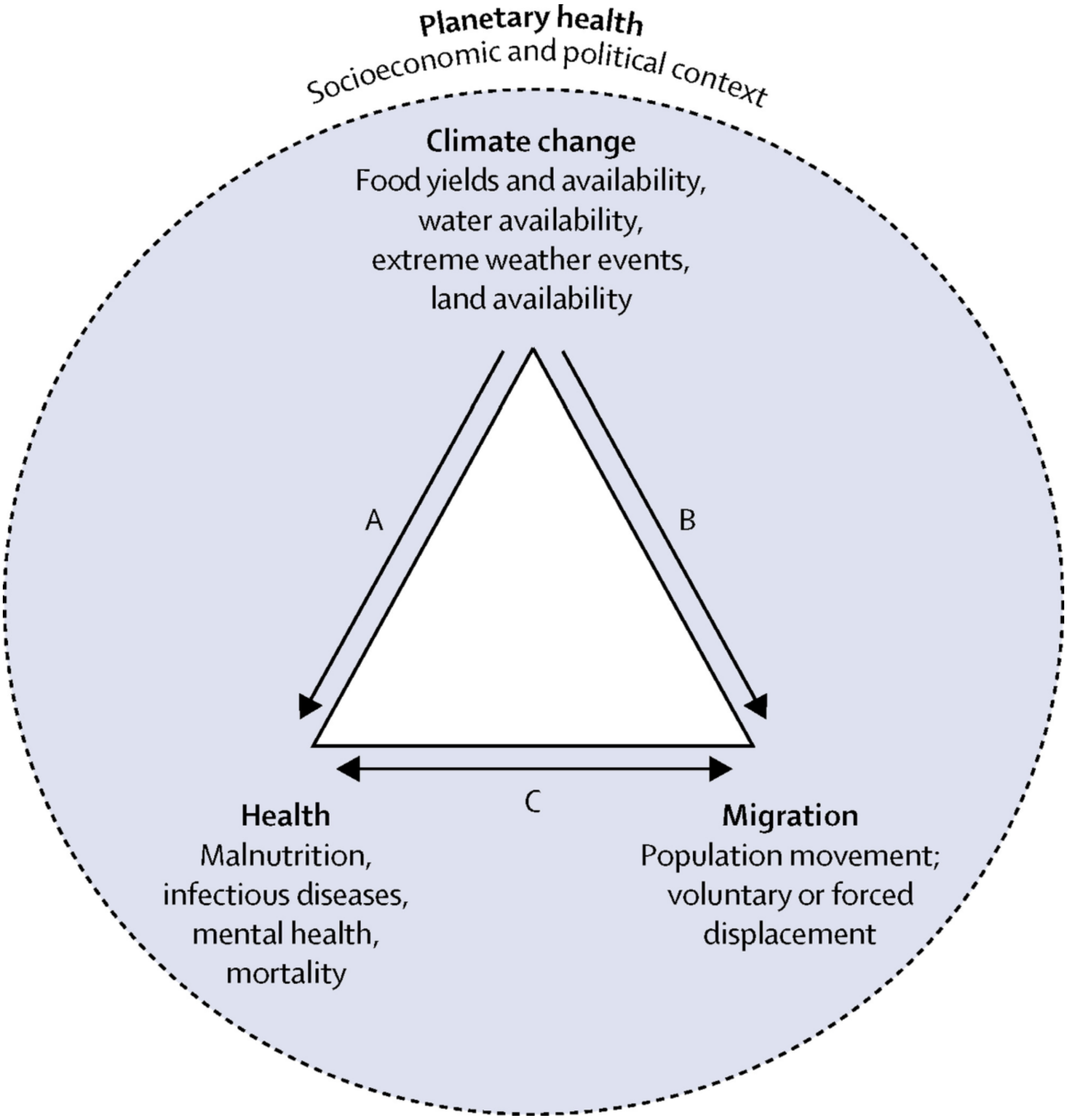


Figure 6.27: Basic explanatory framework of the links between climate change, migration, and health. Retrieved from (Schütte et al, 2018).

Equally important, a recent paper in the journal *Science* called *Asylum applications respond to temperature fluctuations* (Missirian & Schlenker, 2017) argues that an indigence and privation-driven migration, evaluated by asylum applications is practicable and that these respond to temperature fluctuations. As a matter of fact, preceding studies had found a relationship between weather variations and migration (Bohra-Mishra, Oppenheimer & Hsiang, 2014; Cai et al, 2016; Gray & Wise, 2016). Not to mention that current research indicates that in agricultural production areas, there should be a negative relationship between economic conditions and conflict, which then materializes into asylum applications (McGuirk & Burke, 2017).

In consonance with Missirian and Schlenker (2017) the average temperature for which asylum applications are lowest is 21.4ºC for the quadratic model and 19.9ºC for the spline model (figure 6.28). These values correspond to the optimal temperature range for agriculture (Schlenker & Roberts, 2009). Countries that are presently warmer than the optimal temperature would thus be predicted to generate an upsurge in asylum applications under a warmer climate. The range of observed average temperatures over the 15-year panel is portrayed as green horizontal lines in figure 6.28, and green "x" symbols denote the average overall 15 years (McGuirk & Burke, 2017).

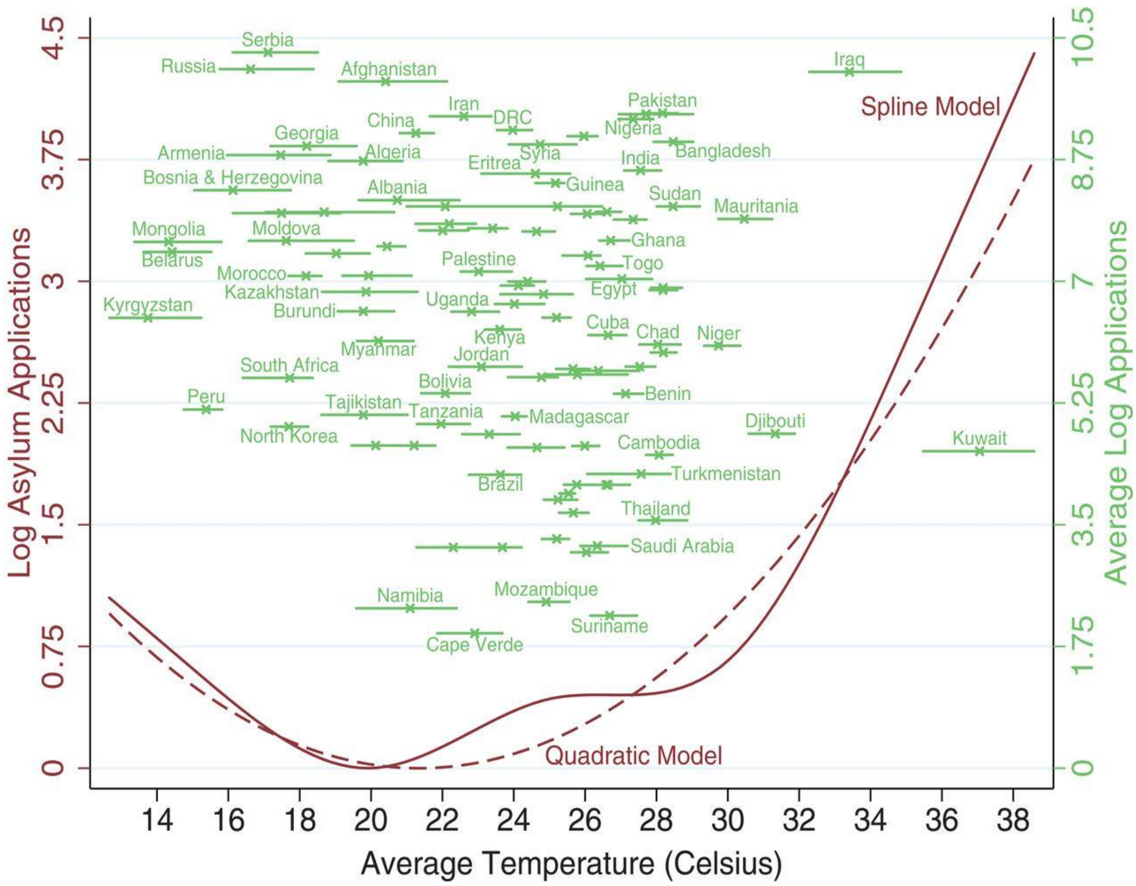


Fig. 6.28: Response of asylum applications to the EU with respect to the annual average temperature over the maize growing season. The quadratic response function is shown as a dashed brown line, whereas the restricted cubic spline is shown as a solid brown line (knots at 15°, 20°, 25°, 30°, and 35°C). Standard errors for the coefficients are given in table S1 (Missirian & Schlenker, 2017). Because the models are in logs, the left *y* axis indicates the relative impact of changing temperatures on asylum applications. Each model controls for a quadratic function in season-total precipitation, as well as source-country and year fixed effects. The mean of the 15 annual average temperatures and log asylum applications (right *y* axis) for each source country are denoted by green "x" symbols. Because the models use weather anomalies in the identification, the green lines display the variation in annual average temperature in each country, ranging from the lowest to the highest observed value in the 15-year period. Retrieved from Missirian and Schlenker (2017).

Total precipitation, on the other hand, does not seem to be an as critical prognosticator of migration as temperature elevations, which is consonant with prior research on conflict that indicates that temperature, as opposed to precipitation, is a stronger predictor of conflict (Burke et al, 2009). Moreover, the relative changes in temperature under future climate change scenarios translate into larger changes in yields than do precipitation alterations (Schlenker & Lobell, 2010).

Furthermore, Missirian and Schlenker (2017) devised a model to predict the change in the percentage of total asylum application filed in the EU (figure 6.29). To point out, moderate temperatures around 20ºC attenuate asylum applications. Both colder and hotter temperatures heighten migration flows. Extrapolating from these results, an increment in temperatures in source countries is envisioned to generate an increase in asylum application to the EU as well.

The findings from Missirian & Schlenker (2017) assist the assessment that climate change, particularly lingering warming, will add another "threat multiplier" that urges people to seek refuge abroad. A point often overlooked is that conflict and intensified weather phenomena aftereffects in low-income source countries will not be imprisoned in those countries or regions but will instead presumptively spill over into developed countries through increased refugee flows.

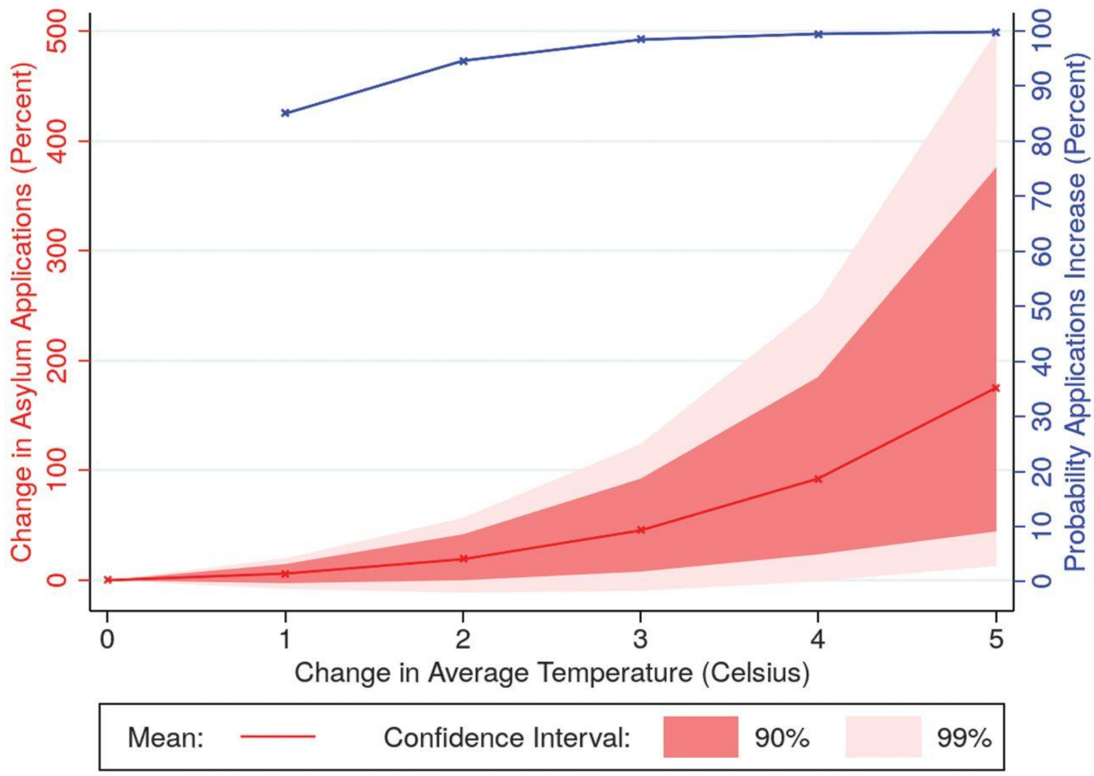


Figure 6.29: Predicted changes to asylum applications under uniform climate change scenarios. Authors used 1000 samples drawn from the joint distribution of the model parameters (solid brown line in prior figure 6.28) to repeatedly predict the change in the percentage of total asylum applications filed in the EU. In detail, the solid red line portrays the presumed alteration in asylum application, in percentage, whereas the shaded areas highlight the 90 and 99 percent confidence intervals. The blue line depicts the probability that asylum applications augment. Retrieved from Missirian and Schlenker (2017).

If unchecked, climate change could draw up from 720 million people back into extreme poverty (Granoff, Eis, McFarland & Hoy, 2015) and create millions or even billions of climate refugees (Hadlock, 2017). This would translate into, by 2050, one in every 9 humans being on the move, on a temporary or permanent basis (Kamal, 2017). Evidently, this comes at a cost of peace and security for the receiving nations as well, with a study published in 2013 prognosticating that the effects of climate change could precipitate as much as a 56 percent surge in the frequency of intergroup conflicts across the world (Hsiang et al, 2013).

In the *Waking Up* podcast (Harris, 2017), the neuroscientist and philosopher Sam Harris is joined by the author and climate expert Joseph Romm, who states:

> "We have altered the frequency of rare events, and historically these events have done most of the devastation. Katrina and Sandy super storms were considered outliers, and were augmented by rising sea levels [...] El Nino years which tend to have the freakish weather and are hotter than usual. 2014 was the hottest year on record, then 2015 beat that easily, and then 2016 beat that. 2017 is on track to being the second warmest year but the hottest year without El Nino. We are starting to see levels of warming that we only see during extreme years to be the normal weather."

Romm concludes:

> "If the planet warmed 2ºC and stopped we would probably adapt. It wouldn't mean that probably 2 billion people wouldn't have to move, and these numbers of climate refugees would be a catastrophe. We saw how 2-3 million refugees from Syria turned global politics upside down."

The European Union (EU) has seen an unparalleled wave of immigration in 2015 (Frontex, 2016) as part of a larger intensification in migration across the Mediterranean Sea that began in 2014. A substantial fraction was fleeing war-torn countries such as Syria, Afghanistan, or Iraq, and there is an ongoing deliberation as to whether a reversal in climatic circumstances did augment, and strengthen in the future, such migration flows. In detail, a study published in *PNAS* titled *Climate change in the Fertile Crescent and implications of the recent Syrian drought* (Kelley, Mohtadi, Cane, Seager & Kushnir, 2015) has demonstrated that the unrest in Syria came second to a record drought that provoked lower agricultural yields and forced farmers to migrate to urban areas. Global warming is already leading some to conclude that climate-change migrants are being forced to move because of extreme changes in the amount of rain and temperature changes wrecking their ability to farm (Griffin, 2017).

The *Lancet's* annual Countdown report (The Lancet, 2017) states that climate change could force a billion people from their homes by 2050, potentially triggering major health crises around the world, and says, "migration driven by climate change has potentially severe impacts on mental and physical health, both directly and through the disruption of essential health and social services" (Watts et al, 2017*)*. The report also reinforces the theory that the Syrian conflict was made worse by migration into the cities that was engendered by a drought that is to have been induced by climate change (Griffin, 2017).

Again, Brigadier General Stephen Cheney who forewarns (EJF, 2017) that:

> "If Europe thinks they have a problem with migration today… wait 20 years. See what happens when climate change drives people out of Africa - the Sahel especially - and we're talking now not just one or two million, but 10 or 20 million. They are not going to South Africa, they are going across the Mediterranean."

Under these circumstances, Sir David King, former chief scientific adviser to the UK government, disclosed with the Environmental Justice Foundation (Taylor, 2017):

> "What we are talking about here is an existential threat to our civilisation in the longer term. In the short term, it carries all sorts of risks as well and it requires a human response on a scale that has never been achieved before."

The Rising Tide of Climate Refugees

Forty millimeters. Conceivably 33 millimeters, or even no more than 23 millimeters. Roughly the thickness of a small pebble on the beach or the depth of a shallow rock pool. Had the people of the Mesolithic been told that these were the best deductions for the average yearly surge in sea level during the century following 7500 BCE, they would have presumably not advertised much unease and apprehension (Christensen et al, 1997). All in all, between 1900 and 1990 studies demonstrate that sea level ascended between 1.2 millimeters (Gillis, 2015) and 1.7 millimeters (Church & White, 2011) per year on average. By 2000, that rate had risen to about 3.2 millimeters per year and the rate in 2016 was estimated at 3.4 millimeters per year (Mooney, 2016). Furthermore, the scientific community agrees that sea level is foreseen to rise even more quickly by the end of this century (Willis, 2018) with such statistics essentially becoming indistinguishable from the ones that affected our ancestors millennia ago, and none of our governments seem too agitated about it (Mithen, 2004).

Admittingly, these figures sound negligible and insignificant, the ramifications of such water advancement for Mesolithic times were staggering: coastal catastrophe (Mithen, 2004). Its fundamental determinant was the final melting of the great ice sheets, especially those of North America. Millions upon millions of gallons of water gushed into the oceans and touched the lives of many thousands of people - sometimes quite literally (Törnqvist & Hijma, 2012; Smith et al, 2004; Mithen, 2004).

The Mesolithic coastal dwellers of Doggerland - the region now engulfed below the North Sea - began to see their landscape being reshaped- sometimes within a single day, sometimes within their lifetime, sometimes only when they recollected and reminisced what parents and grandparents had told them about lagoons and marshes now permanently drowned by the sea. A premature harbinger of change was when the ground became boggy, when pools of water and then lakes appeared in hollows as the water table rose. Trees began to suffocate while the sea dwelled quite distant. Soaring tides became higher and then refused to retreat. Sandy beaches were deluged. Coastal grasslands and woodland turned into salt marsh. The North Sea penetrated and ravaged Doggerland. Marine waters percolated their way into the valleys and around the hills; new peninsulas emerged, became offshore islands and then receded into the ocean (Mithen, 2004).

This example from a thousand years back is designated to portray that climate change and its effects are nothing new in the history of our planet. The rise in sea level and the dire consequences it creates are a part of the cycles of heating and freezing that the Earth has undergone many times during its course. The difference this time is that humanity is the leading force behind the global warming currently encroaching the planet, and with a population that has virtually occupied every corner of the world in high numbers and density, the effects of sea level rise will be much more disseminated and generalised, creating immense human misery in the process.

How far might the sea level rise? Rob Young and Orrin Pilkey note in *The Rising Sea* that planning panels in Rhode Island and Miami presuppose a minimum rise of 3.5 feet by 2100. A California planning study uses a 4.6-foot rise by century's end. The Dutch, for their coastal planning purposes, are assuming a 2.5-foot rise for 2050 (Young & Pilkey, 2009; 2010). If the Greenland ice sheet, which is well over a mile thick in places, were to melt all together, sea level would surge twenty-three feet. And if the West Antarctic ice sheet were to break up entirely, sea level would ascend sixteen feet. Together, the melting of these two ice sheets, which scientists believe to be the most exposed and open to attack by the elements, would raise sea level by thirty-nine feet. And this does not encompass thermal expansion as ocean water warms, a vital contributor to sea level rise (UNEP, 2007; 2009).

With this in mind, a study published by the International Institute for Environmental and Development has investigated the aftermath of a ten-meter (thirty-three-foot) increment in sea level. At the time of the study, the first thing observed was that 634 million people lived along coasts at ten or fewer meters above sea level, in what they call the Low Elevation Coastal Zone (McGranahan, Balk & Anderson, 2007). The most vulnerable country is China, with 144 million potential climate refugees. India and Bangladesh ensue, with 63 million and 62 million respectively. Viet Nam has 43 million vulnerable people, and Indonesia 42 million. Also in the top ten are Japan with 30 million, Egypt with 26 million, and the United States with 23 million. Some of the refugees could merely withdrawal to higher ground within their own country. Others - facing extreme crowding in the interior regions of their nations - would seek refuge elsewhere (McGranahan et al, 2007).

It is necessary to emphasize that all the populations of these countries - with the exception of Japan - have and are continuing to grow since the study was conducted, which means, that more people face this immediate danger than these projections account for. Since the list includes several countries with high fertility and base population, those numbers will probably reach additional millions - research from 2015 already put that value up to 760 million (Strauss, Kulp & Levermann, 2015; Surging Seas, 2015).

Demonstrably, in late August 2005, as Hurricane Katrina converged on the U.S Gulf Coast, more than one million people were pulled out from New Orleans and the small towns and rural communities along the coast. New Orleans withstood the initial hit, but it was overwhelmed when the inland levees were punctured and water covered large parts of the city (Brown, 2006). Once the storm passed, it was postulated that the million or so Katrina evacuees would, as in past cases, circle back to repair and rebuild their homes. Some seven hundred thousand did rebound, but close to three hundred thousand did not. Nor did they plan to do so. Most of them had no home or jobs to come back to. They were no longer evacuees. They were climate refugees (Brown, 2011). To put it another way, the first large wave of modern climate refugees surfaced in the United States - the country most accountable for the rise in atmospheric carbon dioxide that is warming the Earth. A point often overlooked is that New Orleans was the first modern coastal city to be, in some measured, deserted (Grier, 2005; Brown, 2006).

Coastal countries are exceptionally predisposed to sea-level rise, which leads to salt-water intrusion and increased salinity levels in agricultural land. Not to mention, emblematic for these regions are floods and waterlogging precipitated by cyclones and typhoons, as well as lengthened drought periods. According to the World Bank, salinity issues in Bangladesh will without a doubt induce considerable shortages of drinking water and irrigation by 2050. It is also conjectured that heightened soil salinity, both in coastal and inland areas, may result in a decline in rice yield by 15.6 percent, thus reducing the income of the affected farmers substantially (Gulden, 2017).

The situation is analogous in Vietnam where coastal areas are already under distress from sea-level rise and saline intrusion. Vietnam also endures strong storm surges, rising temperatures and variability in the seasonality of rainfall. Udaya Sekhar Nagothu from the Norwegian Institute of Bioeconomy Research, NIBIO explains:

> "Due to their extensive coastline and many river deltas, countries like Bangladesh and Vietnam are hotspots for climate change impacts such as sea-level rise and saltwater intrusion. High levels of salt in agricultural soil or irrigation water make it difficult for salt sensitive rice plants and other crops to absorb water and necessary nutrients, and as a result, plant growth is suppressed and crop yields significantly reduced” (Gulden, 2017).

By the same token, sea level rises will tarnish drinking water, obstruct agriculture and food production, alter the composition of plant life, threaten wildlife and impact biodiversity (Neumann, Yohe, Nicholls & Manion, 2000). It will demolish local economies and distress national and global economic stability and wealth (Mimura, 2013). Sea level rise and the salinity of soils that ensues can be regarded as a **[B]** link (figure 6.27), since climate change is decreasing the availability of land, which in turn forces populations to abandon their *places* due to food insecurity and loss of livelihoods.

River deltas accommodate some of the largest, most defenseless populations. These include the deltas of the Mekong, Irrawaddy, Niger, Nile, Mississippi, Ganges-Brahmaputra, and Yangtze Rivers. For example, a six-foot sea level rise would dislodge fifteen million Bangladeshis living in the densely populated Ganges-Brahmaputra delta (Young & Pilkey, 2010).

In effect, the London-based Environmental Justice Foundation (2009) defends that:

> “A one meter [three foot] sea-level rise would affect up to 70 percent of Nigeria's coastline affecting over 2.7 million hectares. Egypt would lose at least 2 million hectares in the fertile Nile Delta, displacing 8 to 10 million people, including nearly the entire population of Alexandria.”

Low-lying islands will also be hit hard. Correspondingly, the Islands of the South Pacific are regarded as exceedingly vulnerable to climate change, and they are regularly framed as sites of future - and in some accounts present - calamitous forced migration (Locke, 2009). As it was encapsulated in the most recent Intergovernmental Panel on Climate Change assessment report, there was a ‘risk of death, injury, ill-health, or disrupted livelihoods’ in small islands developing states ‘due to storm surges, coastal flooding, and sea-level rise (IPCC, 2014a). These are modifications that are known to impose migration and given that most communities in most small islands live in the coastal zone, and most livelihoods are contingent on natural resources, the risk that climate change may compel forced migration in the future should be seen as highly likely (Nurse et al, 2014).

The thirty-nine members of the Alliance of Small Island States stand to become dispossessed of part of their expanses of territory as sea level creeps further in. Among the most immediately endangered are Tuvalu, Kiribati, and the Marshall Islands in the Pacific Ocean and the Maldives in the Indian Ocean. Prior to total inundation, islanders face saltwater intrusion that can contaminate their drinking water and make it inconceivable for deep-rooted crops to persevere. Eventually, all crops will fail (Alliance of Small Island States, 2015). Some three thousand of

Tuvalu's ten thousand people have already migrated to New Zealand (Brown, 2011), which is also on track to creating the world's first humanitarian visa for climate refugees. The undertaking stems from a deep sense of climate justice, within New Zealand, like many developed countries, having historically been conducive to more climate change responsibility then small island developing states, that have low emissions profiles, and are facing the costs first-hand (Hall, 2017).

It is unambiguous that climate change is having a critical impact in the Pacific but it isn't the sole cause for migration since it can be impelled by many determinants - social, economic and political. Tarawa, the capital of Kiribati for instance, has strenuous overcrowding (Gray, 2013). Simon Donner, a climate scientists at the University of British Columbia maintain that:

> "Climate change is a definite long-term threat to Kiribati, there's no doubt whatsoever about that, but that doesn't mean it's the biggest problem right now… Any first-time visitor to Tarawa is not struck by the impact of sea level rise, they're struck by how crowded it is."

South Tarawa's population density of more than 3,000 per sq km is proportionate to Los Angeles or parts of London - without the high rises. The government fears South Tarawa's population could double to more than 100,000 by 2030 unless the birth rate and internal migration decelerate. Bwabwa Oten, Kiribati's director of hospital services, says current annual population growth in Kiribati is roughly 6 percent, with overcrowding a major component to disease and an infant mortality rate among the highest in the region (Gray, 2013).

Given the magnitude of future environmental transformations envisioned in the Pacific Islands due to climate change, it seems feasible to conceive that human forced mobility in the region will be strongly triggered to elevated numbers (Campbell & Bedford, 2014). Correspondingly, communities in coasts, deltas and floodplains are markedly susceptible, and resettlement inland is a plausible coping mechanism (McNamara & Des Combres, 2015). Unfortunately, in the longer term, the lack of higher ground may signify some atoll populations may need to relocate to other islands or other countries (Barnett, 2017; Barnett & McMichael, 2018).

In the long run, populations escaping the advance of the rising tide will most likely amass the biggest share of climate/environmental refugees. Notwithstanding, there are other categories worth being reviewed.

The second category of environmental refugees is also closely related to the augmentation of global temperatures and its ensuing consequences. A higher surface water temperature in the tropical oceans translates into more energy to drive tropical storms systems, which can induce more devastating storms. The mixture of more vigorous storms and potent storm surges can be devastating, as New Orleans discovered (Brown, 2011) and as the rest of the world slowly comes to realize (the previous segment ***In Extremis*** considerably illustrates this new reality extensively).

The regions that are most at risk for more-mighty and calamitous storms are Central America, the Caribbean, and both the Atlantic and Gulf coasts of the United States. In Asia, where hurricanes are called typhoons, it is East and Southeast Asia, including Japan, China, Taiwan, the Philippines, and Vietnam, which are most at risk. The other region in danger is the Bay of Bengal, particularly Bangladesh (Brown, 2011).

A third source of refugees stems from encroaching deserts, which are now on the move almost everywhere. The Sahara Desert is widening in every direction. As it advances northward, it is compressing the populations of Morocco, Tunisia, and Algeria against the Mediterranean coast. The Sahelian region of Africa - the vast swath of savannah that separates the southern Sahara Desert from the tropical rain forests of central Africa - is withering and narrowing as the desert moves southward. As the desert breaches Nigeria, Africa's most populous country, from the North, farmers and herders are forced southward, choked into a dwindling area of productive land. Some desert refugees end up in cities, many in illegal settlements and tents, and others migrate abroad (Brown, 2011).

While the world's forests, farm areas and grasslands are on the retreat, only the deserts continue to advance. The UN appraises that 6 million hectares of productive land, an area roughly the size of England is being lost to desertification every year (Saier, 2010) with the FAO foreseeing that by 2030 Africa alone will surrender two-thirds of its land to the march of desertification, henceforth prompting ever more people to relinquish their lands and move (Bafana, 2017). Under these circumstances, the UN projected that until 2045 up to 135 million people could be displaced globally due to the encroachment of deserts (Global Humanitarian Forum, 2009; UNCCD, 2018).

As it has been already stressed in the segment On Dangerous Grounds - dedicated to soil degradation and its connection to food security - at the start of the Syrian uprising in 2011, before it assumed the form of the tragic and drawn-out civil war, it became the accepted view that one major trigger of the revolt was a harsh drought that drove farmers to the cities (and before that the policies of unrestricted pastoralism), which added to the political adversity that then exploded in the streets (Laipson, 2018). Scientists have conceived two major investigations into the drought that have provided plausible and cogent evidence (Freedman, 2016) of its severity and potential to unsettle normal economic patterns, in one case concluding that from 1998 to 2012, the Levant region withstood its driest conditions in 500 years (Kelley et al, 2015).

In the same way, Iran has been confronted by Malthusian perils that stem from the encroachment of desertification, of its central plateau, converting large portions of the country into inhospitable regions (Laipson, 2018). Villages vacated on the grounds of the diffusing deserts or scarcity of water number in the thousands. In the proximity of Damavand, a small town within an hour's drive of Tehran, eighty-eight villages have been forsaken (Iranian News Agency 2002, quoted in Brown, 2009). Soil erosion is comparatively considered a paramount menace to this arid country, and according to Agriculture Ministry of Iran has exceeded 900 million tons, which translates into six tons of soil loss per hectare (Financial Tribune, 2018). Expressly, environmental matters can be overruling and even ominous in the crowded and contested space of many Middle Eastern societies (Laipson, 2018).

In Latin America, expanding deserts are obliging people to move in both Brazil and Mexico. For example, in Brazil, some 250,000 square miles of land is impaired in this way, much of it concentrated in the country's northeast (Matallo, 2006 quoted in Brown, 2011; Brown, 2005). Likewise, in Mexico, many of the migrants who abandon rural communities in arid and semiarid regions of the country each year are compelled to do so because of desertification. Some of these environmental refugees end up in Mexican cities; others cross the northern border into the United States. With attention to this, U.S. analysts conjecture that Mexico is forced to abandon four hundred square miles of farmland to desertification each year (Schwartz & Notini 1994; Alscher, 2010).

In China, desert expansion has sped up in each successive decade since 1950, due to overgrazing by livestock, over cultivation, excessive water use and climate change (Nieuwenhuis, 2016).

Desert scholar Wang Tao asserted that over the last half century or so, roughly twenty-four thousand villages in northern and western China have been conquered by the elements either entirely or partly because of desert expansion (Wang et al, 2004). Indeed, China's Environmental Protection Agency discloses that from 1994 to 1999 the Gobi Desert widened by 20,240 square miles, an area half the size of Pennsylvania, and every year is responsible for gobbling up 3,600km^2 of grassland (Tudela, 2012). With the advancing Gobi within 150 miles of Beijing, China's leaders are coming forth to sense the gravity of the situation (Yan, Wang, Song & Xie, 2017), when taking into consideration that desertification is imperiling subsistence for about a third of China's population, which corresponds to hundreds of millions of people, especially those in the north and west, and also fomenting political and economic instability (Luedi, 2016) - it costs the nation around 6.9 billion dollars per year (Tao, 2014).

In the book *China's Environmental Crisis: Domestic and Global Political Impacts and Responses* (Kassiola & Guo, 2010) the authors state:

> "For seriously desertified regions, the loss amounts to as much as 23.16 percent of … annual GDP. [droughts damage] about 160,000 square kilometres of cropland each year, double the area damaged in the 1950s."

The fact that one-third of the nation's land area is now deteriorated has prompted some 400 million people to wrestle with the scarcity of productive soil, unpredictable climatological conditions and relentless water shortages. As a result, the Chinese government initiated a contentious "ecological migration" programme (Tsunekawa, Liu, Yamanaka & Du, 2013) to redistribute millions of people from dry and barren territories to other regions (Nieuwenhuis, 2016).

The U.S. Dust Bowl of the 1930s, which was generated by overplowing and triggered by drought, forced more than two million inhabitants to abdicate the land, many of them heading west from Oklahoma, Texas, and Kansas to California. In contrast, the dust bowl taking shape in China is much larger, and so is the population: during the 1930s the U.S. population was roughly 150 million - it sits in 2018 at around 325 million, compared with China's 1.3 billion. Whereas U.S. migration was calculated in the millions, China's may account for tens of millions. And as a U.S. embassy report entitled *Grapes of Wrath in Inner Mongolia* underlined, "unfortunately, China's twenty-first-century inhabitants have no California to escape to - at least not in China" (Montgomery, 2012; Brown, 2011).

The fourth group of people who will be inducted to depart from their homes are those in places where water tables are weakening and abating. With the lion's share of the three billion people conceived to be supplemented to the world by 2050 being born in such countries, water refugees are to all appearances to become prevalent. They will be most customary in arid and semiarid regions where populations are eclipsing the water supply and sinking into hydrological poverty (Brown, 2011). In particular, villages in northwestern India are being relinquished as aquifers are exhausted and people can no longer unearth water. Millions of villagers in northern and western China and in northern Mexico, face dire fates by constant consternation about having to be uprooted due to the dearth of water reserves (Shah, Molden, Sakthivadivel & Seckler, 2000).

Still, it is the African continent that is most affected by displacement, with more than 15 million people being internally displaced in 2015, for a multitude of reasons, in which environmental ones are also concerned (Laczko & Aghazarm, 2009). With more than half of the world's fragile states being located in sub-Saharan Africa, as well as the continent being predisposed to droughts, it becomes increasingly susceptible to food and water scarcity (Laczko & Aghazarm, 2009; Niang et al, 2014).

Hussein Amery, a Middle East water expert from the Colorado School of Mines, states it in a straightforward fashion:

> "Water scarcity is forcing people off the land" (quoted in Amos, 2010).

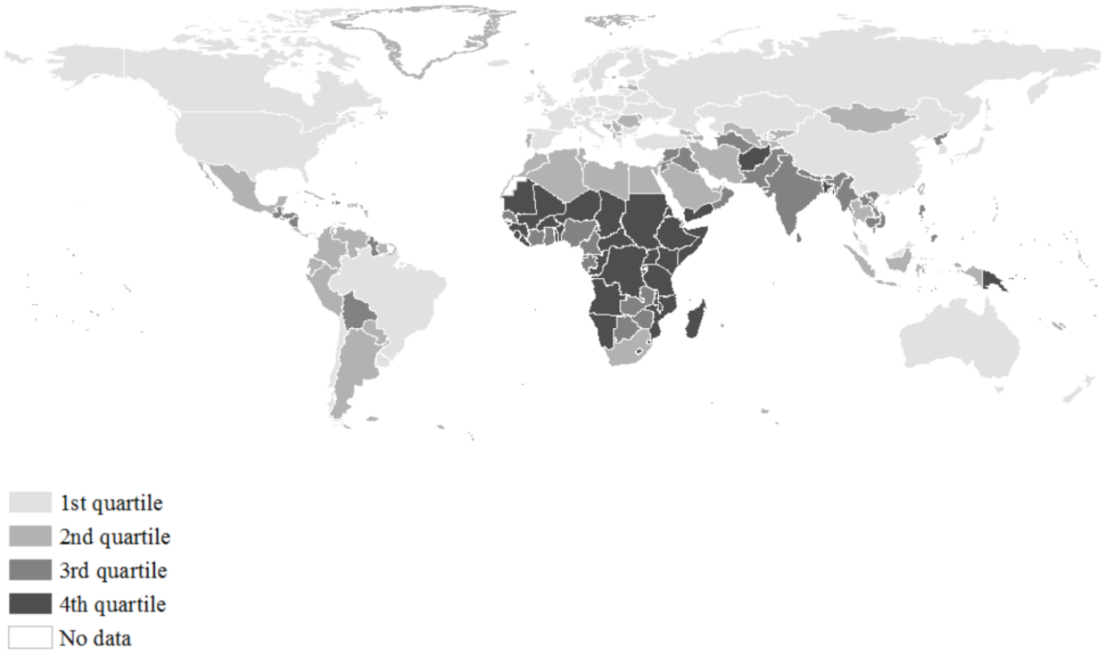
The theme of water scarcity is further explored in the previous chapter, in the segment Watermark.

In a final analysis, there is a conspicuous spatial patterning in climate vulnerability scores across population and places, as these categories of climate susceptibility demonstrated. Countries can be measured on a scale of vulnerability and susceptibility to climate-change-induced-migration, as figure 6.30 and 6.31, which refer to the 2010-2015 period, portray. To that effect, countries in the first climate vulnerability quartile are the least vulnerable to climate change. The preponderance of the countries in the first climate vulnerability quartile are located in North America, Europe, and Eastern Asia. Countries in the fourth climate vulnerability quartile are the most imperiled by climate change, and comprehend most countries in Sub-Saharan Africa, as well as others in South America (Grecequet et al, 2017).

There is also evidence of spatial patterning in rates of net migration across countries during the 2010-2015 period. Countries with the highest positive rates of net migration underwent the more considerable population increases due to migration. These implicated countries in North America (e.g., Canada and the United States), Europe (e.g., Germany, the United Kingdom, and the four Nordic countries of Denmark, Finland, Norway, and Sweden among others), Western Asia (e.g., Qatar, Saudi Arabia, Turkey, etc), Oceania (e.g., Australia) and South-Eastern Asia (e.g., Malaysia). Countries with the most negative rates of net migration sustained the largest population debits due to migration. These countries are disseminated across most world regions, with Syria, Libya, Tonga, Georgia, and Samoa weathering the lowest negative rates of net migration (Grecequet et al, 2017).

Countries that are dissipating and exhausting their environmental resilience, through water scarcity, severe weather or the loss of natural resources by increases in demand from augmented populations, have to make pragmatic and sometimes burdensome choices about how to sustain life and multiply jobs in defying conditions. Some countries can prosper from early interventions to alleviate the trappings of climate change and to be more conscientious stewards of their natural resources. In some cases, it may mean abdicating crops that impoverish water resources, or ushering in new technologies to improve water efficiency (Laipson, 2018). Good governance is a necessary ingredient, since so many countries have squandered what could have been sources of national wealth through corruption and illicit trade (Anderson, 2015).

All things considered, Steve Trent, the former chief scientific adviser to the UK government states that although climate change assuredly posed an "existential threat to our world" it is not too late to take decisive action (Taylor, 2017). He argues:



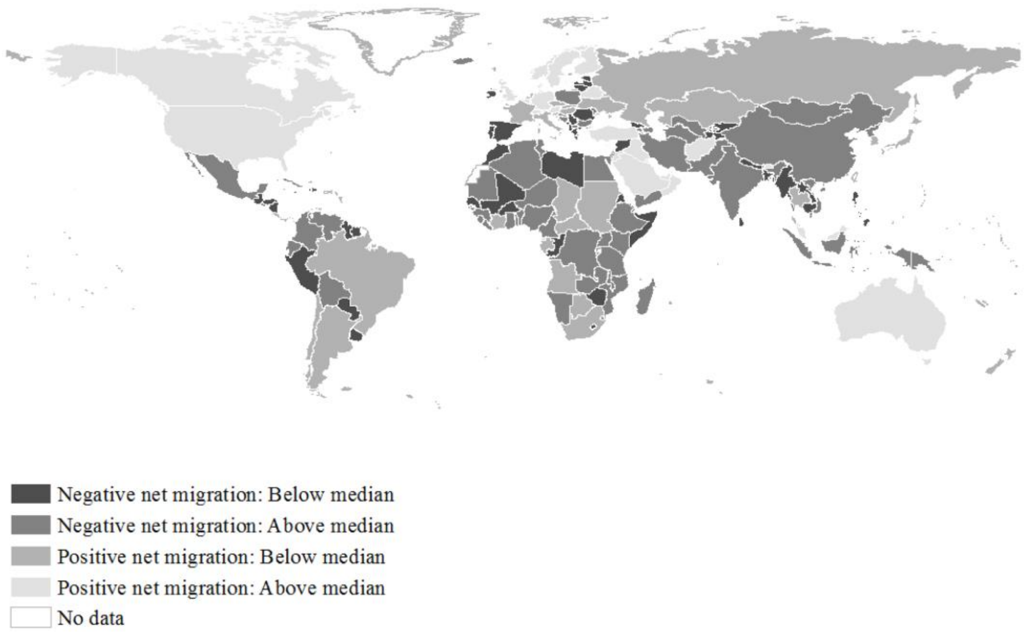


Figure 6.30: **Climate vulnerability score,** 2010. Shading reflects climate vulnerability quartiles, with cut points of 0.35 (25th percentile), 0.43 (50th percentile), and 0.54 (75th percentile). Mean climate vulnerability score was 0.44, with a range of 0.47 (min = 0.22; max = 0.69). Data taken from the Country Index of the Notre Dame Global Adaptation Index (ND-GAIN), and cover 179 countries. Data deficient countries shown in white. From Grecequet et al, 2017.

Figure 6.31: **Net migration rate per thousand population**, 2010–2015. Net migration rate is an occurrence-exposure rate, calculated as the difference between in- and out-migration flows, divided by total person-years lived in the five-year window. Negative (darker shading) and positive (lighter shading) net migration rates indicate population loss and gain due to migration, respectively. Negative and positive net migration rates are further cut at 50th percentiles, with values of −1.46 and 2.45 per thousand, respectively. Mean net-migration rate was 0.44 per thousand, with a range of 121.18 (min = −38.90 per thousand; max = 82.28 per thousand). Data provided by Abel (2015). Countries for which for which data are not available and/or for which data are not also available from the Country Index of the Notre Dame Global Adaptation Index (ND-GAIN) shown in white. From Grecequet et al, 2017.

> "By taking strong ambitious steps now to phase out greenhouse gas emissions and building an international legal mechanism to protect climate refugees we will protect the poorest and most vulnerable in our global society, build resilience, reap massive economic benefits and build a safe and secure future for our planet. Climate change will not wait. Neither can us. For climate refugees, tomorrow is too late."

However, 'Borlaugian' (recall chapter Prometheus) ideologies can only go so far if population growth is not put to a halt. For all the gains acquired through innovation and efficiency development, these are in turn revoked when more consumers and passengers and brought upon this world. After all, when contrasting the average fertility (figure 6.32) rate with figure 6.30's climate vulnerability a pattern begins to take shape. I must signal that I do not claim that a correlation between climate vulnerability and fertility rates is at work here, much less a causation. What I will argue, is that in fact, the world regions that are considered to be the most vulnerable also appear to demonstrate the most elevated fertility rates, although I can safely assert that when the carrying capacity of regions is clearly being breached, no amount of technological revolution will tower above the hardship and despair faced by populations that are begetting more life than the ecosystems can sustain.

As it was previously discussed in the segment Friend or Foe? mounting humanitarian relief programs are crucial and vital for populations undergoing misfortune and facing adversity, but these have to be supplemented with reliable and safe access to contraceptive methods, abortion services, and family planning courses, in order to have the goal of decreasing population growth, and the final ambition to reduce the number of people exposed to wretched and agonizing circumstances.

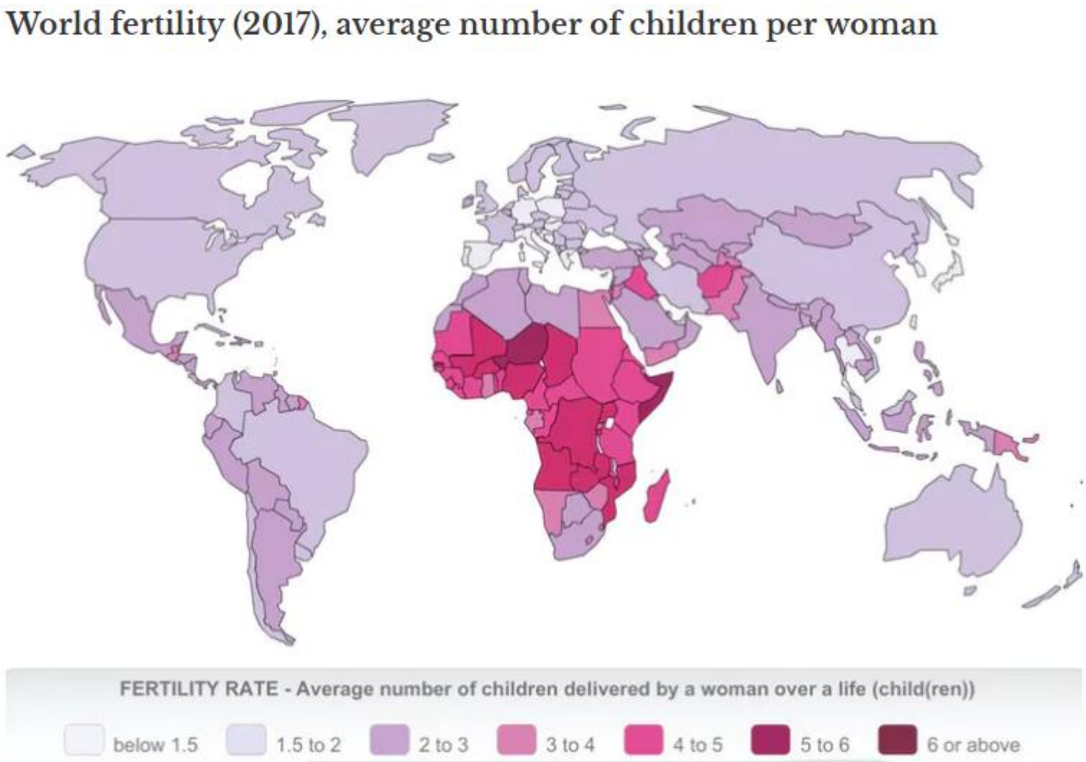


Figure 6.32: World fertility (2017), average number of children per woman. Gilles Pison (2017b), based on United Nations data, CC BY-SA.

This segment is meant to be an introductory section for the theme of migration that is examined in a far more detailed fashion in the next chapter Exodus, nevertheless, at this point in the document, the reader can presumably draw his or her own inferences and postulate that the internal displacement and immigration of climate refugees won't be solved by accepting millions or tenths of millions of people into developed nations, while the developing world (special attention to the African continent and India), is responsible for begetting the most substantial share of human life (table 6.1). Coincidentally enough, these are the countries with the highest vulnerability to climate change, so internal displacement and migration are highly likely scenarios.

Region	*Population (millions)*			
	2017	*2030*	*2050*	*2100*
World	7 550	8 551	9 772	11 184
Africa	1 256	1 704	2 528	4 468
Asia	4 504	4 947	5 257	4 780
Europe	742	739	716	653
Latin America and the Caribbean	646	718	780	712
Northern America	361	395	435	499
Oceania	41	48	57	72

Table 6.1: Population of the world and regions, 2017, 2030, 2050 and 2100. According to the Medium- Variant Projection. United Nations, Department of Economic and Social Affairs, Population Division (2017). *World Population Prospects: The 2017 Revision.* New York: United Nations.

If we want to avoid falling prey to a condition in which we keep chasing our own tails in this international stage of cracks and ruptures in human rights affairs, the most efficient procedure would be for countries to harness their resolve and mount an international initiative and plan of action to have a homogenous and shared human fertility rate, on a global level. Humanity - and the rest of non-human life - is not in a position to keep neglecting and overlook the weight that procreative decisions of individuals all over the world - but crucially for this immigration debate in the developing world - will have on the world stage.

If the reader is still on the fence about our collective responsibility to override personal procreative decisions - and think about our place on this planet not just as individuals and populations, but as a species among many other such species that have as much right to be passengers on this Earth as we do - or that it falls dangerously close to accusations of racism or xenophobia for humans with contrasting phenotypic characteristics to go around and discuss their reproductive choices, I would exhort the reader to give this work another chance in the upcoming chapter Exodus and ensuing Volumes II and III, where I will go deep into the business of the morality of procreation, access to available and reliable contraceptive methods, the necessity to have legal and safe abortion procedures, education, the banning of child marriage, equal rights for women among many other subjects. For now, please do consider not abandoning ship, as we are reaching the climax of this essay.

CHAPTER VII

EXODUS

"What becomes of the surplus of human life? It is either, first, destroyed by infanticide, as among the Chinese and Lacedaemonians; or, second, it is stifled or starved, as among other nations whose population is commensurate to its food; or, third, it is consumed by wars and endemic diseases; or fourth, it overflows, by emigration, to places where a surplus of food is attainable."

- James Madison US President 1801-1809 (1751 - 1836)

Figure 7.1: Migrant crisis in Europe at its peak, in the summer of 2015. Retrieved from Sandbrook, 2017.

In our contemporaneous swelled and interconnected world, international migration has become an absoluteness that stretches to nearly all corners of the globe. Present-day transportation has made it manageable, inexpensive and expeditious for people to move in search of jobs, opportunity, education and quality of life. Simultaneously, conflict, poverty, inequality and a lack of sustainable livelihoods impel people to forsake their homes to seek a better future for themselves and their families abroad.

Migration is one of the most imperative and clamant matters of contention of the here and now. The issue stands out in the global narrative because the world is experiencing an unparalleled and *sui generis* surge in population movement as people seek shelter from conflict, relinquish their material belongings to circumvent poverty or lose their sustenance due to climate change. In order to ensure intrinsic aspirations like, the longing to be safe with their families, to see their children mature and blossom as healthy, strong and educated individuals, as well and to provide the next generation more opportunities than what prior ones might have had. Owing to this, humans have traversed and sought better conditions in far-away places from time immemorial (UNICEF, 2017).

The International Organization for Migration (IOM, 2017) describes the term and the contemporary state of affairs as the following:

> "Migration is a term that encompasses a wide variety of movements and situations involving people of all walks of life and backgrounds. More than ever before, migration touches all States and people in an era of deepening globalization. Migration is intertwined with geopolitics, trade and cultural exchange, and provides opportunities for States, businesses and communities to benefit enormously. Migration has helped improve people's lives in both origin and destination countries and has offered opportunities for millions of people worldwide to forge safe and meaningful lives abroad. Not all migration occurs in positive circumstances, however. We have in recent years seen an increase in migration and displacement occurring due to conflict, persecution, environmental degradation and change, and a profound lack of human security and opportunity. While most international migration occurs legally, some of the greatest insecurities for migrants, and much of the public concern about immigration, is associated with irregular migration."

International migration is a Daedalian and a labyrinthine phenomenon that encroaches on a multitude of economic, social and security aspects affecting our daily lives in an increasingly interconnected world (IOM, 2017). Despite the fact that migration is natural to humans, at present, the perception of the phenomenon has convoluted into a spiral of complexity. The theme is at present, hugely deliberated because it interferes with points of several orders, such as state sovereignty, national identity, abiding by the law, the continuity and feasibility of the social State, employment, population, public health, national and cultural identity, the external and international relationships, internal and peripheral security and public order. All the aforementioned reasons, make immigration one of the most prevailing themes contested in public debate, as well as one of the main components of state politics (Gil, 2017).

Environmental change and environmental degradation - desertification, deforestation, land degradation, loss of ecological functions and services, loss and extinction of populations and species, climate change, water scarcity - are fundamentally reshaping the map of the world. Environmental degradation influences where and how people are able to live. It drives human displacement and forced migration by imperiling lives and making people's sustenance untenable, particularly the poorest and most vulnerable (UNEP, 2016). Further still, there is a generalized agreement that one of the determinant forces driving worldwide displacement of people is globalization; which is diagnosed with increased pauperization of natural environments, increased inequality in the distribution of wealth and required resources, escalating contamination of air, water and soil; overall, it is extensively acknowledged that neo-liberal market mechanisms (as presently implemented) cannot overcome ecological limits (Karam, 2008; Kates, 2004; Chapman, 2000; Daly, 2000; Pimentel, Giampietro & Bukkens 1998).

Environmental issues have been one factor in population movements ever since humans set out to explore the world outside of the African continent. Those factors have always been heterogeneous and complex, the difference now is the degree to which environmental degradation and the ability to move are linked to create a mass exodus on a scale never seen before (Ionesco et al, 2017). Figure 7.2 portrays the influence of environmental change on the drivers of migration.

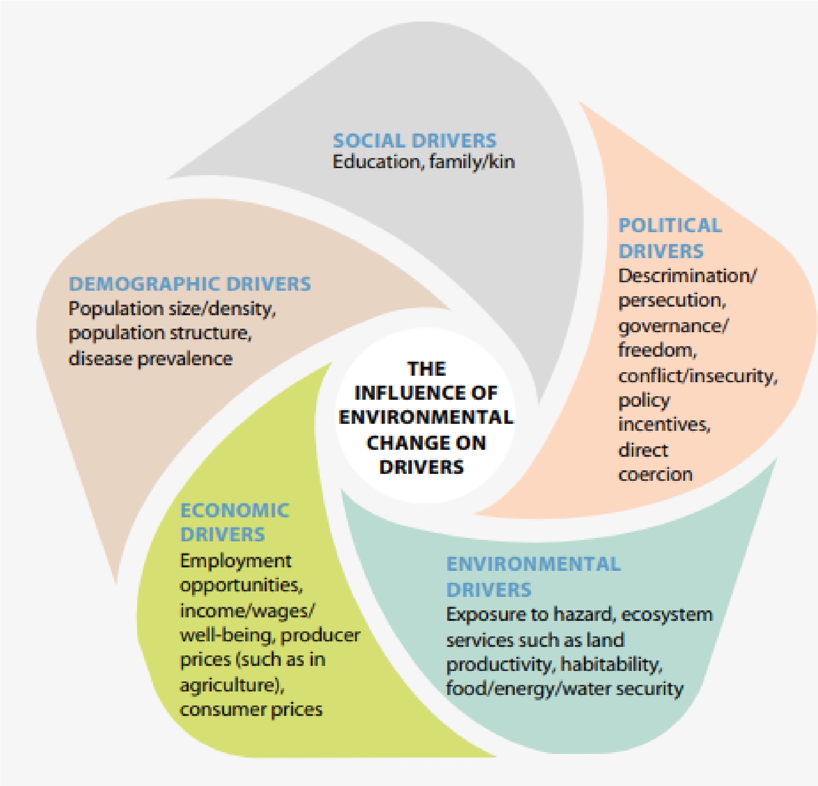


Figure 7.2: Adapted from the conceptual framework of the drivers of migration and the influence of environmental change, adopted by the UK Government's Foresight Project. Government Office for Science (2011). Foresight: Migration and Global Environmental Change: Future Challenges and Opportunities. Final Project Report. The United Kingdom Government Office for Science, London. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/287717/11-1116-migration-and-globalenvironmental-change.pdf. Retrieved from ENVIRONMENTAL DISPLACEMENT: HUMAN MOBILITY IN THE ANTHROPOCENE - FRONTIERS 2017: EMERGING ISSUES OF ENVIRONMENTAL CONCERN (UNEP, 2017).

In a world where most of all, population growth is leading to more people living in marginal and environmentally vulnerable areas (Huppert & Sparks, 2006), the interlacing trends of climate change, rising consumption, large infrastructure projects and environmental degradation may produce larger numbers of people being displaced. This is particularly likely if these trends are met in a context of inappropriate responses on the part of governments and international communities to build resilience (UNEP, 2017), but also for nations to be reflective and resolved on the matter of prevention by stabilizing unrestrained population growth, by tackling elevated fertility rates.

In a world inhabited by ever more humans, on conditions that are quickly degenerating as to provide a dignified life, the most commonly cited figure is that there could be as many as 200 million additional people on the move for environmental complications by 2050 (Ionesco et al, 2017), on top of the almost 258 million already accounted to be international migrants in 2017 - 3.4 percent of the world's population (Batalova, Shymonyak & Mittelstadt, 2018). That would translate to, in a world of 9.9 billion people (projection by 2050), one in 45 would be forced to relinquish their home for environmental justifications, and entire low-lying island territories may have to be deserted. Addressing such a large scale diaspora might be the defining environmental, social, political and civilizational challenge of the 21st century (UNEP, 2017).

Even though the theme of mass migration has achieved some prominence in recent years due to Europe's 'migration crisis,' it is not exclusive to that region. Just as migration takes place across the globe, every corner of the world has the potentiality to be affected by environmental displacement, be it on the source or the receiving end. For example, models extrapolate that the Asia and the Pacific region will experience an upsurge in deracination as the impacts of climate change run amok (Hijioka et al, 2014; Cruz et al, 2007).

A point often overlooked is that displacement itself can contribute to further the impacts on the environment. Informal urbanization or disorganized refugee camps can also exert a strenuous effect on scarce land, water, energy and food resources. These situations can cripple ecosystem services, lead to health risks from improper water disposal and increase direct competition for resources with local communities (Berry, 2008; Xu, Tan & Yang, 2013). Equally important is the fact that planned relocation of populations in the face of a specific environmental risk, such as major land degradation can act as a release valve, reducing environmental constraints on ecosystems that have surpassed their carrying capacity, but, at the same time, 'exporting' their footprint elsewhere (Foresight, 2011).

This condition of transferring the environmental impact of one region to another through migration will be a recurring issue discussed throughout this chapter. It becomes an emerging matter when taking into account migration from developing nations to the developed world, since that permutation will most likely also modify one's consuming habits and behaviors. Considering that the average ecological footprint of developed nations is far higher than that of the developed world, one has to expostulate that through migration, an increment of the ecological footprint is a reality that has to be cogitated. Markedly, it is one of the main postulates of the restriction of migration to developed nations, since not only are individuals increasing their ecological footprint, contributing to further accelerate climate change problems, but immigration is also the main cause of population growth in the developed world, where it is most urgent that a reduction in consumption patterns occurs. This chapter will focus, among other things, on the synergetic effects of population growth, ecological footprints and immigration, and attempting to answer the question of: "Is it ethically justifiable to have a restrictionist migration policy based on environmental degradation?"

In her book, *Immigration and Human Rights* (2017), Ana Rita Gil, an expert in fundamental human and asylum rights and immigration law, makes the case that the study of immigration and human rights has been hugely influenced by disciplines such as sociology as well as political science and political philosophy. My objective, is that the reader may connect immigration to all the curriculums and branches of knowledge already probed and scrutinized during the extent of this work, and see immigration as an imperative and pivotal theme that requires a wide range of interdisciplinarity to understand and make sensible as well as analytical decisions.

Immigration will presumably persist as a first concern on the political agenda in both developing and industrialized countries during the following decades. Withal, it is not yet clear what role environmental issues will play in the academic and political discussion. So far, environmental and ecological concerns have been rather peripheral in the political debate about immigration in the U.S. and Europe. Even so, among activist groups and academic circles, particularly in the U.S., a dialectic regarding the environmental/ecological significance as well as ramifications of immigration has been initiated. The academic discussion on this topic is highly quarrelsome, petulant and belligerent at times, due to the fact that the disputation developed by scholars is highly dependent upon political stances, assumptions, scales of analysis and adopted perspectives. In practice, it is hard to disunite the academic debate from the political one, since initial value judgments - for instance determining the way the positive and negative social, cultural, environmental and economic effects of immigration are weighted and summed up - need to be taken into account (Muradian, Neumayer & Røpke, 2006).

In the Intelligence Squared debate *If You Believe You Are a Citizen of the World, You are a Citizen of Nowhere* (2018b), the historian Simon Schama professes that:

> "There are three enormous long-term, dominant, problems over the next half-century. One is the fate of the ecology of the Earth, the other is the immense and growing distance between the well-off and the not so well-off inhabitants of this planet, and thirdly, there is this great tidal-wave of migration, which is not going to really go away over the long-term. These are going to be three profound upheavals that are going to affect long-term history."

To this effect, the *International Migration Report* from the United Nations (UNDESAPD, 2017) highlights that:

> "Between 2000 and 2015, positive net migration contributed to 42 percent of the population growth observed in Northern America and 31 percent in Oceania. In Europe, instead of growing by two percent, the size of the population would have fallen by one percent in the absence of a net inflow of migrants."

Keeping this information in mind - and recalling that the main thesis of this work is the revision of the demographic dynamics that are leading to ecological and environmental disturbances, and the defense of a reduction of the human population - the next segment will delve into the pre-historical roots of immigration and consociate it with an innate and instinctive trait shared by all beings with locomotive capabilities, as well as attempting to distinguish what made *Homo sapiens* virtually capable of colonizing every available expanse of this planet. The postliminary segment consists of a variety of descriptive and quantitative data that get the measure of our contemporaneous trends in international migration. The graphs and predictions will have, mainly, a neutral predisposition, but I would ask of the reader to remain conscious and aware of the shadow of overpopulation/consumption while presenting the data. With this in mind, further elaboration and commentary will follow in the ensuing segments.

To commence this inquiry, a historical examination into the roots of human existence will be fruitful and advantageous, in order to illustrate the universality of this practice among all the beings that natural selection and evolution have shaped to carry such a faculty. In spite of the gap in time that separates us today and our human ancestors, I intend to establish in the next segment, that we were and are constrained and confined by the same natural limits, which ultimately, draw us together.

The Great Leap Forward

"History shows that it is not only senseless and cruel, but also difficult to state who is a foreigner."

- Claudio Magris, *in* Danube: A Sentimental Journey From the Source to the black Sea

Something that we can assuredly assess about *Homo erectus* is that their population size was thriving. It is infeasible to gauge with precision how many of them there were, or how fast they were expanding their numbers. But the conjecture becomes palpable and indisputable on the grounds of the geographic spread of their population by virtue of the scattered and dispersed *Homo erectus* fossils across Africa. *Australopithecus*, as well, numbers among a widely spread throughout the Rift Valley of East Africa, down to South Africa. As time went by in the Pleistocene, *Homo erectus* eventually branched off into North Africa, and beyond (McKee, 2003).

Indeed, *Homo erectus* was the inaugural and primogenial pioneer of our ancestors to move outside the confines of the African continent, possibly as early as 1.7 million years ago, as told by the earliest non-African *Homo* fossils - those of Dmanisi, Georgia (Gabunia et al, 2000). Positively, by one million years ago, if not earlier, they had advanced as far as East Asia (McKee, 2003).

With an embryonic population of just twenty individuals, at a population growth rate of 0.01 percent (which is a small fraction of today's human growth rate of roughly 1.2 percent), there would be over 65 million *Homo* erectus individuals in just 150,000 years. If each individual required one square kilometer to find commensurate subsistence, then some of the growing population would have had to spill from Africa after 142,320 years. Acknowledging as well that not all of Africa would have been all that welcoming and alluring: the Sahara desert was set up to endure by the Pleistocene epoch, and probably would have confined human expansion in that area. Moreover, there is ambivalence with respect to how well our ancestors would have made headway in other demanding environments such as mountains, which may also have thwarted even the most versatile mammal of the time. The tropical and subtropical regions of Asia would have manifest more enticing features to our ancestors, and thus we find the earliest evidence of movement beyond Africa at the West Asian Dmanisi fossil site of 1.7 million years ago - shortly after the appearance of *Homo erectus* (McKee, 2003).

Homo erectus populations must have been microscopic compared to our own, and it is not easy to envisage the humongous continent of Africa not satisfying all their needs. Then again, given the progressively meat-based diet and possible use of fire among the *erectus,* the steadfast accumulation of modest reproductive success likely would have constrained local resources, stimulating hominids to stroll and stray widely in search of new lands. During much of the past, migration was likely triggered by population growth that could not be sustained without dispersal (Engelman, 2008).

The most likely conjecture for what sent the first bipedal primates out of Africa is a prehistoric version of crowding. The undeviating survival of third children pressured populations outside the limits of what local animal prey and food plants could stomach. Without agriculture, diluted and emaciated populations of hominids that scantily crossed paths with each other on the landscape would nonetheless have withstood scarcity. To manage the low population-to-land ratios their survival demanded, the groups would inevitably have no alternative but to spread out (Engelman, 2008).

Clive Gamble, in his book *Timewalkers* (1993), avouches that most migration was pioneered by fleeting and transient incursions into uncharted territory, and when the pilgrims returned to the larger conglomerate with gossip and evidence of new and auspicious territory, they acquired status, that could be taken advantage of to become leaders of new groups that fissioned off and wandered away (Engelman, 2008).

In spite of the efforts of those hominids to endeavour ever farther and farther afield, they couldn't always outpace sparsity. A multitude of demographers diagnoses resource shortages as the major check on population growth throughout prehistory. The paltry *carrying capacity* of the landscape – the theorized highest population of organisms that a unit of land can support – established extremities on human density (Engelman, 2008). The genus *Homo* has an inborn predilection to seize all befitting habitats and use up all vacant resources. This insinuates that human migration has an ancient biobehavioral tap-root. People have always sought out greener – or at least tenantless – meadows. This is how we have come, over the past 50,000 years, to have jurisdiction over a geographic range unparalleled by that of any other mammalian species. Humans have come to occupy virtually the entire planet (Rees, 2008).

Present Day

According to the United Nations *International Migration Report 2015* (UNDESAPD, 2016), there were, globally, 244 million international migrants in 2015. This number has escalated to 258 million in 2017, up from 220 million in 2010 and 173 million in 2000. Amidst 2000 and 2005, the international migrant figure widened by an average of 2 percent per year. In the interim of the course of 2005-2010, the annual growth rate sped up, reaching 2.9 per cent. Subsequently, however, it has slowed, ebbing to around 2.4 per cent per year during the period 2010-2015 and to 2.0 per cent per year during the period 2015-2017 (UNDESAPD, 2017).

In 2017, of the 258 million international migrants worldwide, 106 million had Asia as their continent of birth (Table 7.1). Europe succeeded Asia with 61 million individuals. Regarding European migration this data requires some scrutiny, as The Schengen Agreement permits the free movement of individuals between European countries, in what came to be known as the Schengen Area, and most likely, played a considerable role in the the 41 of the 61 million international migrations accounted in Europe, as figure 7.3 illustrates. Subsequently, Latin America and the Caribbean amounted to 38 million, and Africa's share was of 36 million. Not surprisingly, scarcely any migrants were born in Northern America (4 million) or Oceania (2 million). All things considered, when inspecting each region's proportionate share in the world population, international migrants from Europe, Latin America and the Caribbean as well as from Oceania were overrepresented, whereas migrants from Asia, Northern America and Africa were underrepresented, when taking into account the total population of each region (UNDESAPD, 2017).

Between 2000 and 2017, the number of international migrants emanating from Asia documented the largest upsurge (40.7 million), succeeded by the migrant population originated from Africa (14.7 million), in Latin America and the Caribbean (12.9 million), in Europe (11.6 million), in Northern America (1.2 million) and in Oceania (700,000) (see figure 7.3). In comparative terms, however, the number of international migrants born in Africa registered the most substantial increase since 2000 (+68 per cent), followed by the population of migrants born in Asia (+62 per cent), in Latin America and the Caribbean (+52 per cent) and in Oceania (+51 per cent) (UNPD, 2017).

Share of regions in world population and international migrants by origin (in thousands), 2017

	Total population	Percentage of global population	International migrants by origin	Percentage of international migrants
World	7,550,262	100.0	257,715	100.0
Africa	1,256,268	16.6	36,266	14.1
Asia	4,504,428	59.7	105,684	41.0
Europe	742,074	9.8	61,191	23.7
Latin America and the Caribbean	645,593	8.6	37,720	14.6
Northern America	361,208	4.8	4,413	1.7
Oceania	40,691	0.5	1,880	0.7
Unknown	n/a	n/a	10,560	4.1

Table 7.1- Source: United Nations, Department of Economic and Social Affairs, Population Division (2017a). Trends in International Migrant Stock: The 2017 revision (United Nations database, POP/DB/MIG/Stock/Rev.2017).) (UNDESAPD, 2017).

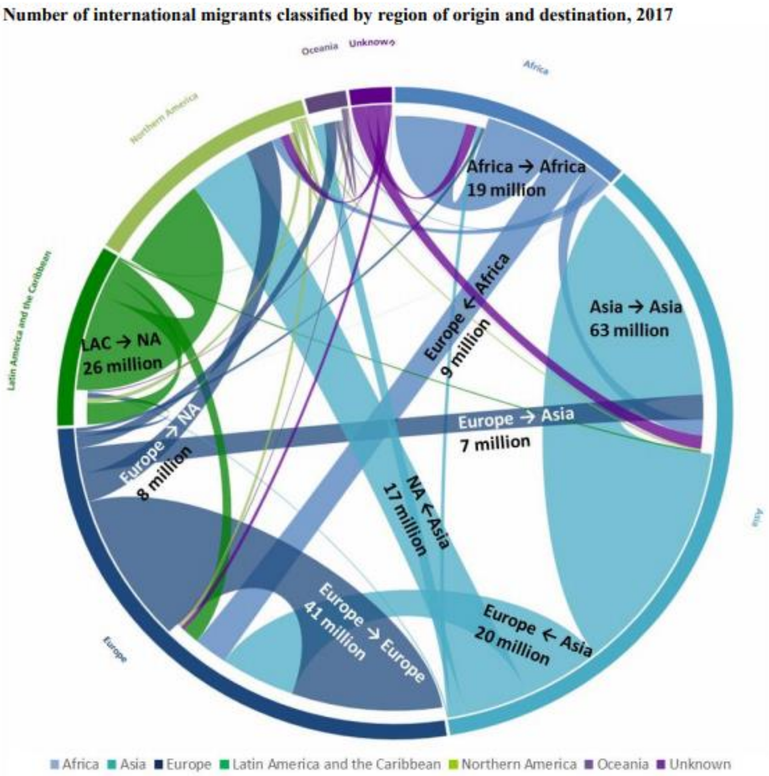


Figure 7.3 - Source: United Nations, Department of Economic and Social Affairs, Population Division (2017a). Trends in International Migrant Stock: The 2017 revision (United Nations database, POP/DB/MIG/Stock/Rev.2017).) (UNDESAPD, 2017).

Interpreting the data by geographic region provides further insights into prevailing trends (figure 7.4). More than 60 per cent of all international migrants worldwide settle in Asia or Europe. In

2017, 80 million international migrants were residing in Asia, compared to 78 million in Europe. Northern America sheltered the third largest number of international migrants (58 million), followed by Africa (25 million), Latin America and the Caribbean (10 million), and Oceania (8 million) (UNDESAPD, 2017).

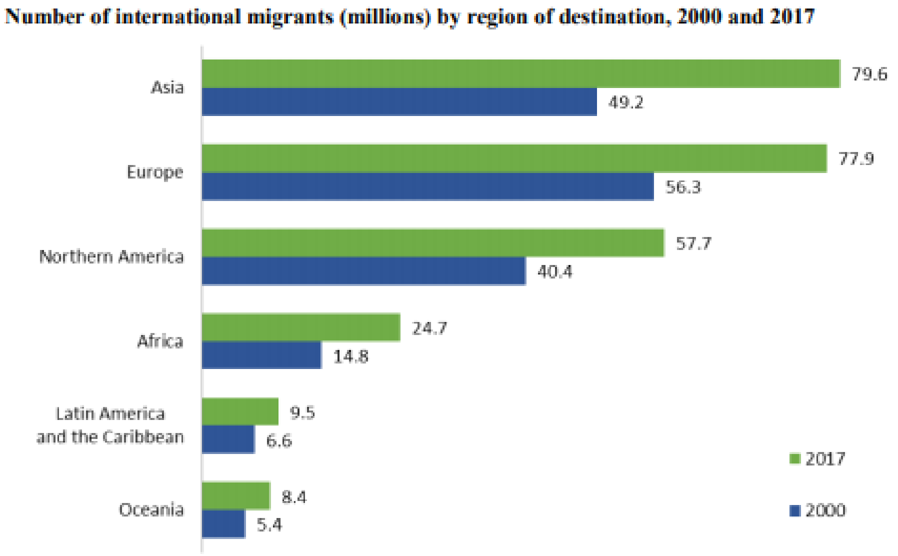


Figure 7.4 - Source: United Nations, Department of Economic and Social Affairs, Population Division (2017a). Trends in International Migrant Stock: The 2017 revision (United Nations database, POP/DB/MIG/Stock/Rev.2017).) (UNDESAPD, 2017).

Between 2000 and 2017, Asia intermixed more international migrants than any other region. Asia acquired some 30 million international migrants during this period, representing a net increase of about 1.8 million migrants per annum. Europe fused the second most sizable number of international migrants between 2000 and 2017 (22 million), pursued by Northern America (17 million) and Africa (10 million). Latin America and the Caribbean and Oceania furthered their total populations by comparatively smaller numbers of migrants during this period (3 million in each of these regions). Undeterred by this prolonged growth, international migrants accounted for two per cent or less of the total population of Africa, Asia and Latin America and the Caribbean. Inversely, in **Europe, Northern America and Oceania, international migrants amounted to, at least 10 percent of the total population** (UNDESAPD, 2017).

The aggregate of international migrants worldwide has augmented faster than the world's population. Due to this nimble growth rate, the share of migrants in the total population increased from 2.8 in 2000 to 3.4 per cent in 2017. The celerity of growth in the migrant population fluctuates considerably across regions. Between 2000 and 2017, the number of international migrants in Africa and Asia sprouted by an average of 3.0 and 2.8 percent per annum, respectively (compared with the global growth rate of an estimated 1.2 percent). Oceania documented the third most rapid average annual growth rate in the international migrant stock during this period (2.7 percent) followed by Latin America and the Caribbean (2.2 per cent). Europe and Northern America, where the volume of the migrant stock was by the time mentioned capacious, cataloged a hardly noticeable slower pace of change, with a general annual growth rate of 2.1 per cent in North America and 1.9 per cent in Europe (UNDESAPD, 2017).

Moreover, most of the international migrants, nearly 67 per cent were living in just twenty countries (figure 7.5). The most sizable portion (50 million) resided in the United States of America. Saudi Arabia, Germany and the Russian Federation, hosted, respectively, the second, third and fourth most substantial share of migrants worldwide (estimated to be close to 12 million each), supervened by the United Kingdom of Great Britain and Northern Ireland (nearly 9 million). Of the 258 million international migrants, 106 were born in Asia. Europe was the region of birth of the second largest sample of migrants, ensued by Latin America and the Caribbean (38 million) and Africa (36 million) (UNDESAPD, 2017).

Twenty countries or areas hosting the largest numbers of international migrants, 2000 and 2017, number of migrants (millions)

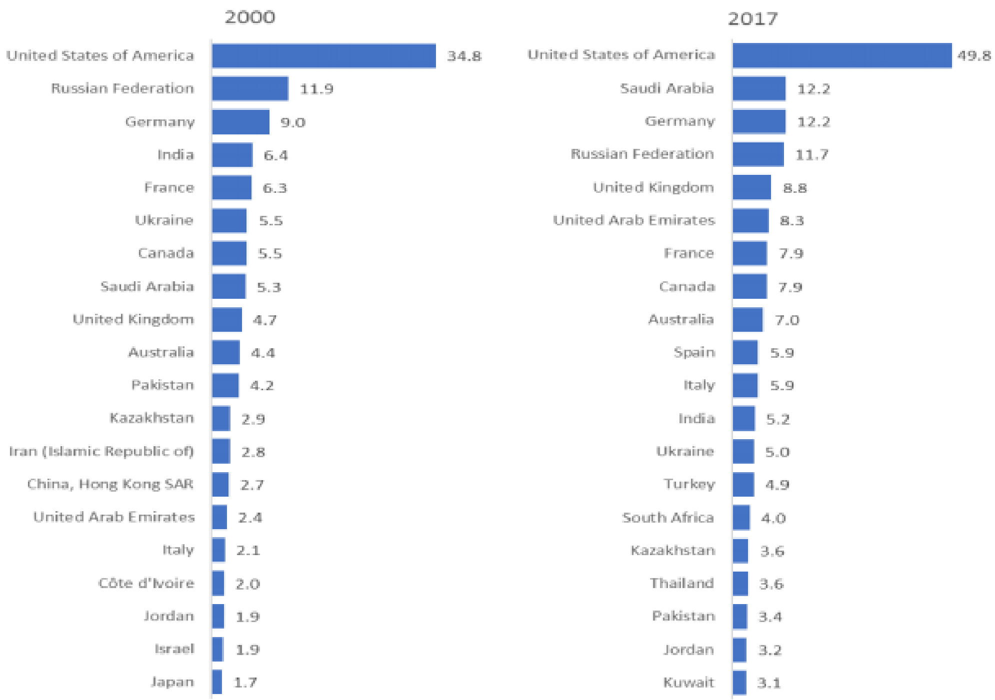


Figure 7.5 - Source: United Nations, Department of Economic and Social Affairs, Population Division (2017a). Trends in International Migrant Stock: The 2017 revision (United Nations database, POP/DB/MIG/Stock/Rev.2017).) (UNDESAPD, 2017)

Additionally, in 2017, the countries with the most substantial 'diaspora' population were:

- India was the country that contributed with the largest constituent of international migrants (17 million).

- Mexico pursuing closely (13 million).

- Ancillary countries of origin are the Russian Federation (11 million), China (10 million), Bangladesh (7 million), Syrian Arab Republic (7 million) and Pakistan and Ukraine (sharing 6 million each).

HIGH-INCOME COUNTRIES host close to two-thirds of all international migrants (figure 7.6). As of 2017, 64 per cent of all international migrants worldwide - equal to 165 million international migrants - lived in high-income countries. Thirty-six per cent - or 92 million - of the world's migrants resided in middle- or low-income countries. Of these, 81 million take up residence in middle-income countries and 11 million in low-income countries. Contrasting with 2000, the apportionment of international migrants living in high-income countries heightened inappreciably, while the share of middle- and low- income countries was brought down (UNDESAPD, 2017).

High-income countries have absorbed most of the recent buildup in the global population of international migrants, incorporating 64 million of the 85 million migrants that were generated worldwide between 2000 and 2017. Proportionately, the rate of growth of migrant populations was zenithal during 2000-2017 (2.9 per cent per year) in high-income countries. The medium growth rate in low-income countries was approximately 2.4 per cent per year. Despite dropping in the period from 2000 to 2010, the rate of growth of the migrant population in low-income countries precipitated to 6.6 per cent per year in 2010 to 2015, and slowed again, to 2.0 percent per year, most recently (2015-2017). In middle-income countries, the growth rate was at its minimum during this period (1.4 percent per year) (UNDESAPD, 2017).

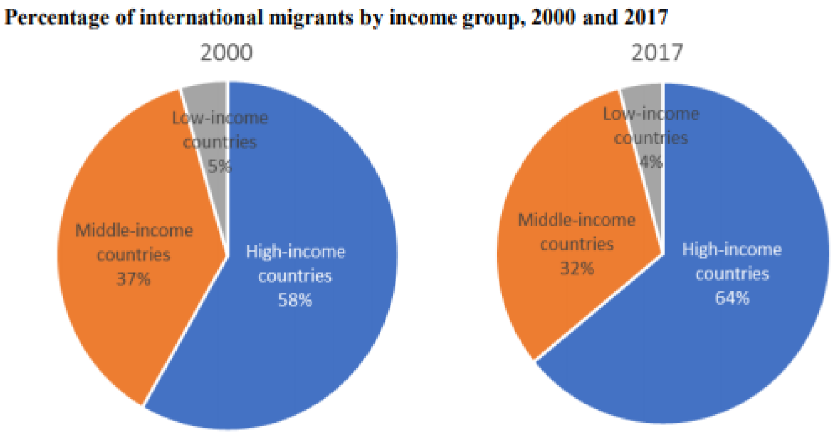


Figure 7.6 - Source: United Nations, Department of Economic and Social Affairs, Population Division (2017a). Trends in International Migrant Stock: The 2017 revision (United Nations database, POP/DB/MIG/Stock/Rev.2017).) Note: For both charts, the classification of countries and areas by income level is based on 2016 gross national income (GNI) per capita, in U.S. dollars, calculated by the World Bank. UNDESAPD, 2017

Finally, as it was already described in the previous chapters of Category: Chaos and Hunger Games, both the lack of food security and the increase in intensity and frequency on natural phenomena has led to an escalation of forced displacement. By the end of 2016, the sum of all refugees and asylum seekers in the world was predicted to be 25.9 million, accounting for 10.1 percent of all international migrants. Developing regions sheltered 82.5 percent of the world's refugees and asylum seekers. Turkey received the largest refugee number, with 3.1 million individuals, proceeded from Jordan (2.9 million), the State of Palestine (2.2 million), Lebanon (1.6 million) and Pakistan (1.4 million). Germany followed suit (1.3 million) and Uganda (1.2 million) (UNDESAPD, 2017).

Breaking down the geneses of the contemporary 'refugee or migration crisis' is not a task to be taken lightly. Recurrently, the environmental and economic afflictions that propel migration are meticulously interfolded. Notwithstanding whatever justification for renouncing one's *place*, individuals are undertaking progressively audacious measures (Brown, 2011). Failed states like Somalia and many other African and Middle Eastern countries generate economic, political and environmental refugees. We do know that Somalia is a lawless entity and an ecological basket case, with overpopulation, overgrazing, and the culminating desertification ravaging its pastoral economy (Cowell, 2003 quoted in Brown, 2008).

Two essential points regarding immigration in the context of human overpopulation are that, habitually, the immigration overflows from countries which are overpopulated to those which are soon to be overpopulated (Shragg, 2015). Equally important is another feature that has been recurrently stressed in this work and which Robert Engelman (2012) epitomizes as such:

> "A world of empowered women and intended pregnancies will fairly quickly reverse global population growth. It seems logical that a sustainable world population will encourage sustainable national ones as well, on both sides of the development divide. That would logically reduce the desperation of so many people to leave the countries of their birth to escape conflict, environmental degradation, and scarcity of resources, jobs and hope."

To emphasize on the complexity of this issue, the United Nations International Children's Emergency Fund (UNICEF)'s *In Search of Opportunities - Voices of children on the move in West and Central Africa* (2017), enumerates on the myriad of drivers for the recent (and quite possibly long-lasting) migration movement. The report focuses on the African continent, with a specific spotlight on the regions of West and Central Africa. The remainder of this segment will address these regions in particular, but by no means are these situations only endemic to the African continent.

Poverty

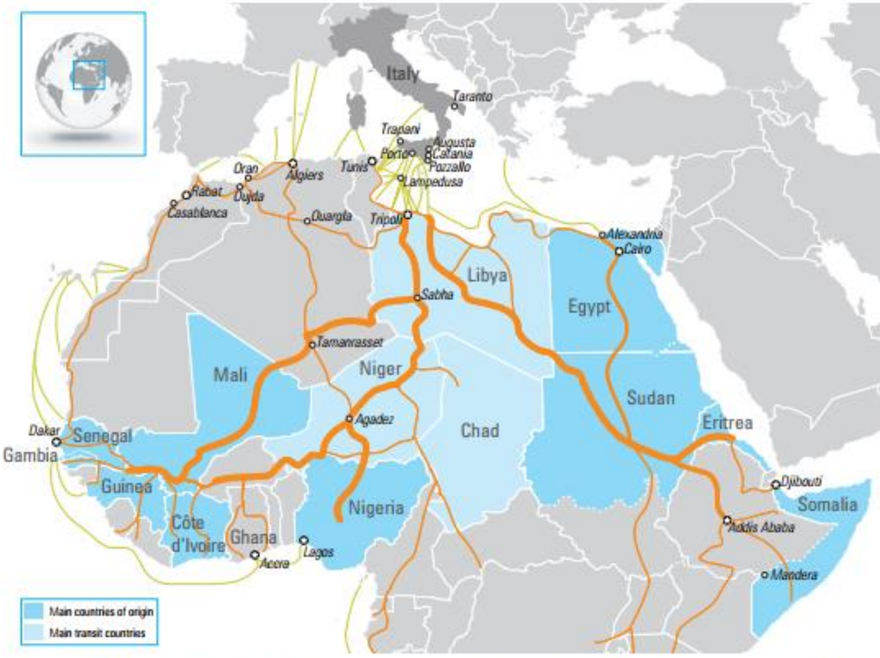
Poverty is usually spelt out as a key driver of migration, but what does that entail exactly? Not all migrants come from a background of abjection, and not all people living in destitute conditions become migrants. Countries like Burkina Faso and Niger have the maximal percentage of people in the world living on less than US$2/day, nevertheless, they are not the dominant points of supply in the region (figure 7.7) (UNICEF, 2017).

Poverty is essentially about the exiguity of economic opportunity, education, access to health care and access to information. These divestitures, when linked, create a profound sentiment of dissatisfaction, which can force people to traverse to distant shores, looking for a better life. Yet, it is apparent that poverty drives migration, as countries with elevated levels of poverty are inferable to produce more migration (UNICEF, 2017).

UNICEF (2017) postulates that until we deal with the root causes of poverty by:

> "Providing solutions in the form of economic opportunities, access to health care and access to quality education, we will likely continue to see people living in poverty who will be willing to risk their lives for a better future."

Still no mention of how overpopulation perpetuates a state of poverty of the denizens of a nation. Even if by 'access to healthcare' UNICEF is referring to the plethora of services that have been shown to indirectly affect demographics, one would expect a more unprejudiced and transparent stance on population growth and the necessity of nations to stabilize one's population in order to escape the endless cycle of poverty and misery, that eventually leads to migration.



Source: Adapted from European Union, Emergency Response Coordination Centre (EERC), Refugee Crisis – Central Mediterranean Route: ECHO Daily Map, 4 November 2016, http://erccportal.jrc.ec.europa.eu/getdailymap/docId/1801

Figure 7.7: Central Mediterranean Migration Routes.Dark blue countries are ones of origin while the light blue show the main countries of transit Source: Adapted from European Union, Emergency Response Coordination Centre (EERC). Retrieved from UNICEF, 2017.

Climate Change

It is almost with a twist of sardonicism and derision that the countries that have contributed the least to cause climate change are going to be impaired the most by it. Countries that have insignificant carbon footprints are going to be the first to be convulsed by the consequences of flooding, drought and displacement. In West and Central Africa (figure 7.7), the brunt of climate change will be especially intemperate, with the region set to go through a 3 to 4 degree rise in temperature this century – more than one and a half times higher than anywhere else on the planet (UNICEF, 2017).

Following from the example in figure 7.7, across the Sahel, communities have lived through inconstancy in rainfall and weather patterns for centuries and have traversed and perambulated accordingly. As climate change begins to have a preeminent influence in these areas, some forms of agriculture or pastoral lifestyle may become unforeseeable and ultimately unfeasible. When these means of providing begin to waver, people are unable to feed their families, to make a living, and to give their children a better life. As a consequence, occupations like farming or herding may surcease to be operable in some areas (UNICEF, 2017).

With drought and temperatures aggravating, West and Central Africa will take a considerable toll, concocting tensions in accessing scarce resources for cattle, which is leading to augmenting animosity in many rural areas, squishing greater numbers of people towards cities. At the same time, with more than 100 million people living in coastal cities less than one metre above sea level, even moderate estimates of a sea-level rise could result in the unwilling deracination of millions of climate refugees (UNICEF, 2017).

Climate change has the wherewithal to launch a chain reaction, with drought inciting dislocation to urban areas, oftentimes in questionable encampments or marginal neighbourhoods that are in swamps or areas close to water level. These territories are more susceptible to flooding, which could motivate waves of displacement as people seek sanctuary for their families and children. Unless the long-term planning of governments and civil society is outfitted to prognosticate these climate distresses and subsequent migration, the undiluted impingement of these forces will create prejudicial outcomes for the denizens across the region and the globe (UNICEF, 2017).

Urbanization

In 2008, the world reached a critical juncture: more people inhabit cities than rural areas. This tendency is set to linger – and aggravate – and it is one of the main forces for migration in West and Central Africa, with people navigating through borders to get to urban centers.

Cities encourage not only more jobs, but more stable ones – jobs that are not subordinate to the amount of rainfall or the amount of crop yield. Urbanization is a big part of the story of migration, as people are crossing the borders of their own countries in order to seek the activities, economic opportunities and stability that comes from living in cities (UNICEF, 2017).

More on Urbanization and its implications in the chapter Crowded Eden.

Education

For some migrants who stargaze of reaching Europe, education was cited as the primary impetus for their expedition. In interviews, young people illustrate their intention to get to Europe, get a university degree then revert to their former homes to share their proficiency, while other migrants are more persuaded by the conviction of acquiring money. Nevertheless, migrants express a desire to learn at European universities that minister quality education that is less susceptible to strikes, overcrowding and lack of resources that is endemic in African institutions (UNICEF, 2017).

Conflict

There is no greater trigger to move than conflict. Seized in the middle of armed groups wrecking each other and everything around them, families naturally do everything imaginable to keep themselves and their children safe. Over the past 20 years, there have been 25 major conflicts in the region depicted in figure 7.7 (also recall figure 6.26 in the previous chapter). This bloodshed and disorder has compelled millions of people to pursue physical assurance in different parts of their own country, and often by crossing borders in neighboring countries. This agitation of people lengthens the enormous challenges for the host countries and, of course, for the refugee families who often deal with dispossession, dislocation and a strife for basic survival in a new land (UNICEF, 2017).

Access to Information

As more people, especially young people, are laid bare to global trends, ideas and cultures through the Internet and social media, they utter a longing to become a part of it. The enticement of the Western lifestyle as it is rendered in the mass media often inveigles many to take on the migration excursion in pursuit of wealth, status and easy fortunes. Young migrants express a sense of lust as they see photos of friends in Europe on social media, often posing with expensive vehicles or other signs of wealth. This window into the possibility of prosperity cannot be overemphasized enough as a key motivation for migration, both to Europe but also to neighboring countries (UNICEF, 2017).

Despite the puissance of technology and information as catalysts of migration, overall connectivity rates in source countries remains relatively low. When inspecting Africa, Senegal, the Gambia and Guinea are all countries where less than 25 percent of the population is online, yet this is where an inordinately high number of migrants derive from. The estimates on Internet access do not mirror the high numbers of young people who do have social media and the persistent visual indication of what is attainable outside the borders of their country. Many migrants recounted how access to information was a critical part of their determination to leave and an essential factor in planning their expedition. Some boastfully showed WhatsApp groups where they get updates on changes in the route and advice for reliable places to stay or buses to take (UNICEF, 2017).

Notwithstanding often seeing graphic images of the prospects and uncertainties of the desert or sea crossing, in interviews, some migrants disclose they were indomitable in their decision to try, and that they would use social media to help maneuver them to safety. Access to information, like education, presents another paradox in the migration deliberation. Widening and expanding connectivity in developing economies is predicted to drive economic growth and education, yet in many cases, this introduction to information is inciting migration by displaying the riches of European ascendancy and equipping young people with the tools to get there (UNICEF, 2017).

Smuggling

Not all smugglers are mischievous or felonious; but they are organizers of dangerous, risky journeys. Supplying information such as which bus to take, which house to stay at, how to get a job when arriving at a region is part of the services afforded by smugglers. They expedite the movement of people across the region, especially, and in the case of Europe, along the central Mediterranean route into Libya through to Italy and the rest of the continent (UNICEF, 2017).

Smuggling is a lucrative enterprise, and many smugglers will exploit and beguile the migrants under their care, often forsaking them to kidnapper's whims. Connivance between fraudulent smugglers and kidnappers is ubiquitous along migration passages, with exploitative smugglers merchandising the people that they are professing to help by easing their capture by criminal groups into a form of modern day slavery (UNICEF, 2017).

Trafficking

Trafficking is distinctive from smuggling and kidnapping. Trafficking concerns the compulsory movement of migrants from one country to another, without their awareness or acquiescence. People living in dearth are more likely to suffer trafficking due to the lack of education or access to information, making them more defenseless to the promises of traffickers. Traffickers delude them, with the insurance of jobs in foreign cities – work in a hotel or as a maid or nanny in Europe. This practice is driving sexual slavery in Europe and also in Africa. Children from West and Central Africa are particularly in jeopardy, and are the most disenfranchised when it comes to getting the right resources or taking action to renounce such practises (UNICEF, 2017).

Population Growth

Africa's population is forecasted to double by 2050. This demographic boom will extend the already heightened tug-of-war for scarce environmental resources and limited health and education services, fueling larger movements of population across West and Central Africa – and beyond (UNICEF, 2017). For example, Niger's population has increased from 3.3 million in 1960 to almost 20 million today (19.7 million in 2017 (PRB, 2017) and 22.2 million in 2018 (PRB, 2018) – and is projected to reach nearly 70 million people by 2050. Nigeria's population is pullulating so fast that it lining up to become the third-largest country in the world according to research by the Department of Economic and Social Affairs of the United Nations (UNDESA, 2017). The African nation presently stands as the seventh most-populated country on the planet, but with an exorbitant population upsurge expected in the next few decades, Nigeria's population is predicted to overtake the United States' shortly before 2050 (Kenney, 2017).

Researchers in charge of the report by the UN ascribe the significant increment in population to high rates of fertility and the cultural value placed on having large families. As a matter of fact, over half of the inflation in global population is related to several African nations, including the Democratic Republic of the Congo, Ethiopia, The United Republic of Tanzania and Uganda. All are envisaged to add millions to their populations in the coming years (Kenney, 2017).

It is worth stressing out the words stated in the report (UNDESA, 2017):

> "Current estimates indicate that roughly 83 million people are being added to the world's population every year. Even assuming that fertility levels will continue to decline, the global population is expected to reach 8.6 billion in 2030, 9.8 billion in 2050, and 11.2 billion in 2100."

With an innumerable expanse of people trying to persevere with fewer and fewer resources, fertile ground for new waves of migration is likely to materialize (UNICEF, 2017).

UNICEF's position on migration with a root cause on population growth is still only a reflection of the incomplete realization of the 'Demographic Transition Theory':

> "The demographic dividend has not yet materialized in the region. The predicted boom in growth that would accompany this population explosion as young people enter the workforce is still a potentiality rather than an economic reality. Governments and economists are working to put in place the conditions where education, infrastructure, technology and healthy population can begin to have an exponential benefit to countries with large numbers of young people. Until those conditions are achieved, it is to be expected a continued surge in migration from countries with unrestrained population growth as the struggle for resources makes opportunities elsewhere more appealing. Whether these migrants of tomorrow decide to try for Europe or even just a neighbouring country, without better systems in place to cope with the expected increase, future migration could dramatically expand the risks and challenges faced by host countries" (UNICEF, 2017).

Having completed this brief analysis of the precursors and stimulus acting, essentially, on the inception of current and future Diasporas, the discussion must now advance into a stage where it scrutinizes the repercussions of migration, as well as probing on the synergistic effect it develops on an overpopulated world. The examination progresses into the role of migration on population dynamics.

International Migration as a Driver of Population Growth

"A nation which expects its biological survival from immigration won't survive"
- Viktor Orbán, Hungarian Prime-Minister

A population can expand or recede over time due to *natural increase,* the number of births minus the number of deaths, as well as *net migration*, the number of immigrants minus the number of emigrants. That being said, migration influences population size by the inclusion of immigrants and the deduction of emigrants. Moreover, migration can also modify the age distribution of a population and its ranks of mortality and fertility (UNDESAPD, 2016).

Between 1950 and 1990, the populations of both developed and developing regions swelled essentially on the grounds of natural increase. However, while in the developing regions the net change in population size ascended from 391 million between 1950 and 1960 to 800 million between 1980 and 1990, in the developing regions it subsided from 102 to 63 million over the same interval of time. By the decade of 1990 to 2000, net migration had overtaken natural increase as the main factor of population growth in the developed regions. Furthermore, it is contemplated that net migration will become the sole driver of growth in the developed regions as a whole starting from 2020 to 2030. Simultaneously, the population of the developing countries persisted in expanding due to an excess of births over deaths, even if at lower rates than observed in the previous four decades. Moreover, the significance of net emigration on overall population change in the developing countries remained relatively small (UNDESAPD, 2016).

In Europe and Northern America, and to a lesser degree Oceania, positive net migration has become a progressively important part of population growth. Starting in the period between 1990 and 2000, the number of deaths exceeded births in Europe, while, at the same time, positive net migration countervailed an expected reduction in population. If immigration rates into Europe continue to swell, after 2020, the projected surplus of deaths over births won't be large enough for Europe to experience a reduction in population size. Following the decade of 2030 to 2040, net migration is framed to engulf natural increase as the main driver of population growth in Northern America. For Oceania, although natural increase will remain the dominant component of population growth, the contribution of net migration as an element of total growth is expected to increase over the next several decades (UNDESAPD, 2016).

Examining, in contrast, the estimated size of the population in 2050 based on the medium variant and the zero-net-migration scenario provides some insight into the relative impact of international migration on population change during the period of 2015 to 2050. Under the zero-net-migration plot, the developed regions would comprise a population size in 2050, 8 percent smaller than they would have had if current migration trends lingered (UNDESAPD, 2016).

With this information in mind, as well as what perceived in the segment *Climate Change as the Precursor for Migration and Conflict*, Martin Rees, former president of the Royal Society and current Astronomer Royal argued the following when asked in *The Science Show* (2018a) by Robyn Williams :

> - Williams: "Population obviously could mean lots and lots of immigrants, lots of refugees. Similarly, a small effect of climate change could produce many millions of immigrants, way beyond what we know now, and we know it's changed the politics of Britain with Brexit, it's changed the politics of all sorts of countries. Do you look at those sorts of consequences from what otherwise are perceived as narrow causes?
> - Rees: If we look at the way population trends are going, the current growth is fastest in parts of East Asia and of course in Africa, and the African population will double between now and 2050, and it's possible if there happens to be a social preference for large families it will double again between 2050 and 2100. Indeed, one of the UN projections says that the African population will be 4 billion by the end of the century. And that population will be 10 times the population of Europe. Nigeria will have a population of 900 million which will be equal to Europe and North America combined. Now, in that situation, coupled with the fact that everyone knows exactly what they are missing through the social media they have already, indicates to me that there will be huge migrations or international problems."

Under these circumstances, I will now propel the discussion into one of the most contentious subjects in the entire book, our pressing requisite to examine the exigency of lowering international immigration, if our aim is ecological integrity and endurance.

Malthusian Restrictionism

"It's our population growth that underlies just about every single one of the problems that we've inflicted on the planet. If there were just a few of us, then the nasty things we do wouldn't really matter and Mother Nature would take care of it - but there are so many of us."

- Jane Goodall

Nearly all political liberals and an exceedingly large share of *Academia*, across the West and other developed nations uphold expansive immigration policies, often with free movement and settlement across national boundaries (what is denominated as "open borders"). In the case of an accord to scale down that movement for strategic reasons, it is because their unenlightened fellow citizens are not enthusiastic to be charitable (Cafaro, 2018). Nevertheless, they remain persuaded that an accurately moral immigration policy always translates into more immigration (Skerry, 2017). In most, if not all cases, they presume, it is unrighteous to confine the mobility who are purely attempting to guarantee their physical integrity or economic wellbeing by transposing national borders. As the discourse stands, those who maintain circumscriptions to immigration are racists, or at the very least, narrow-minded and egotistical defenders of their unmerited advantages (Cafaro, 2018).

A novel thesis titled *Immigration Ethics: Creating Flourishing, Just, And Sustainable Societies in a World of Limits* by Addison Phillips from Colorado State University's Philosophy Department (Phillips, 2018) convincingly argues in contrast to this view. Phillips asserts that in a crowded and environmentally overburdened world, legitimately ethical immigration policies must acquiesce the existence of limits (Cafaro, 2018). Phillips writes that:

> "Talk of limits is generally unpopular […] but, on a finite planet, it is simply irresponsible not to think about limits and their implications for how we should act as individuals, and the kinds of policies and projects we should pursue as a society."

Owing to justice being the first virtue of political institutions and policies, which embroils a proper distribution of limited resources, it stands to reason that there can be no applicable notion of *justice* and fairness, as long as limits – both environmental and socio-political - are neglected. Certainly, too many people may swamp the ecological services on which societies are contingent, and surely, too rapid demographic change may cripple social cohesion and solidarity, which are paramount to flourishing societies (Cafaro, 2018). Moreover, the open borders policy appears to omit and disdain the fact that over-developed countries like the United States are already in a state of overpopulation (Hoffmann, 2004), even though fertility rates are close to replacement (PRB, 2018). The preeminent quandary revolving around the open-borders policy is that it seems to prioritize social justice above scenarios of ecojustice (definitions) – fundamentally, there is no possibility of social justice on a defunct and exanimated planet. The priority must be for societies to live within ecological boundaries (Harding, 2018).

Still on the topic of *justice*, Douglas Murray writes in his book *The Strange Death of Europe: Immigration, Identity, Islam* (2017), that the European elites who are at the forefront of the mass migration project profess a moral high ground, while failing to balance between, or advert to, two competing virtues, justice and mercy (Charles, 2017). As Murray declares, mercy is always benign and charitable, “with the swiftest short-term benefits and the [virtue] more admired in the society in which those benefits are received.” Justice, giving each his due, both current inhabitants and migrant populations, is at no time addressed, and no attempt is engaged to extend it to anybody (Charles, 2017).

By the same token, Phillips argues in the first chapter of his thesis (2018), that every nation’s citizens have a right to put in practice self-determination and the aim of creating thriving societies. By and large, such a right is grounded in the fundamental interests mutual to all human beings, which help shape our wellbeing. These interests encompass basic safety and security, mutual regard and a sense of belonging, together with others such as obtaining knowledge about the world and an embellished experience within it. Inasmuch as the right to self-determination legitimizes citizens of a given nation to impose limits on immigration, it is plausible that if the security, the flourishing of the society or just the continuance of certain societal goods is put in jeopardy, it stands to be morally upright to defend such an intervention (Cafaro, 2018).

In his second chapter, Phillips justifies that, presently speaking many such cases have materialized. Contemporaneous ecological, economic and social circumstances required that citizens of the developed world uphold their right to self-determination and restrict immigration from the developing world. With an amalgamation of risks assembling at the gates of their societies, their near and long-term contemplations for flourishing oblige them to do so. Phillips, does not call for an end to immigration since some immigration is compatible with the perpetuation and even renovation of many societies. However, an ‘open borders’ policy is not. In light of the current rate of population growth, excessive immigration levels endanger the social solidarity that has contributed to the longevity of societies with robust welfare systems (Cafaro, 2018), as well as creating more top-chain consumers, which ultimately lead to higher ecological footprints and the instigation of a more expeditious scenario of climatic changes and ecological collapse.

With this in mind, should immigration restriction be used as a policy instrument for environmental improvement? A number of scholars - including renowned ecological economists - and activist groups think the answer is an uncontestable “yes.” A myriad of those immersed in the examination over the impact of immigration on natural environments concur that vast populations have damaging repercussions on ecological systems and for well-documented reasons - generalized increased consumption with all that encompasses (as described throughout this work) (Neumayer, 2006; Muradian, 2006; Daly, 2004; Kates, 2004; Chapman, 1999; Wackernagel & Rees, 1996). Finally, it is also a reality that recent trends in migration have inflated the population of host countries (Miller & Spoolman, 2009, p. 297; Ropke, 2005; Zuckerman & Hurlbert 2001; Christian, 1999; Daily, Ehrlich & Ehrlich, 1995).

Given these points, the environmental assertion for reducing immigration into the developed countries is relatively straightforward:

1. Immigration levels are at a historic high, and immigration is now the main driver of population growth in high-income countries in Europe, the United States, Australia and others.
2. Population growth is significantly instrumental in an assortment of environmental problems within the borders of a country.
3. A burgeoning population expands a country’s large environmental footprint. This is especially disquieting in countries with an elevated ecological footprint such as

Australia, United States, South Korea, the European continent, among many other. This distends the role of a country in straining global environmental systems.
4. In order to vigorously address environmental predicaments and become good global environmental citizens, one must stop population growth in one's country and strive to reduce not just its consumption, but its size. There is also a moral reasoning behind this argument.
5. Consequently, there should be limitations to the extent of immigration into developed, affluent countries (Cafaro & Staples III, 2012.)

Let us start by examining each one of these arguments, using the United States as a case study for each of the premises stated.

In view of some demographic history, between 1900 and 2000, the U.S. population almost quadrupled, from 76 million to 281 million people. The largest decadal population accretion during the previous century was between 1990 and 2000, where a 32.7 million increase took place, resulting in a 13.2 percent growth of the population. In the decade of 2000-2010 that percentage lowered to 9.7, which is still an addition of 27.3 million individuals, as depicted in figure 7.8 (Mackun, Wilson, Fischetti & Goworowska, 2011). This population growth derived from a mixture of natural increase and immigration, which as figure 7.9 demonstrates, has varied widely over the past century (Cafaro & Staples III, 2012).

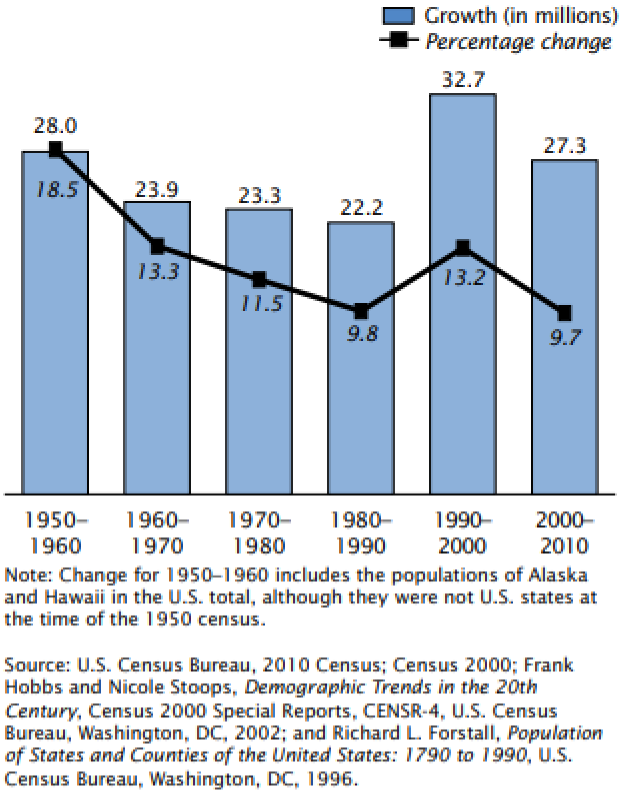


Figure 7.8: Growth of population (in millions) per decade and percentage change of total population in the United States due to immigration. Retrieved from Mackun et al, 2011.

From 1850 to the mid-1930s, America experienced an immigration boom, the Great Wave, during which immigration averaged six hundred thousand annually. U.S. population numbers grew expeditiously in these years, due to an amalgamation of high birth rates and high levels of immigration. For the next forty years, from 1930 to 1970, the United States had a relatively restrictive immigration policy, which allowed two hundred thousand people into the country annually, on average. The U.S. population grew substantially during this time too, from 115 million to 194 million, chiefly due to high rates of natural increase. During the 1950s, for example, American women had an average of 3.5 children, far superior to the 2.1 total fertility rate (TFR) necessary to maintain the population of a nation with modern health care and sanitation (Cafaro & Staples III, 2012), and higher to the contemporaneous observed in the country of 1.8 (PRB, 2018).

By the 1970s, American women were averaging fewer babies - in 1975 the TFR stood at a lowest ever 1.7 - and the United States was well positioned to undergo a metastasis from a growing to a stable, and even dwindling population. One study found that without post-1970 immigration, the U.S. population would have settled below 250 million in the first few decades of this century (Bouvier, 1998), instead of the current (as of 2018) 327, 5 million individuals (United States Census Bureau, 2018). It didn't come to pass, however, because in 1965 and several times thereafter, Congress greatly increased immigration levels. Between 1965 and 1990, immigration averaged 1 million people annually - *five times the average in the previous decades*. Since 1990, immigration has increased even more, to approximately 1.5 million annually (one million legal and half a million illegal) - the highest sustained rate in history (Cafaro & Staples III, 2012). In 2016, 1.49 million foreign-born individuals relocated to the United States, a 7 percent increase from the 1.38 million coming in 2015 (Zong, Batalova & Hallock, 2018). In 2010, there were 40 million foreign-born individuals living in the United States (Grieco et al, 2012), that number has risen to more than 43.7 million in 2016, accounting for 13.5 percent of the total U.S. population of 323.1 million (Zong et al, 2018).

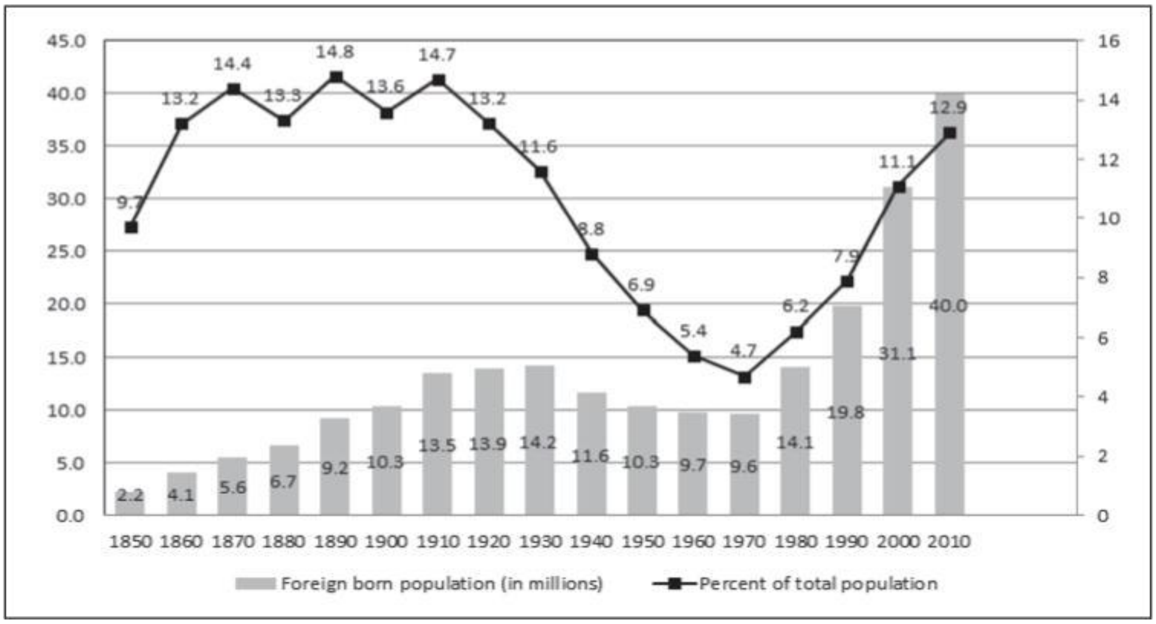


Figure 7.9: Foreign born population and percentage of total population for the United States, 1850–2010**.** *Source:* US Bureau of Census, Census of Population, 1850–2000 (in Gibson and Jung, 2006), and American Community Survey, 2010. Retrieved from (Hirschman, 2015).

According to Pew Research Center census data, most recent growth in the United States has come through immigration, with 88 percent of the growth projected until the year 2065 being immigration driven, accounting for 103 million people, as the nation grows to 441 million. As figure 7.10 illustrates, between 1965 and 2015, new immigrants, their children and their grandchildren accounted for 55 percent of the U.S. population growth. They added 72 million people to the country's population, as it expanded from 193 million in 1965 to 324 million in 2015 (Pew Research Center, 2015).

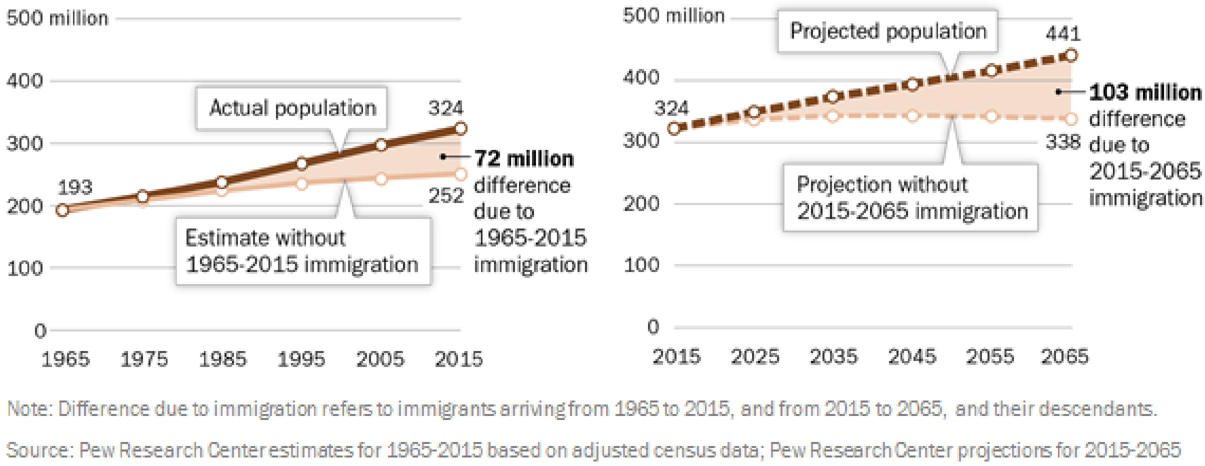


Figure 7.10: Immigrants and their descendants accounted for 72 million in the U.S. Population Growth from 1965 to 2015; Projected to account for 103 million more by 2065. Retrieved from Pew Research Center, 2015.

The fast-growing immigrant population has also lifted the share of the U.S. population that is foreign born from 5 percent in 1965 to 14 percent in 2015, and it is estimated that this value will swell to a projected record of 18 percent in 2065. The joined population share of immigrants and their U.S.-born children, 26 percent in 2015, is envisioned to rise to 36 percent in 2065 (Pew Research Center, 2015). These estimates display that new immigrants and their descendants will drive most U.S. population growth in the next 50 years (Cohn, 2015). For example, in California, virtually 100 percent of the growth is from immigration (Hull, 2003). In this regard, the US is an exception compared to other "Western" countries. France, Japan and most industrialized countries now have a stable or slowly growing population (Cafaro & Staples III, 2012).

As it can be noted in figure 7.11, under a zero immigration model, the U.S. population would stabilize and start to reduce, reaching 343 million at the end of the twenty-first century. Under the middle projection, with immigration at one million people annually, instead would reach almost 500 million individuals. Under the highest scenario, with the annual immigration of two million, the population doubles by 2100, reaching six hundred million people by the end of the century. Obviously, immigration makes a *huge* difference to future U.S. population dynamics (Cafaro & Staples III, 2012).

In *Immigration, Unemployment and Growth in the Host Country: Bootstrap Panel Granger Causality Analysis on OECD Countries* (Boubtane, Coulibaly & Rault, 2011), the authors describe how:

> "During the last decades, most OECD countries experienced an increase in international migration. Indeed, the number of immigrants received in OECD countries substantially increased in the last decades, from about 82 million in 1990 to 127 million in 2010. Immigrants are the main source of population growth in the OECD countries. They contribute more and more to population growth, compared to natural increase (the excess of births over deaths), particularly in European countries."

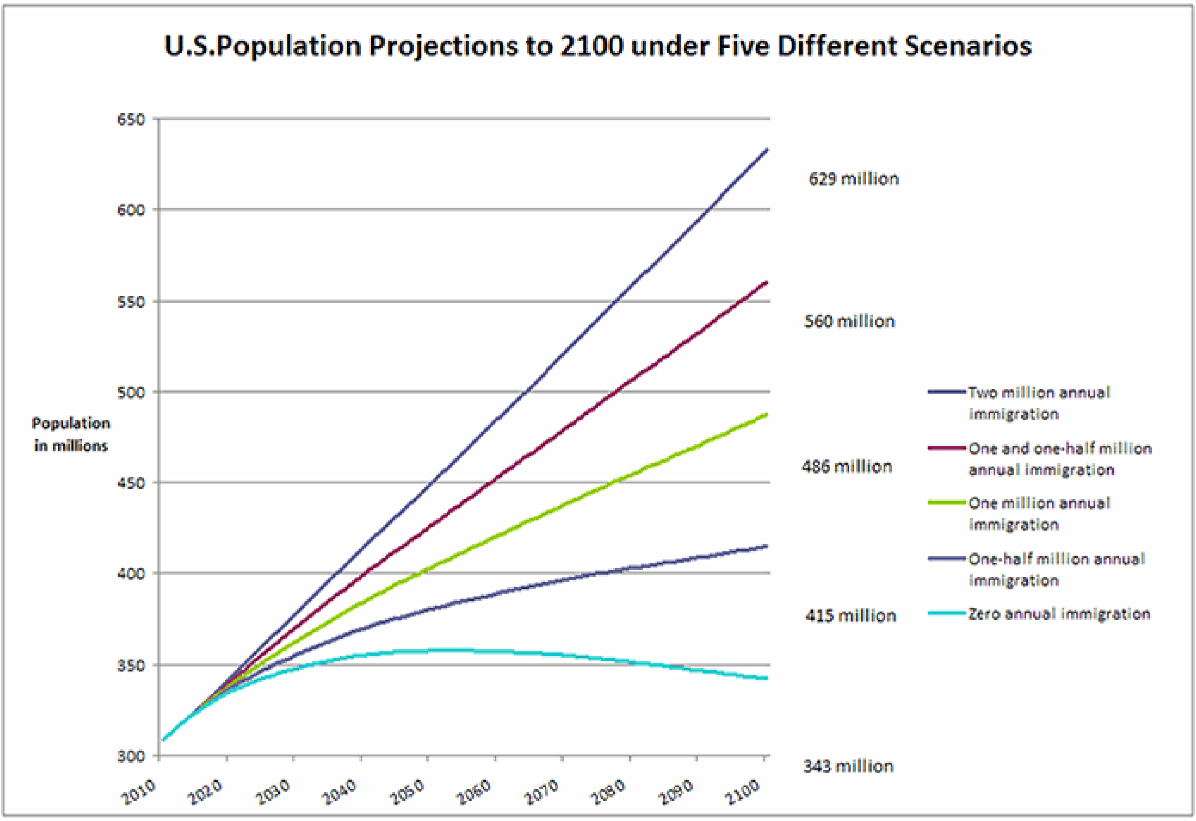


Figure 7.11: Population of the U.S. under five different migration scenarios. Retrieved from United States Immigration Policy, 2016.

The circumstances in the UK are very similar to those described in the United States. In 2001, the UK population was estimated to be 59.1 million, with 4.9 million (8.3 percent) of foreign birth. By 2011, the population of the UK amounted to 63.2 million, an increase of 4.1 million, with the foreign-born population at 8 million (12.6 percent) (Migration Watch UK, 2018a). By June 2016, the population of the UK had expanded to around 65,648,000, displaying a surge of 538,000 in one year (similar to the annual growth rate over the last 12 years) (BBC News, 2017). In accordance with *Migration Watch UK* (2018b), the population of the UK expanded by 6.6 million between 2000 and 2016, with the latest research pointing out to immigration being responsible for 80 percent of that increase (figure 7.12).

A statistic of paramount importance here is the percentage of live births in England and Wales being born to mothers from outside the UK. In 1990, the value stood at 11.6 percent; by 2015, it protracted to 27.5 percent, the highest level recorded (McLaren, 2016). It is appraised that net migration, plus births to foreign-born parents, have been responsible for 85 percent of UK population growth since 2000 (Migration Watch UK, 2018a).

In December 2016, the Office for National Statistics (ONS) reported that 650,000 people migrated to the UK in the year up to June 2016, and 315,000 abandoned, making the total net migration figure 335,000 (Porritt & Hines, 2017).

If net migration continues at around recent levels, then the UK population of 65.6 million is foreseen to climb by over 8 million people in 20 years (to 73.7 million), almost the equivalent of the population of Greater London (8.7 million) (Nash, 2017a). The latest “principal” population growth estimates only presume a long-term net migration figure of 165,000 a year. Yet, notwithstanding migration figures dropping recently, the total net migration to the UK in the year ending March 2017 was 246,000 (Porritt & Hines, 2017).

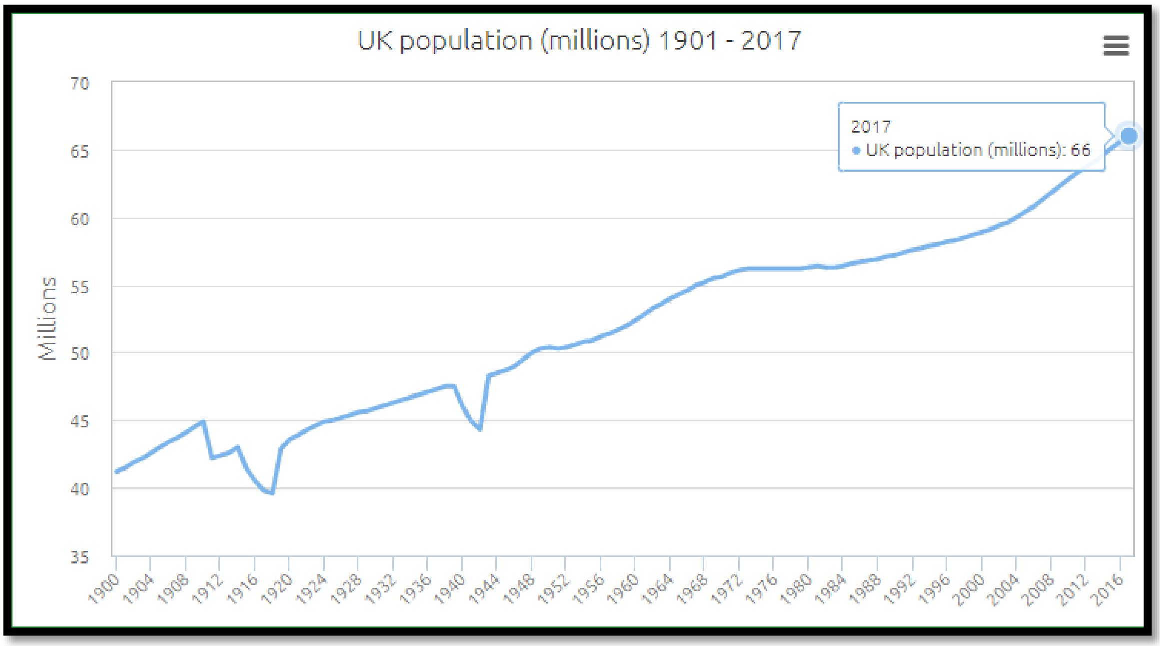


Figure 7.12: Impact of immigration on UK population growth. Retrieved from Migration Watch UK (2018b)

Be that as it may, even using the figure of 165,000, the latest ONS estimates of population growth for the next 25 years projects that 77 percent of this accretion would be from future migration and the children of those migrants. And population growth would not stop there (Nash, 2017b; White, 2017).

At the beginning of 2016, the population of Europe was estimated at 510.2 million, an increase of more than 100 million since 1960. In 2011, around 68 percent of Europe's population growth came from net migration, which continues to be the main determinant of population growth as it has been since 1992. Given the ageing population in Europe, future population decline or growth will depend primarily on the contribution made by migration (Eurostat, 2018). Saudi Arabia is another interesting case to review. According to the most up to date statistics the country's population rose by 2.525 per cent in the year 2017, to stand at 32 million, of whom 20,408,362 are Saudi nationals. In 2016, the Saudi population stood at 31,742,038, whereas the survey revealed that the population increased by 810,298 last year, but only 343,392 were Saudi nationals, which leaves immigration to account for the remaining thousands (Saudi Gazette Report, 2016).

It stands to reason that premise (1) is true (Cafaro & Staples III, 2012).

In premise (2) that *population growth contributes significantly to a host of environmental problems within the borders of a country*, there could be many potential examples, but for the sake of argument let us discuss one: urban sprawl (there is a multitude of chapters in this work that could fit the criteria as well).

In the past two decades, sprawl, characterized as new development on the outskirts of existing urban and suburban areas, has come to be perceived as a paramount environmental problem in the United States. Between 1982 and 2001, the United State denatured 34 million acres of forest, cropland, and pasture to developed uses, an area the size of Illinois. The average annual rate of land transmogrification increased from 1.4 million acres to 2.2 million acres over this time and lingers on an ascending trend (Natural Resources Conservation Service, 2013). Sprawl is an environmental obstacle for a collection of reasons, including increased energy and water consumption, air pollution, and habitat loss for wildlife. Habitat loss is beyond question the number one cause of species endangerment in the United States (Wilcove, Rothstein, Dubow, Phillips & Losos, 1998). Unsurprisingly, some of the worst sprawl centers, such as southern Florida and the Los Angeles basin, also incorporate large numbers of endangered species (Cafaro & Staples III, 2012).

The number one cause of sprawl is by far population growth. New houses, new shopping centers, and new roads are being erected for new residents. As figures 7.13 and 7.14 illustrate, in recent decades cities and states with the topmost population growth rates have also shown the most sprawl (Cafaro & Staples III, 2012). The most encyclopedic study to date on the causes of sprawl in the United States analyzed several dozen possible components and elements. Arranging together all those factors that can increase per capita land use, it found that in America between 1982 and 1997, 52 percent of sprawl was traceable to population increase, while 48 percent was ascribable to unwarranted policies that increased land use per person (Beck, Kolankiewicz & Camarota, 2003).

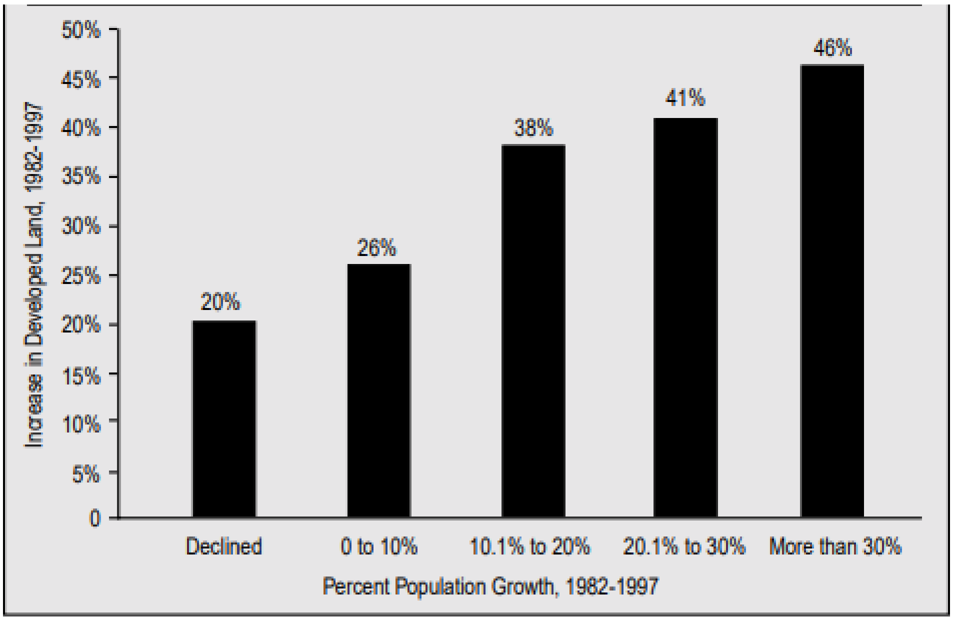


Figure 7.13: States with higher population growth have more sprawl. Source: Beck et al, 2003.

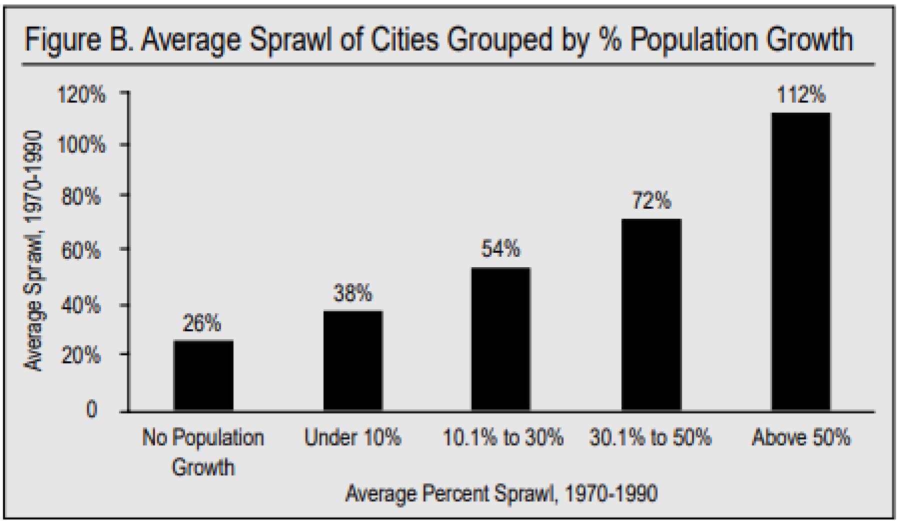


Figure 7.14: Average sprawl of cities grouped by % population growth. Source: Beck et al, 2003.

Given these points, to stop urban sprawl, there is a need to change transportation, tax, zoning and *population* policies that bolster it. Sprawl can only be contained if the factor that accounts for more than half of its cause - population growth - is exhaustively embraced and dealt with accordingly. If nations want to endeavour in solving domestic environmental problems, they have to be resolute in approaching population growth. Premise (2) holds its ground (Cafaro & Staples III, 2012).

If we want to uphold a conservation ethic and live in a biodiverse and prosperous world, we need to "think globally." So what of the premise (3) that a *growing population increases America's large environmental footprint beyond our borders and our disproportionate role in stressing global environmental systems?* As the world's historically largest greenhouse gas emitter, the United States has a moral compulsion to lead the world in meeting this challenge (Singer, 2004). With the most recent *Assessment Reports* from the Intergovernmental Panel on Climate Change (IPCC, 2014a) as well as scientific studies (Hansen et al, 2008) and a cornucopia of literature that has been reviewed throughout this work on the connection between climate change and population (Category: Chaos, Hunger Games and the upcoming volumes), suggest that the industrialized nations will have to curtail emissions by approximately 80 percent over the next four to five decades in order to keep the planet from entering a disastrous cycle of positive feedback loops that would alter the habitability of the world. In order for such an endeavour to succeed, the human population cannot be left unresolved (Cafaro & Staples III, 2012).

One just needs to delve into the numbers. In order to sever this disposition to emit such a large amount of GHG (Greenhouse Gases), over the next half-century, there would need to be a reduction of an average of 80 percent per person *at our current population*. If the United States doubles its population, as was shown in premise (1) that is possible, there would need to occur, instead, a *90 percent* reduction per capita of emissions. An 80 or 90 percent reduction translates into profound lifestyle changes and comfort sacrifices, which are not likely to take place (Cafaro & Staples III, 2012).

Re-engineering the world's largest economy and changing the consumption patterns of hundreds of millions of people are colossal propositions, that will be arduous, costly and most likely only partly successful, when we examine the political will and the dominant narrative of the need for 'economic growth' (this theme will be explored in the upcoming volume, in the chapter Prosperity Without Growth). Al Gore has declared that global warming is "the moral challenge of our time," but if Americans (and the world), are bound and determined about restraining global warming, the "multiplier effect" of population growth is too crucial to overlook (Cafaro & Staples III, 2012).

Again, let us focus on the numbers. Between 1990 and 2003, U.S. *per capita* CO_2 emissions increased 3.2 percent, while *total* U.S. CO_2 emissions grew by 20.2 percent (Carbon Dioxide Information Analysis Center, 2010). How can this divergence be explained? In the course of the same time period, America's population expanded by 16.1 percent (U.S. Census Bureau, 2018). Population growth greatly increased total emissions, and it is *total* emissions, not *per capita* emissions, that quantify the full input to global warming as figure 7.15 demonstrates (Cafaro & Staples III, 2012). This is why the IPAT equation is important (recall its discussion in Diet, Affluence and China), since it gives the full extent of the impact of a country, when the [P] variable is taken into consideration. When we do, we can identify that China and India, both have a similar impact like the United States, even though per capita emissions are much lower.

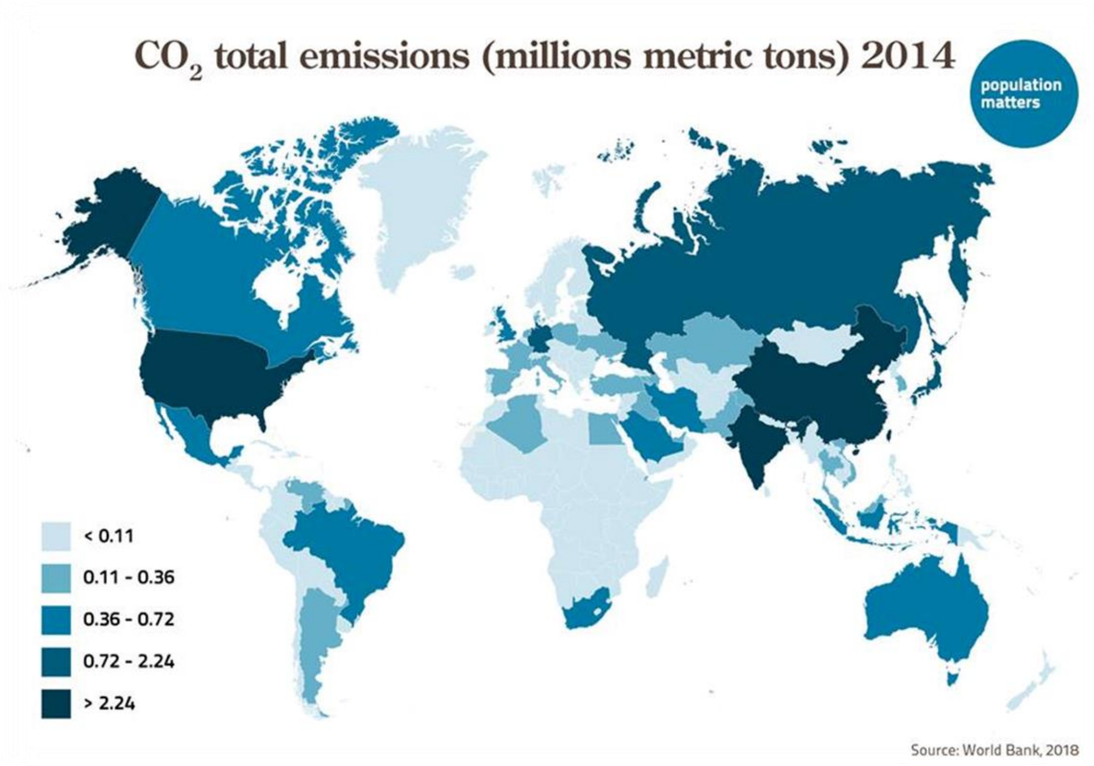


Figure 7.15: CO_2 total emissions in millions of metric tons for the year 2014. The overall emission impact of a country should be the analysed not as a product of per capita emissions but total emissions. Source: World Bank, 2018. Retrieved from Population Matters, 2018a.

Equally important, immigrants who relocate themselves in America, for example, are looking to break free from the shackles of poverty; which means, they reasonably aspire to the American 'standard of living.' That entails becoming American consumers, which increases energy use, carbon emissions, and other problems for the Earth. Americans, eventually including the new ones, consume resources at rates that are quite different from the rest of the world, so the global environmental effects of U.S. population increases are far greater than increases in most other countries (Palmer, 2012).

As it should be clear at this point, is that by itself, halting population growth will not solve sprawl and other national quandaries, or global ones like biodiversity loss and global warming. Generally speaking, there must be a pandemic reduction of per capita consumption above what is considered "sufficient." That isn't to say that the swelling of the population hasn't increased the United States and the world's total land and energy consumption hasn't further exasperated, above all, environmental problems. Humanity must deal with both overconsumption and overpopulation if we aspire to create a sustainable civilization (Cafaro & Staples III, 2012).

Undoubtedly, premises (2) and (3) are legitimate: U.S. population growth contributes significantly to both with-borders and global environmental problems. Premise (4) states that *in order to seriously address environmental problems at home and become good global environmental citizens, we must stop U.S. population growth.*

Given the difficulties of getting three hundred and thirty million Americans to restrict their consumption, there is no reason to assume a scenario with ever more people would benefit the efforts of a sustainable agenda. Indeed, there are good reasons to assume that 300 million individuals with American level affluence are already too high (Cafaro & Staples III, 2012). Scientists David and Marcia Pimentel assert that a U.S. population of forty to one hundred million might be truly sustainable, given the right environmental policies and consumption patterns (Pimentel & Pimentel, 1990).

It is conceivable that Americans might reduce their average per capita consumption levels to that of Western Europe or Japan. It is a goal worth striving for politically. On the other hand, it is harder to picture Americans (or Europeans or Japanese, for that matter) to willingly forego their comfort and living habits while adopting the consumption patterns of Mexico for example, much less of the average Nigerian or Bangladeshi. This is the true impracticality of focusing solely on changing living habits, since there is no population in recorded history, who has voluntarily relinquished well-being and material abundance, and it is pointless to pretend otherwise. Nevertheless, it is pressing that the United States moves toward building a sustainable society. That means consuming less *and locking in the environmental gains made possible by less consumption,* not negating them through an increased population (Cafaro & Staples III, 2012).

All things considered, these considerations suggest that premise (4) is true: there is a moral and civilizational duty to stop U.S. population growth in order to meet global environmental responsibilities. Of course, population stabilization or reduction would not lead directly to sustainability, but in tandem with serious efforts to decrease per capita consumption, they would make it possible. Ending population growth is a necessary but not a sufficient condition by itself, for designing a sustainable society (Cafaro & Staples III, 2012).

In a final analysis, premises (1) through (4) of the "the environmental argument for reducing immigration" are *bona fide.* Therefore, premise (5) that there should be limitations to immigration into developed, affluent countries, in order to curtail population growth and the escalation of human ecological footprints, should be regarded as a legitimate cause of concern and moral significance, since we are dealing with individual decisions that ultimately affect the human and non-human collective on this planet. With this in mind, the philosopher, professor and author Phillip Cafaro injects some much-needed commentary (Cafaro, 2018):

> In the same way that governments in the developed world have too often run down social capital to further globalization and "diversity," they continue rapidly running down the ecological capital that untold *nonhuman* generations have built up over the aeons: the rich soils that grow our food, the forests that provide our oxygen, the wetlands that purify our water, and the free-flowing rivers that gladden our souls. The evidence (Crist, 2015) is overwhelming that the world is well beyond full human capacity, and pushing hard against a variety of ecological limits. Yet liberals happily join conservatives in acting as if it makes little difference environmentally whether the U.S., France, or Germany doubles its population over the next century, through continuing mass immigration, or whether they take advantage of low native birthrates to decrease their populations (Kuhlemann, 2018) and thus decrease their citizens' demands on the natural world. Thus we sleepwalk into the future.

Policy Proposal

"If government knew how, I should like to see it check - not multiply - the population."
- Ralph Waldo Emerson, writer (1803 - 1882)

"Immigration to the U.S. should be no greater than that which will permit achievement of population stabilization in the U.S."
- *Sierra Club population policy*, 1989

Following through with the example of the United States, it is reasonable to present a legitimate proposal to reduce immigration while safeguarding environmental duties. The subsequent measures should be taken into account and are presented by Philip Cafaro and Winthrop Staples III in the book *Life on The Brink - Environmentalists Confront Overpopulation* (2012):

- Bringing legal immigration down from one million to two hundred thousand per year. This number still takes into account the illegal immigration of around five hundred thousand per year.
- Reducing illegal immigration by strictly enforcing sanctions against employers who hire illegal workers (it is futile to lower legal immigration levels while ignoring or condoning illegal immigration).
- Rework trade agreements, and increase and improve development aid, to help people live better lives and rein in population growth in their own countries.

Such a policy would sanction some of the benefits of immigration to continue (provide asylum for refugees, allow the influx of workers with special skills, etc), while allowing the United States to move toward population stabilization, thus decreasing environmental and ecological impacts domestically and globally (Cafaro & Staples III, 2012).

This proposal is well within the mainstream of the best thinking on sustainability. As the President's Council on Sustainable Development put it (Population and Development Review, 1996):

> "Managing population growth, resources, and wastes is essential to ensuring that the total impact of these factors is within the bounds of sustainability. Stabilizing the population without changing consumption and waste production patterns would not be enough, but it would make an immensely challenging task more manageable. In the United States, each is necessary; neither alone is sufficient. To create a sustainable society there is a need to move toward stabilization of U.S. population."

Decreasing immigration should be a part of a thorough U.S. population policy, outlined first to stabilize and then reduce human numbers, slowly and in the most humane way possible, both within borders and abroad. As part of this effort, Cafaro and Staples III (2012), propose that the federal government complies with the following:

- Increase funding for family planning clinics and take other steps to improve easy, inexpensive access to contraception domestically.

Tim Wirth, president of the United Nations Foundation, notes that since 1995 the United States has decreased its support for international population programs by almost 40 percent (Mazur, 2010). Among many others, Wirth advocates that through financial and technical support, the United States should strongly promote family planning programs around the world. Efforts of this type have the potential to be far more effective and sustainable than allowing a tiny fraction of the world's needy to become American consumers by immigrating into the United States (Palmer, 2012). Worldwide about eighty million additional people are added to impoverished countries per year. Even at immigration levels that would overwhelm America in every respect, such immigration would be insignificant help compared to world needs. Immigration is not going to solve the problems of other countries and can, in many ways, exacerbate them (Krikorian, 2008).

- Preserve the right to abortion (forcing women to bear children they do not desire is unjust, and forcing them to have illegal abortions is dangerous).
- End tax breaks and other subsidies that encourage American citizens to have more children.

At the same time, foreign policies should include:

- An increased funding for international family planning efforts, to help secure safe, affordable contraception in other countries.
- Vigorously support women's reproductive rights (including abortion rights) and girl's equal rights to primary and secondary education, worldwide.
- Deny all foreign aid and any immigration slots to nations that fail to commit to stabilizing their populations or sharing wealth fairly among their citizens.

This last point is pivotal as Joseph Bish (2012) explains:

> "Some might ask why there should be concerns about population growth that results merely from migration, if the objective is to bring about stabilization of world population and achieve a sustainable human presence on Earth. Concentrating on lowering fertility in individual nations makes sense toward the goal of stabilizing the global population. But migration is the relocation of existing people, so stabilizing the population of the United States through reduced immigration wouldn't solve, [by itself] the numerical growth of world population."

The policies presented here would make a resounding statement that the age of endless growth has come to an end, and that the United States and other developed nations will no longer act as "safety valves" for failed or unjust societies that cannot or will not arrange for decent opportunities for their citizens. It will disseminate the message that nations which fail to keep their populations from ballooning will undergo a panoply of consequences that were addressed in all of the previous chapters. This approach seems to be the best wake-up call to convince common people and their political representatives worldwide to take the necessary steps to halt population growth (Cafaro & Staples III, 2012).

I chose to leave immigration affairs for the last chapter so the reader could have the proper background to effectively address such an immense and complex problem. It is perfectly understandable if reader still recoils at the idea of decreasing immigration quotas, when we have to acknowledge how the world is changing, for example, with the waves of millions of climate refugees that are expected to be displaced from their lands during this century (recall the last segment from the chapter Category: Chaos).

This puts people in a difficult predicament. Nobody wants to deny the opportunity of immigration to other people. But we don't want to deny other opportunities, either, such as the freedom for our children and grandchildren to have a healthy environment, or the space for other species to live and blossom and flourish, and future generations to see them, and be able to experience wonder by their existence (Palmer, 2012).

In a word, this is a conversation that needs to happen, and as Satyajeet Marar writes for *Quillette* (2018):

> "There is certainly a wrong way to do immigration and the European approach in recent years is a prime example. Pressuring less-wealthy countries to accept asylum seekers, many of whom entered the continent with little vetting, has given far-right parties a *cause celebre* while raising legitimate concerns about national security, crime, and free-riding on welfare. It has also raised the concern that economic migrants are taking the places of those genuinely fleeing persecution.
>
> Other genuine concerns include the disproportionate influx of young men without family support, distinguishing those fleeing persecution from those fleeing poverty. Over a million asylum seekers entered Germany with the backing of Chancellor Angela Merkel who was finally forced to back down (Gonzalez, 2018) after a political backlash which has seen far-right parties not only rise in Germany but across the continent in Italy, Hungary, Austria and Poland. Even billionaire George Soros, a public enemy of the anti-immigration crowd for his funding of progressive organisations, declared earlier in 2018 that the migration crisis is one of the greatest threats to the European Union's survival -vocally backing the right of EU members to determine whether they will accept refugees (European Council on Foreign Relations, 2018) - surprising many of his detractors."

This marks the end of the chapter Exodus. At first, I was inclined to postpone this theme for another volume but ended up deciding on presenting this sneak-peak constituted of mostly the environmental argumentation for a more circumspect and judicious policy on immigration. This is one field in which I suspect my knowledge to still be in its infancy and not yet matured enough to present the reader with the exhaustive and consummate work that I intend to forge. Obviously, this chapter focused on the more ecological and environmental sides of the quandary of excessive immigration, but that isn't the whole story. Societies themselves resemble living organisms, they evolve, grow and subside and most important of all, societies are fragile conceptions, which arise from a collective of individuals. In either case, we still do not understand these mechanisms and how they operate, but we are beginning to realise that population dynamics – which crystallizes in the immigration and fertility rates of a given nation – plays a major role in shaping up a given society and maintaining its integrity, cohesion and continuance. In the upcoming volumes I intend to examine the sociological, economic, cultural and political faces of this issue, as well as improving on the arguments already presented in here.

CHAPTER VIII

The Sword of Damocles

- Concluding Remarks -

"Population stabilization and subsequent reduction is the primary issue facing humanity; all other matters are subordinate."

- Ken Smail

I started off the Human Overpopulation Atlas, by explaining my reasoning behind the adoption of the Greek myth Atlas, as an illustration of this project's message. It is only suitable that I consummate my cogitations by bringing us full circle, and again intercalate my thoughts using the wisdom of our ancestors, this time borrowing from the Roman philosopher, Cicero.

The moral anecdote is known as "the Sword of Damocles," which is a denotation to the impending and looming peril faced by those in positions of power. In this narration, Damocles - a flatterer and courtier- engages with Dionysius II of Syracuse, the king of Sicily, and they end up trading places for one day, with the king allowing Damocles to experience the so desired wealth and power that Dionysius exuded. Damocles sat down on the king's throne, encircled by every luxury, but the king arranged for a sword to be hanged above Damocles' head and held by a single hair of a horse's tail to emphasize the many dangers that lurk when one is in a position of power, such as having many enemies. Needless to say that, as soon as Damocles realized the looming threat over his head, he begged to trade places again.

So what is the moral of this anecdote and how can I incorporate it in the *Atlas* narrative? It is quite simple actually. No one can really thrive in an atmosphere of brewing danger and instability, and that is exactly what humanity is imposing upon the present and future generations, by not managing their numbers with considerations of ecological and biophysical limits. We as a species are hanging this sword over the heads of every living human and non-human specimen on this planet, condemning them to live under an impending pitfall, constraining their potential and collectively concocting and speeding up scenarios contradictory to life as we know it (runaway climate change for example), or one that is not worth living at all (a world devoid of most non-human life).

Throughout this first volume of the Atlas, I endeavoured to demonstrate how human overpopulation - this overhanging Sword of Damocles - is a point in question that relates to a multitude of areas of knowledge and expertise, that encroach and trespass the traditional boundaries that divide distinct fields of science and philosophy, in effect, bringing us all under the same roof. That has been the aim of this work from the start, to erode the many walls that are erected when we compartmentalize knowledge in specific fields, losing sight of the whole picture.

That has been the aim of this work from the start, to erode the many walls that are erected when we compartmentalize knowledge in specific fields, losing sight of the whole picture. Contemporaneously, each field is finding itself dissecting the many symptoms of overpopulation separately, be it Geography and Public Health when dealing with urban sprawl and mass movement to cities; Ecology and Conservation Biology when examining how populations of species and their habitats are fading under our very eyes; Geopolitics and Demography when surveying skyrocketing fertility rates that overstep the food security of nations and increase the propensity of its citizens to seek better conditions elsewhere; Anthropology and Paleoarchaeology that polish up our knowledge of past human events and realize that wherever humans went a trail of local degradation and extinction followed; Engineers and Policy Makers that strive to boost efficiency, and implement technological solutions, while completely in the dark to the fact that humanity is growing by 83 million/year and all those people will have a non-zero consumption; Climate and Earth Scientists that appeal for rich-nations to reduce their greenhouse gas emissions, while overlooking the role that procreative decisions have in that regard; the Agronomists and Biochemists pondering over ways of increasing yields to feed a 9.9 billion population in 2050; the human rights activists that nobly work towards reducing human misery, while often disregarding the many benefits of aiming to reduce fertility rates. These are but a few examples, but I'm sure that during the process of apprehension of the *Atlas*, some proportion of readers have realized how the magnitude of the human populace is an upstream factor, with consequential ramifications to their area of expertise or field of knowledge.

Something else that the reader might have become increasingly aware as he or she was leafing through the pages of the Atlas was that I made sure to be sufficiently breviloquent and laconic in my examination of the solutions to this congested mess.

Just to put everyone on the same page, as this work is concluded, our best strategies to deal with human overpopulation and climate change are the education of girls on a worldwide scale and the availability of family planning, alongside reliable contraception and safe and legal abortion practices. In effect, when adding these two solutions together (figure 8.1), they amount to our best collective exercise in hampering the massive continued discharge of greenhouse gases into the atmosphere as well.

In fact, there is a plethora of advantages and conveniences in extending these services and aspirations to half of the population on this planet, but one of the main reasons I did not prolong and expand on those benefits in this first volume of the Atlas is because I want to properly address them in the upcoming Volume II, in the chapters Access and Suffrage, since they are crucial to women's empowerment, participation in the labour market, improvement of the woman's health and her children's, among other reasons.

Solutions by Rank

Rank	Solution	Sector	TOTAL ATMOSPHERIC CO2-EQ REDUCTION (GT)	NET COST (BILLIONS US $)	SAVINGS (BILLIONS US $)
1	**Refrigerant Management**	Materials	89.74	N/A	$-902.77
2	**Wind Turbines (Onshore)**	Electricity Generation	84.60	$1,225.37	$7,425.00
3	**Reduced Food Waste**	Food	70.53	N/A	N/A
4	**Plant-Rich Diet**	Food	66.11	N/A	N/A
5	**Tropical Forests**	Land Use	61.23	N/A	N/A
6	**Educating Girls**	Women and Girls	59.60	N/A	N/A
7	**Family Planning**	Women and Girls	59.60	N/A	N/A
8	**Solar Farms**	Electricity Generation	36.90	$-80.60	$5,023.84
9	**Silvopasture**	Food	31.19	$41.59	$699.37
10	**Rooftop Solar**	Electricity Generation	24.60	$453.14	$3,457.63

Figure 8.1 List of top 10 solutions to deal with climate change. When added together, Family Planning and Education of Girls become our best effort. Project Drawdown (2017)

My other motivation for not embellishing and lingering too much on these desirable *solutions* is the fact that – *spoiler alert*! – Human overpopulation cannot be solved by relying solely on them. Allow me a moment to explain.

A study from the Guttmacher Institute titled *Adding It Up: Investing in Contraception and Maternal and Newborn Health* (Singh, Darroch & Ashford, 2017) arrived at the conclusion that: "In developing regions, 214 million women want to prevent pregnancy but are not using modern contraception." According to their results, if all of these women's unmet need for contraception were to be met, 23 million unplanned births would be prevented every year. Needless to say that this would be an incredible and glorious achievement. Nevertheless, it is vital that we dissect this statistic of 23 million unplanned births in more detail. Although it would be a prodigious achievement for women in developing countries to be empowered and able to control their reproductive choices, this figure of 23 million fewer births still falls short to the current net gain of 83 million people added to the planet every year. This is relevant because there are many population advocates, environmentalists, activists and anyone who campaigns on population management that believe that achieving universal contraceptive use and education for girls worldwide would solve the population problem. In regards to contraceptive use alone, it would surely help, but wouldn't be enough to stop population growth, much less put us on track of reducing the human population to sustainable levels.

The other "solution" to population growth is girl's education. A study from *Science* dating to 2011 by Lutz and Samir, investigated the demographic analysis of girls education and concluded that even if we achieved a fast-track scenario, based on South Korea's expeditious and swift education program – the country climbed from one of the least educated to the most educated countries in the world - and if all nations adopted that similar rate of girls education and achieved 100 percent enrolment in primary and secondary school, the study estimated that there would be less 843 million people worldwide, than if we had current enrolment rates. Once again, this would be a magnanimous goal, without a doubt women's lives would improve greatly, but it needs to be accentuated that population projections for 2050, expect it to inflate to roughly 9.9 billion humans on the planet (PRB, 2018). Given these points, achieving worldwide unmet contraceptive use and education would still leave humanity with an incredibly unsustainable number of roughly 8.5 billion by 2050. In essence, our two "greatest weapons" cannot reasonably be expected to control the rise of our numbers, much less invert its tendencies so we can attain a sustainable population with a reduced human regiment.

My final preoccupation, and quite possibly the most important of all, stems from the research published in the journal *Proceedings of the National Academy of Sciences of the United States* (PNAS) by Bradshaw and Brook (2014) titled *Human population reduction is not a quick fix for environmental problems*. I can safely articulate that this study alone robbed me of countless hours of sleep – perhaps due to my present lack of knowledge in the field of demography – and even though several vital ripostes have been redacted that I invite the reader to examine (O'Neil, Jiang & Gerland, 2015; O'Sullivan, 2015; Spears, 2015), one still can't shake one of the hypothesis put forward by Bradshaw and Brook (2014). They claim and I quote:

> "Although not denying the urgency with which the aggregate impacts of humanity must be mitigated on a planetary scale (Ehrilich et al, 2012), our models clearly demonstrate that the current momentum (Bongaarts, 2009) of the global human population precludes any demographic "quick fixes." That is, even if the human collective were to pull as hard as possible on the total fertility lever (via a range of economic, medicinal, and social interventions), the result would be ineffective in mitigating the immediately looming global sustainability crises (including anthropogenic climate disruption), for which we need to have major solutions well under way by 2050 and essentially solved by 2100 (Ehrilich et al, 2012, IPCC, 2014a, MEA, 2005). However, this conclusion excludes the possibility that global society could avoid all unintended births or that the global average fertility rate could decline to one child per female by 2100. Had humanity acted more to constrain fertility before this enormous demographic momentum had developed (e.g., immediately following World War II), the prospect of reducing our future impacts would have been more easily achievable."

Bradshaw and Brook (2014) devised several scenarios (figure 8.2) of population reduction strategies, and I quote again their observations:

> The population projections for the "business-as-usual" (BAU) (Scenario 1) and realistic changes in vital rates (Scenario 2a) produced similar 2050 and end-of-century populations. The more draconian fertility reduction to a global one child per woman by 2100 (Scenario 3) resulted in a peak population size of 8.9 billion in 2056, followed by a decline to ~7 billion by 2100. Enforcing a one child per female policy worldwide by 2045 and without improving survival (Scenario 4) resulted in a peak population size of 7.95 billion in 2037, 7.59 billion by 2050, and a rapid reduction to 3.45 billion by 2100. Avoiding the approximate 16 percent of annual births resulting from unintended pregnancies (Scenario 5) reduced the projected population in 2050 to 8.39 billion and in 2100 to 7.3 billion.
>
> The most striking aspect of the "hypothetical catastrophe" scenarios was just how little effect even these severe mass mortality events had on the final population size projected for 2100. The climate change (childhood mortality increase) (Scenario 5), future proportional "World Wars" mortality event (Scenario 6), and BAU (Scenario 1) projections all produced between 9.9 and 10.4 billion people by 2100. The catastrophic mass mortality of 2 billion dead within 5 years (Scenario 7) resulted in a population size of 8.4 billion by 2100, whereas the 6 billion-dead scenario (Scenario 8) still led to a population of 5.1 billion by 2100 [...] Projecting Scenario 3 (worldwide one-child policy by 2100, assuming no further reduction in total fertility thereafter) to 2300, the world population would fall to half of its 2013 size by 2130, and one-quarter by 2158."

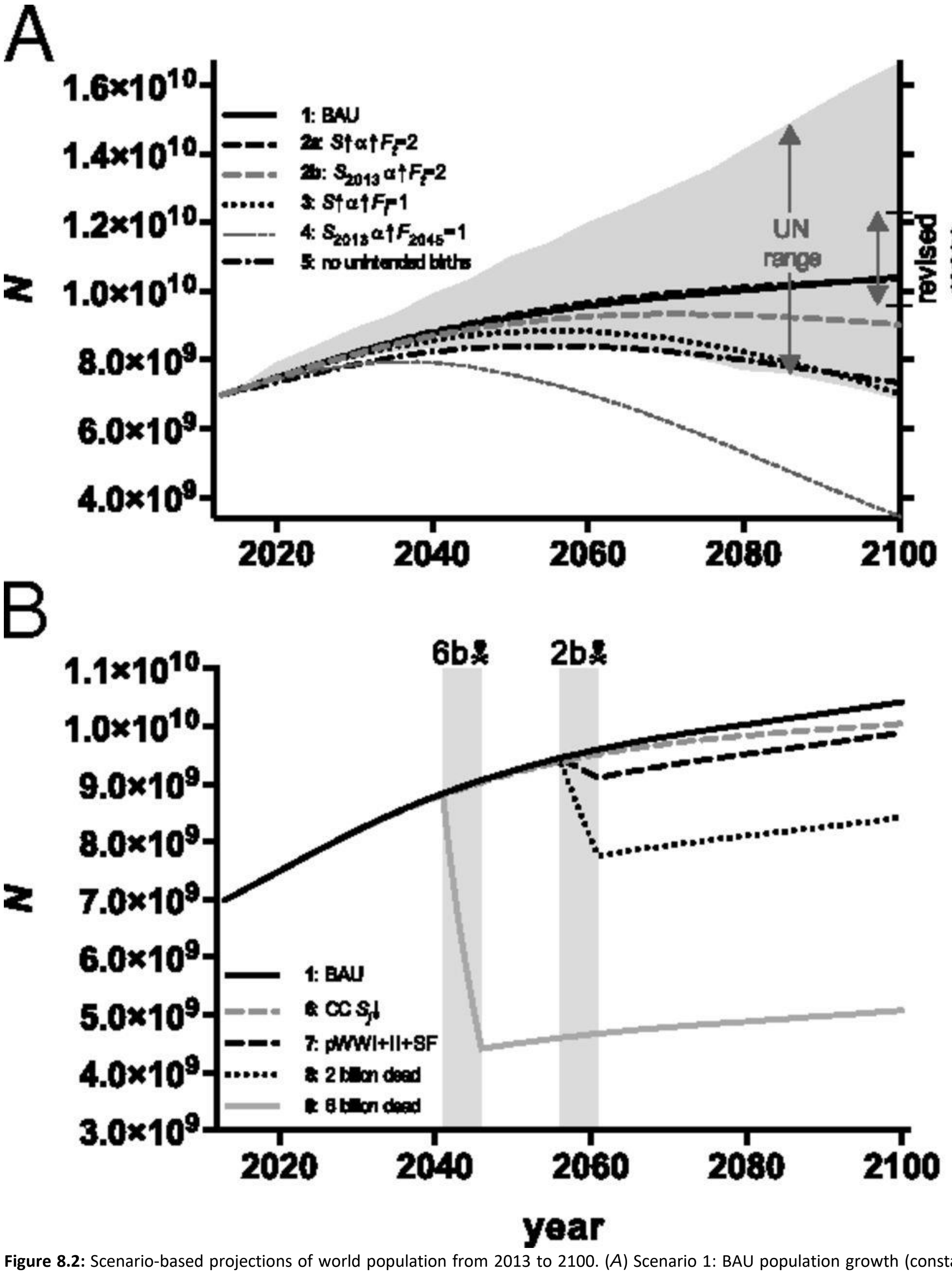


Figure 8.2: Scenario-based projections of world population from 2013 to 2100. (*A*) Scenario 1: BAU population growth (constant 2013 age-specific vital rates); Scenario 2a: reducing mortality (*M*), increasing age at primiparity (α), declining fertility to two children per female (*Ft* = 2) by 2100; Scenario 2b: same as Scenario 2a, but without reduced mortality; Scenario 3: same as Scenario 2a, but *Ft* = 1; Scenario 4: same as Scenario 3, but without reduced mortality and *Ft* = 1 by 2045 and thereafter constant to 2100; Scenario 5: avoiding all unintended pregnancies resulting in annual births. High and low projections by the United Nations (12) are shown as a grayed area, and the revised range for 2100 (13) is also indicated. (*B*) Scenario 6: elevated childhood mortality (*Mj*) from climate change (CC); Scenario 7: mass mortality event over a 5-y period starting 2056, equal to the proportion of combined number of deaths from World War I, World War II, and Spanish flu scaled to the mid-21stcentury population; Scenario 8: 2 billion people killed because of a global pandemic or war spread over 5 y, starting midway (i.e., 2056) through the projection interval; Scenario 9: 6 billion people killed because of a global pandemic or war spread over 5 y and initiated one-third of the way through the projection interval (i.e., 2041). The mass mortality windows are indicated as gray bars. Retrieved from Bradshaw and Brook (2014).

In a word, these results paint a desolate and harsh reality. On top of already so many adversities forged by the human hand that can be considered to have escaped "technological fixes" (runaway climate change, species extinction, acidification of the ocean, habitat transmogrification, etc.), it appears that human overpopulation can easily slip into that category as well, invalidating our best efforts of averting an ecological collapse and impeding a scenario in which humanity will undergo immense misery and suffering. In any event, if even the optimum scenarios of action regarding population, set us on this barren and ruined path, what can we expect to happen if humanity continues to disregard and sidestep the significance of this hovering threat – this Sword of Damocles – that is human overpopulation?

Before laying down this pen, there is one remaining exasperation that requires close inspection and scrutiny, and that is the argument that individuals who dedicate themselves to studying the many intricacies surrounding population are somehow anti-human. This is a perverse and pervasive assertion, and one can always expect this insistence to come up in any social gathering or intellectual debate. I will try to condense my views regarding this contention in the briefest way possible.

If there ever was a time to be alive and flourish as a human, this would be the age one would want to live their brief, but now longer and better existence. Without a doubt, humans have engineered this world and remodelled it to better suit their homeostatic desideratum, by erecting the civilizational foundations required for humanity to thrive. That has come upon by revising many of the Malthusian forces that were bounding much of our human potential, recalibrating much of our relationship with the natural world. We have, to a considerable degree invalidated our subjugation of many gruesome and terrifying diseases, as well as given admittance to a stable health system available to anyone in need; we have conceived of methods to enlarge the production of food and widened its access to more people than ever before (even though in absolute terms, the number of people who go to bed hungry is increasing); more people now have a reliable connection to an energy grid and access to the Internet; humanity has taken a stand and championed an impetus to safeguard and progress the status of women, minorities, atheists and apostates as well as many other oppressed groups; we have extended conscious protection and conservation for other species besides our own as well as having elevated our civilizational machine with an unrivalled output of knowledge and material wealth. All of these aspects, and many others have made life noticeably better for the chunk of humankind which has benefited from this revamping, and this is an undeniable fact, which isn't automatically countered or negated just because an individual stands for population stabilization and eventual reduction. It is because I don't want these achievements to come crumbling down that I advocate for the need to manage our fertility on a worldwide scale, for the reason that our excessive numbers will be a catalyst for their disintegration.

Notwithstanding all the advancements attained by our species, it does not stand to reason that the way we have been doing things is the preferred or most desirable approach because it just cannot be argued so. When optimists and believers of the human potential argue that life is better than ever before and that the momentum has every incentive to continue unabated due to the *Homo sapiens* ingenuity and resourcefulness, these individuals are ignoring our ecological reality as well as the fact that most of 'triumphs' have been built on the 'backs of the natural world.' By and large, we have successfully extracted resources, disfigured entire landscapes, desecrated water courses, adulterated the soil, violated our primeval forests, and we have exterminated and dishonoured our commitment to safeguarding other non-human passengers on this planet. In spite of all of these atrocities, I'm still a part of the majority of the environmental movement that does not want humanity to disappear completely since I hold, just like Carl Sagan once did, that "Extinction is the rule. Survival is the exception," and humans play a paramount role in this, not for ourselves, but for all other species on this planet. Allow me to explain.

If we follow the scientific record of every species that has ever inhabited the planet, estimates point out that 99 percent of life that has ever existed is already extinct, since the pattern for life is always a brief and momentary existence, in the geological scale of time, of course. Now insert humans. The *Homo sapiens* has a magnificent and unrivalled capacity to acquire cumulative knowledge, which in turn is used to better make sense of reality. The way I see it, humans have the unique (at least in this point in time) ability to amass the necessary knowledge to prevent a major extinction phenomena (like one forged by an asteroid impact), and although we are still not currently capable of doing something on that scale, we sure do have the potential to achieve it. Obviously, an asteroid impact would probably be enough to send our species to the fossil record, but it would as well do the same to the majority of life on Earth. For this reason, we carry with us the responsibility and a moral obligation to act as a shield or umbrella for the multitude of Life on this Earth, since no other species can fill these shoes and carry this planet on their shoulders. Among the many reasons that would stand for the perpetuation of human life on this Earth – potential for wellbeing, experience, acquisition of knowledge and understanding of reality, etc. – the preservation of other lifeforms is the one that I personally care most about, and that is what drives my argument for the permanence of humanity on Earth. However, that does not mean that we should propagate our numbers indefinitely and neglect ecological limits and non-human life just so we can flourish and thrive. That is completely antithetical to my vision of human coexistence with other lifeforms on Earth.

In the end, our allegiance and devotedness to Life should not be circumscribed to Humanity, we should think of our patriotic duties to animated existence to be prolonged far beyond our provincial anthropocentric perspective. In other words, if human numbers are required to be confined in order for all the aggregation and assemblage of life to propagate and proliferate, then it is our duty to vigorously act in this regard. In short, I could firmly state that:

My Loyalty Lies with Life

Appendix

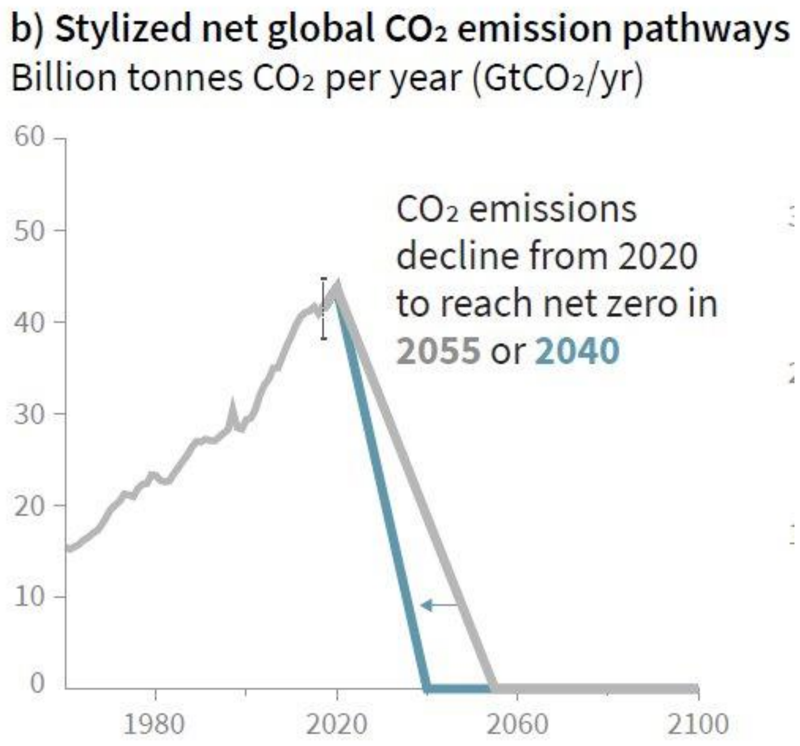


Figure I: Stylized net global CO_2 emissions pathways – Billion toones CO_2 per year ($GtCO_2$/yr). Required CO_2 to keep warming below 1.5ºC. Retrieved from IPCC (2018).

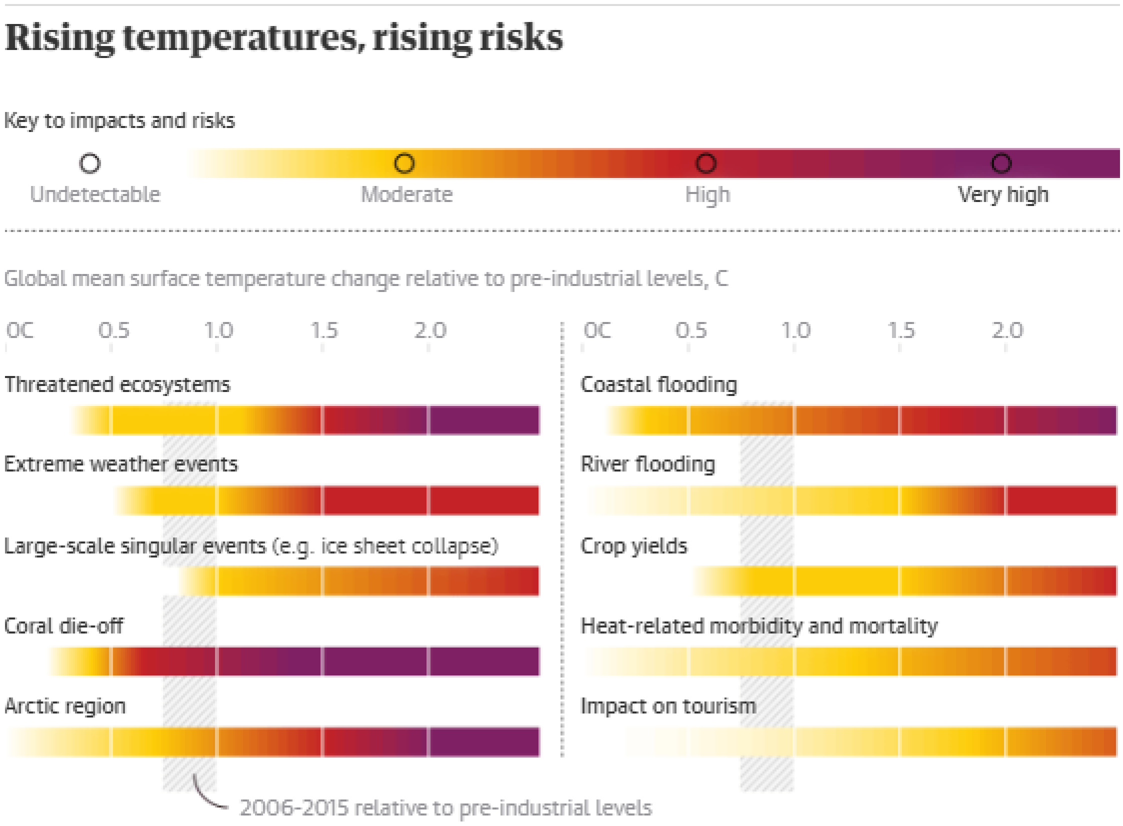


Figure II: Rising temperatures, rising risks. *The Guardian* graphic (Watts, 2018b). Retrieved from IPCC Special Report on Global Warming of 1.5º.

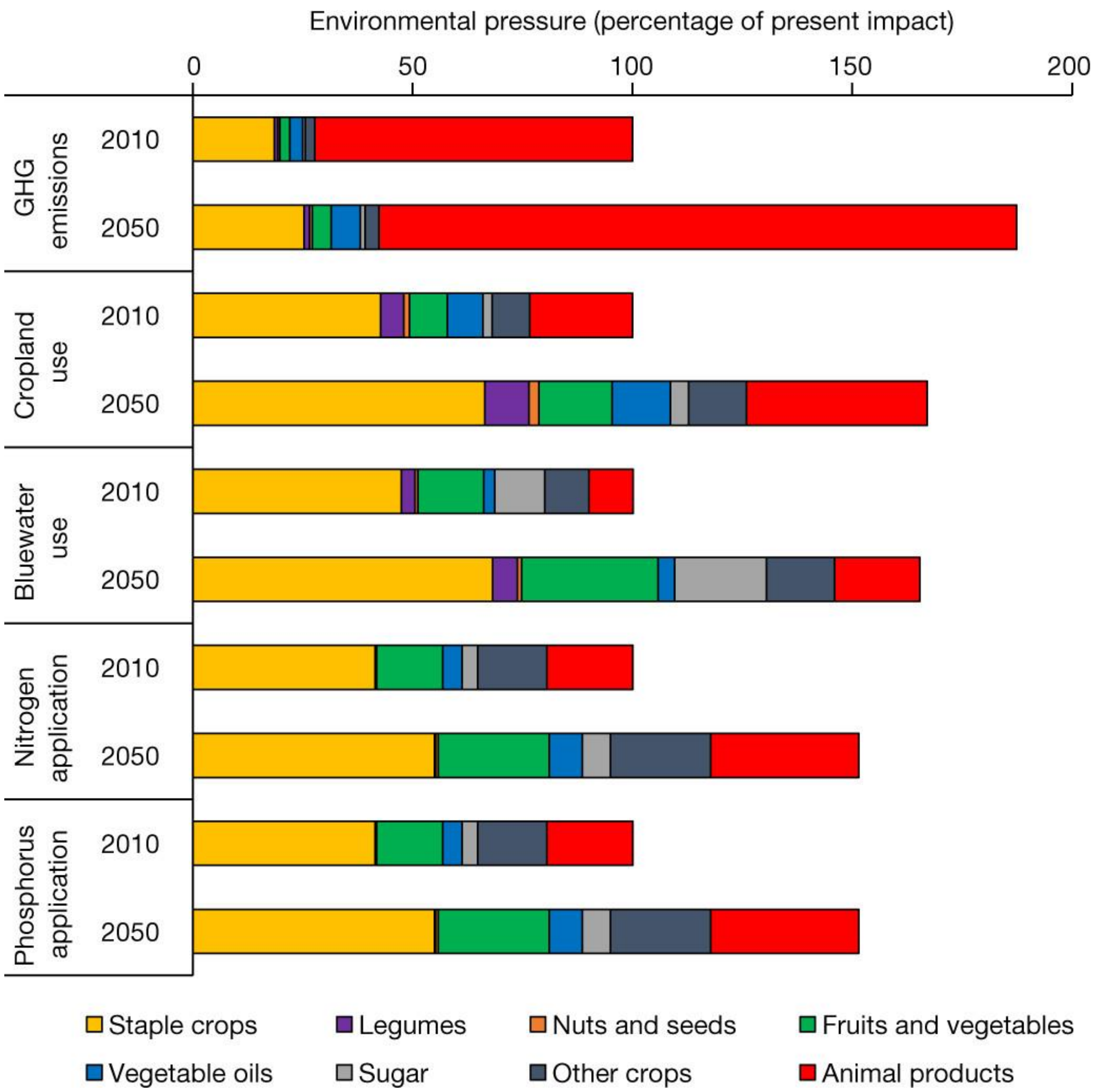


Figure III: Present (2010) and projected (2050) environmental pressures on five environmental domains divided by food group.Environmental pressures are allocated to the final food product, accounting for the use and impacts of primary products in the production of vegetable oils and refined sugar, and for feed requirements in animal products. Impacts are shown as percentages of present impacts, given a baseline projection to 2050 without dedicated mitigation measures for a middle-of-the-road socioeconomic development pathway. Retrieved from [Springmann et al, 2018].

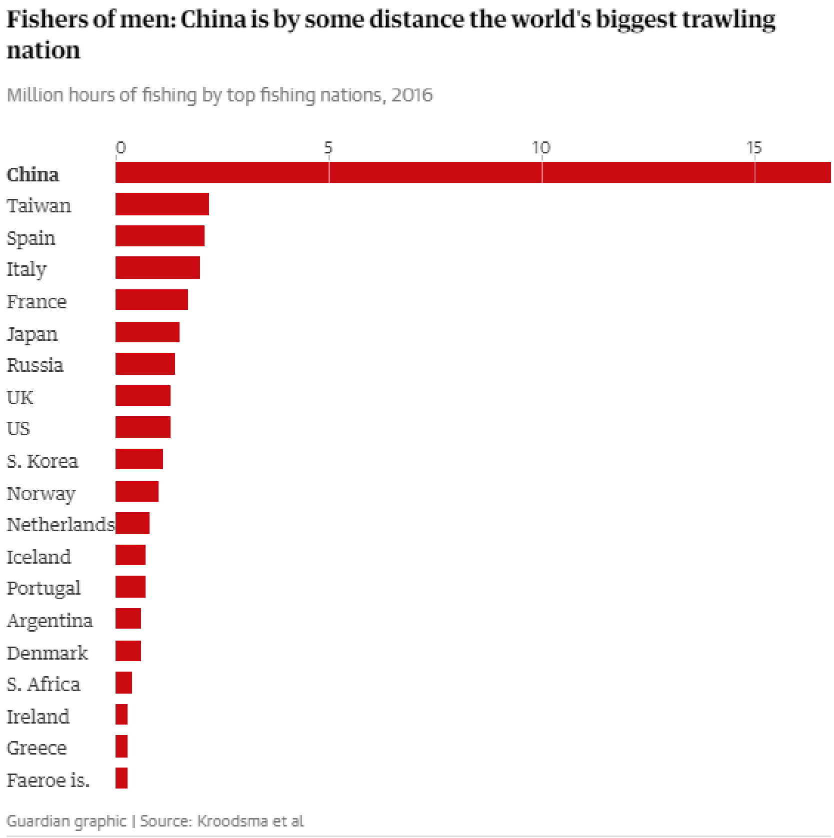


Figure IV: Millions of hours of fishing by top fishing nations. Source: Kroodsma et al, 2018. Retrieved from Jowit, 2018.

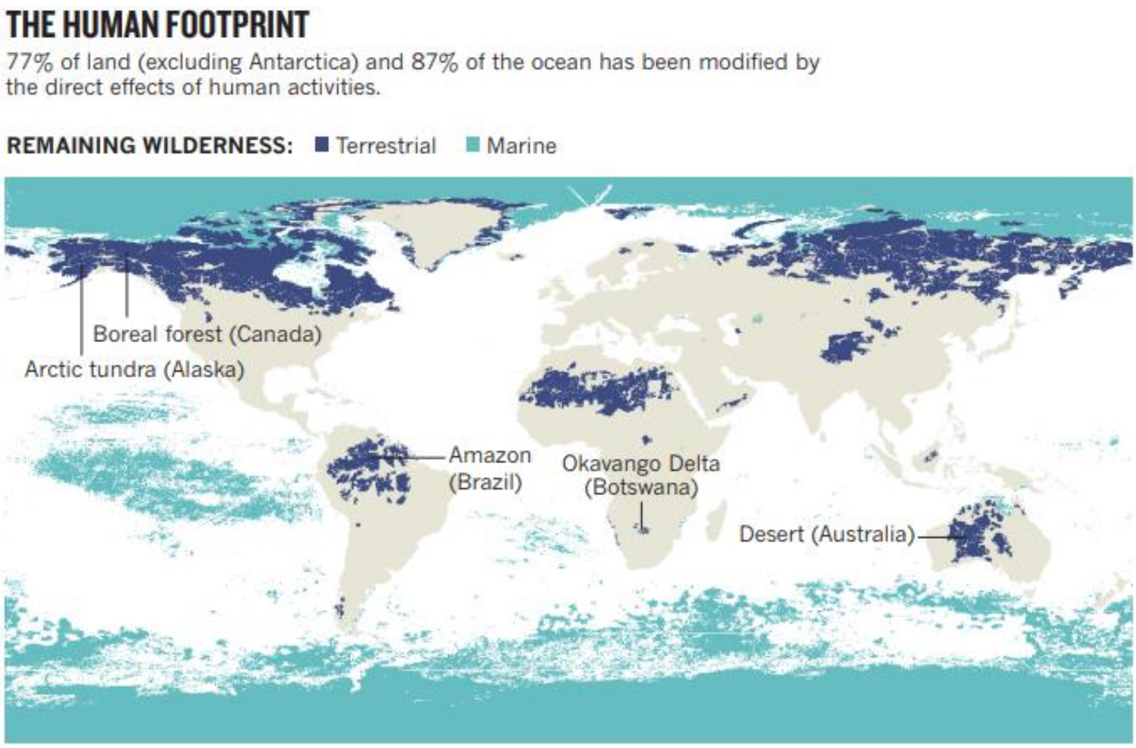


Figure V: Earth's remaining wilderness areas. The human footprint on the planet: 77 percent of land (excluding Antarctica) and 87 percent of the ocean has suffered modification at the hands of humanity. Retrieved from Watson et al, 2018.

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