ENVIRONMENTAL LIMITS AND BOUNDARIES:
EVOLVING MEANINGS, HOW DIFFERENT SCHOOLS OF THOUGHT DRAW A ROADMAP AND WHAT WE LEARN FROM THAT

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List of Acronyms

LtG	Limits to Growth
DG	Degrowth
PB	Planetary Boundaries
SRC	Stockholm Resilience Centre
SD	Sustainable Development
SDGs	Sustainable Development Goals
ICTA	Institute of Environmental Science and Technology, Autonomous University of Barcelona
CSIRO	Commonwealth Scientific and Industrial Research Organisation
MIT	Massachusetts Institute of Technology
S&T	Science & Technology
STS	Science and Technology Studies

Please note, limits and boundaries used individually, as *limits* or *boundaries*, or together as *limits and boundaries* stand for *environmental limits and boundaries* unless otherwise specified.

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Abstract

This paper seeks to trace the evolution of the intellectual debate on environmental limits and boundaries to understand the varied interpretations and aspects of this debate and ask how and why these limits are politicized the way they are. It does this by examining how three schools of thought conceptualize environmental limits, and investigates the reason for differences in articulation of the problem as well as the solution. In the process we see how the scientific framework and the discourse of environmental limits is a co-production with interpretive flexibility, and usually unacknowledged, non-environmental aspects together making it a much-contested concept.

Relevance to Development Studies

Understanding how the concept of environmental limits originates, evolves and lends itself to different articulations and uses by scientists and thinkers and their respective audiences such as policy makers, governments and the industry, as well as laymen, could help gain insight into the debate, scientists' motivations, how and on what basis they construct particular arguments, who they appeal to and why some framings are more acceptable than others.

1 Environmental limits and boundaries: Evolving meanings

Reflection on and talk of natural limits and boundaries has been around for a long time, relatively speaking, the world over, as evidenced later in the chapter. Although one might not always recognize it as such since it is done in diverse contexts by scholars from various fields using different languages, as well as by thinkers and activists outside academics. But about four decades ago this critical intellectual debate was popularized and brought to the forefront by a group of scientists from MIT who published *Limits to Growth*, a study sponsored by the Club of Rome (Victor 2013; Ekins 1992). The message of the report, reflected in all contemporary conversations on limits and boundaries today, was very well received initially. However, starting with the 80s it was misrepresented, misinterpreted and or deliberately ignored by policy makers, governments, industry and the media, so much so that all talk of Limits to Growth almost became taboo (Bardi 2011). Today once again there is a buzz in academics about limits. Some believe the publishing of Planetary Boundaries is responsible for the revival of this discourse (McAfee 2015). In addition, many scientific institutions, few of them listed later in the chapter, are working to provide empirical evidence on environmental limits and boundaries to create 'sustainable futures' and bring about socio-economic transformations. "These new scientifically framed threats are currently attracting unprecedentedly intense attention in global governance" (Stirling 2015: 55). Why this reorientation. Could it be because people have changed their mind in light of recurring economic recessions and extreme weather events, or are the alternate pathways available and policy suggestions more astute or because the framing of the problem is different? These are some of the queries this paper addresses.

The tracing of the concept reveals there has been an evolution and shift of focus and language from *limiting* consumption (intrinsic value, ethical behavior and moral responsibility) to *limiting* growth (especially 60s and 70s) to environment *limiting* growth or environmental limits. What does this signify? How does this transpire if the problem remains the same. The shift implies arguments on limits change based on different ideologies, origins and values, and the times and place they are raised in, and that some arguments are perhaps more acceptable than others. For example, even today not all intellectual framings, like that of the Degrowth school, get similar reception. Besides, it matters which angle one looks at the argument from. Because fundamentally there is nothing 'natural' about limits. Limits are a result of human endeavor. A fact that often gets obscured, deliberately or subconsciously, in interpretations, articulations and translations. Such that the issue becomes about getting around the problem, instead of confronting it. For instance, finding an alternative to fossil fuels without enquiring why, for whom and for what purposes is the energy required.

Barack Obama (2016) recently wrote an essay for The Economist defending the 'American-style capitalism' and free trade in which he emphasizes the necessity of advancing productivity growth while tackling inequality and unemployment. Towards the

end of this essay he mentions the need to address climate change, adding, "over the past five years, the notion of a trade-off between increasing growth and reducing emissions has been put to rest" (pp26). Some scientists, from the Limits to Growth and the Degrowth schools specifically, would disagree. They believe there are serious tradeoffs to be confronted if significant reduction in emissions is to be achieved since complete decoupling of the economy from the environment is an Elysian dream. Scientists from the Planetary Boundaries school believe many phenomenon, not only natural, whether it's inflation, extreme weather events, wars, antibiotic resistance, or refugee fluxes (Rockstrom 2015) are because humanity has been transgressing environmental boundaries. In addition, there are new uncertain phenomena related to crossing of limits in store that need immediate attention, such as storms in intensity and in places that didn't experience any before; or exposure to unexpected pathogens similar to the anthrax outbreak in Siberia because of the permafrost melting.

At first glance it seems intuitive, almost obvious that of course the planet is finite. 'Spaceship Earth' (Boulding 1966) is a closed system after all, except energy exchange, so there are bound to be physical limits that we'll run into at some indefinite point in the future. But when thinking of the details and the implications of these limits we have started hitting it gets very complicated very quickly. For instance, to what degree is it about land, water and atmosphere? In what measure is it about population, resource depletion, species extinction or waste generation? How much of it is locally situated, how much a globally interconnected phenomenon? Who is responsible? Is there a natural-science based empirical definition of these boundaries, or physical limits, such that operating within them guarantees safety. Or is it more a subjective limit, that's about accepting and interpreting scientific definitions, risk and uncertainties and then about "normative judgments of how societies choose to deal with (these) risk and uncertainties" (Rockstrom et al. 2009). Thus a *co-production*, that is a product of the natural and the social order all being created simultaneously (Jasanoff 2004) and that is why about political choices, 'fact making practices' and the related 'social influences and biases' (Latour 1987). Then the questions arise who sets the limits and for whom, what are the different aspects and how are the arguments constructed, how is this knowledge accepted or rejected, and how and why do the scientists talk about the same subject in different manners. This paper traces the journey of these ideas and tries to make sense of the meanings attached.

1.1 Objective and methodology

The objective of this study then is to understand how the concept of environmental limits and boundaries evolves, how it is conceptualized, and the reasons for differences in articulation, perspectives and its reception, followed by exploring the significance of these differences for the concept/debate, the scholars and their respective audience. This entails comprehending the intellectual origins of the concept; asking how scientists' talk about environmental limits based on different methods of enquiry and backgrounds; what

social, political, and economic contexts they use it in; what their assumptions are; and how they reach the conclusions on the problems and solutions that they do. This is done by examining how three leading schools of thought conceptualize the idea of ecological limits and consequently chart a course to overcome the current economic growth-ecology impasse.

The first step was to select schools based on the interest and objective of the paper. Schools that are active participants in today's debates, are from different geographical locations, and that regularly publish or get coverage in western academic journals. Different locations mattered because the political and socio-cultural leanings of a place and time are reflected in the evolving beliefs and philosophies of the schools, which is showcased in the next chapter as well as chapter 5, that in turn shapes the scientists' perception of the problem and their choices in looking for alternatives. As Jasanoff and Martello expound, "how we understand and represent environmental problems is inescapably linked to the ways in which we choose to ameliorate or solve them" (2004: 5). The three schools that feature prominently in the western Anglophone academic literature and which specifically (directly or indirectly) deal with environmental limits vis-à-vis the current socio-economic organization are:

1. Limits to Growth (LtG), original research was conducted at MIT, later the scientists moved on to different institutions but continued with the research and publishing.
2. Planetary Boundaries (PB), Stockholm Resilience Centre.
3. Degrowth (DG), Barcelona and France based school of thought and a movement.

Reasons and justification for selecting particularly the above three is covered in the next chapter. It should be mentioned, the Degrowth school has many scholars and activists from across the world, from both the global North and South who work for, believe in and contribute to the literature. "Different people arrive at it from different angles" (D'Alisa et al 2015: xx). Thus the theory also draws from various sources and disciplines where not all scholars agree on all issues although bound by the same basic principle of degrowth. For example, some are 'skeptical' (ibid xxv) of steady state while others like Kerschner advocate the concept arguing steady state is in fact complementary and not contradictory to degrowth's aspirations (2010: 549). Hence it was assumed that the contributors to the book on DG (A Vocabulary for a New Era 2015) and collaborators of these authors speak for this school of thought even if not always in agreement, nor necessarily belonging to the movements they draw from.

The next step was to choose appropriate lenses. The implications and actions these schools talk about, based on environmental limits, are intrinsically about dealing with the problems of economic organization, as is apparent from the very name of the two schools, therefore the lenses chosen, which are chapters by themselves, are:

1. Economic Growth (including GDP accounting, accumulation and profit).
2. Solutions and recommendations.

The two lenses initially act more like analytic filters since the analysis is not included in these chapters instead comes towards the end, in chapter 5, after first looking at how and why the schools find fault with the current economic system and what changes they recommend. Why these two lenses specifically? The reason for the first is it covers essential elements of economic growth, which all three schools identify as the paradigm that requires transformation. In this context other lenses considered included development and progress, utilitarian versus intrinsic value, few more specific elements of growth such as production and consumption, markets and technology, and firms, investment and marketing. Upon closer reading of the literature it became apparent that economic growth in general, and some of its fundamental features in particular, would best serve the purpose of a. shedding light on the main issues vis-à-vis boundaries, and b. highlighting the schools' process of problematizing growth. As for the second lens, the differences in the thinking of these schools, and politicizing of limits, is better revealed in their alternate pathways or worldviews, their imagined sustainable societies. That is why how they guide or try to resolve the issue was important to get an insight into different viewpoints and the larger conversation on limits.

This study is not a comparative analysis, although it does give an appreciation of how different origins lead to different ways of thinking, along with insights into where the schools converge and where they diverge. Nor is it about the concept but about how limits are treated by various interest groups. In addition, the objective is rather broad and the research a non-linear process, that is why a scoping or selective review was carried out. This included published work, books, talks and presentations, podcasts, as well as interviews and grey literature to understand the theory as well as opinions and beliefs of the scientists and activists and get an insight into their backgrounds. Papers included their most cited articles as well as some that are not, but definitely comprises more work by the most prominent of the scholars of the respective schools. There were certain assumptions when deciding on whose work to include and who conforms to which school of thought, since each school involves many scientists working on the primary project and then teaming up with different people to work on offshoot projects. This posed a bit of a challenge since most authors publish often and regularly collaborate on the evolving theories and policy suggestions.

A word on natural and environmental: they are not interchangeable. The etymological distinction applies when used with limits and boundaries as well. *Environmental* in this sense is sometimes interchangeable with *ecological*. N*atural* is that which is not fully accessible to human instrumentation. Also, Van Den Bergh (2010) begins his paper Environment versus Growth saying it's an old debate and probably 'everything has been said about it' (881), on the same lines then this paper doesn't claim to unfold new revelations about the conversation on environmental limits but hopefully presents a somewhat novel juxtaposition. And for that reason some ideas are not referenced since the context here is assumed to be different nor, due to lack of space and time, established

theories on for example 'knowledge construction', 'power' or 'evolution of ideas' in their own right further elaborated upon.

Ensuing chapter introduces the origins and basic concepts of the three schools. It showcases how the time, place and related ideologies are reflected in the origin of the concept of limits. This is followed by the problematizing of economic growth and the schools' recommendations and solutions for the way going forward in chapters 3 and 4 respectively. Then comes the analysis in chapter 5 which discusses the implications of the differences in articulation of boundaries, followed by the conclusion. First what follows is a peek into the origin of this concept.

1.2 Origin of limits and boundaries

The idea of keeping within limits human materialist aspiration is not new. Although the context has changed over the years. For that matter prescriptions of virtues of simple living have values of anti-materialism, which can be traced as far back as in epics written five thousand years ago, the same values that Gandhi and Thoreau propagated and that many of today's anti-growth movements (environmental) are based on. Alier et al. (2010: 1742) trace the intellectual beginnings of the Degrowth school to mid-1930s, during the great depression, in Bernard Charbonneau and Jacques Ellul's work in which they appeal for an "ascetic society" and criticize modernity and gigantism as well as "productivity and individualism", with Ellul expanding on these concepts in his influential book *The Technological Society* (written in 1954) in which he explains how efficiency produced through 'technique' alienates man from all aspects of life. Guha quotes Gandhi from 1928 for his critique of the productivist paradigm and the multiplying of unrestricted wants: "'God forbid', writes Gandhi, 'that India should ever take to industrialization after the manner of the West. The economic imperialism of a single tiny island kingdom (England) is today keeping the world in chains. If an entire nation of 300 million took to similar economic exploitation, it would strip the world bare like locusts.'" (2006: 231).

Apprehensions about damaging the environment, resource depletion (particularly forests), waste generation and pollution (mainly smoke from coal) arose in the UK in as early as mid-1800s (McKitrick 2011). As well as interest in conservation for the sake of conservation. In the US it was in 1940s and 50s that depletion of resources and conservation in relation to population growth and economic collapse gained prominence and consequently had the government (Roosevelt, Truman) looking into possible responses. In this context Vogt published *Road to Survival* in 1948, *Limits of the Earth* came out in 1953 authored by Fairfield Osborne; *Resources and the American Dream* in the same year by Samuel Ordway (ibid), J K Galbraith in 1958 published *The Affluent Society,* which was about social and environmental consequences of mass consumption. All these were preceded by *Fight for Conservation* in 1910 authored by Pinchot. John Ruskins, an artist, art critique, writer and social commentator published *Unto The Last* in 1862. In the book he writes about the effect of industrialization on environment commenting, "any given

accumulation of commercial wealth may be indicative, on the one hand, of faithful industries, progressive energies and productive ingenuities; or on the other hand, it may be indicative of mortal luxury, merciless tyranny, ruinous chicanery" (Ruskin paraphrased by Gandhi 1908: 17[1]). In the same essay Ruskin also discusses justice, what entails 'legal' for the economists who believe in the 'science of getting rich', distribution and moral responsibility.

These concerns were not about crossing a border or limits regarding the planet and endangering the survival of its many species including humans though. They were about a limit nevertheless. Although climate science is nearly two centuries old and some scientists, like Tyndall in 1859, have been for decades suggesting that raising CO_2 levels (concentration of GHGs) could lead to climate change, the idea backed by increasing scientific data and advanced computing ability that we are crossing a threshold of some sort and that neo-liberal capitalist economic model that depends on producing and consuming more and more 'goods' is unsustainable and might lead to a calamity jeopardizing the Earth System, gained momentum in the 60s and 70s. Especially with the controversial LtG mentioned above. So in a way the 60s and 70s are arguably recognized as the most important decades for promoting the idea of limits to the Earth vis-à-vis human economic growth and material consumption. Some examples include *Small is Beautiful* published in 1973 by Ernst Schumacher also known as "first of the 'holistic thinkers' of the modern Green Movement" (Porritt 1993: vii); *The Closing Circle* by Barry Commoner in 1970; Lovelock and Margulis' *Gaia Hypothesis,* which Earth System science is said to trace its history to (Steffen et al. 2016); and development of the French concept decroissance and the subsequent Degrowth movement which has a following across several countries currently.

Today there are many institutes and movements dedicated to researching and finding alternatives to the current growth paradigm because of growing concerns over climate change. Some of these are purely research based and some run social projects based on these ideas across the world. Future Earth, Earth system governance, Gaia Hypothesis, Worldwatch Institute (headquartered in DC), IGBP, International Geosphere-Biosphere program (1987-2015), Millenium Ecological Assessment, Anthropocene Working Group, etc., are a few such organizations committed to bringing about a transition in thinking and behaving. The next chapter introduces three such leading and prominent schools of thought that help tell this critical and momentous story of environmental limits and boundaries.

[1] In 1908, impressed and influenced by Ruskin's book, Gandhi translated and published a paraphrase of this in Gujarati for the newspaper Indian Opinion, published in South Africa.

2 Ideas, people, places and times

Ramchandra Guha in his book *Patriots and Partisans* quotes Wallace Stegner on the "'tracing of ideas"' as being a "'guessing game"' and that "'we can't tell who first had an idea—we can only tell who first had it influentially, who formulated it in some form, poem or equation or picture, that others could stumble upon with the shock of recognition"' (2013:13). The three schools presented here have interesting beginnings and some of them have themselves in detail traced the origins of their study or movement. Yet even for them it is difficult to comprehensively know, and to put down, when, where, and what exactly sparked an idea, since their opinions and concepts draw from and encompass many aspects of life, across space and time, that must have arisen simultaneously at several locations. Nevertheless, for those interested in the emergence and coming together of these ideas and groups, which are interlinked, one can delve further into the progression of socio-political scenarios in their respective countries or continents, cultural frames, world wars and its effect on socio-economic conditions, different movements and thinkers and their influence on these actors, political allegiance, life experiences, like travels, and much more. In the Appendix is a comparative table that provides a quick basic idea of where the schools converge or diverge. Following is a brief overview of the origins and the concepts of the three schools.

2.1 Limits to Growth

The Club of Rome[2] is an informal organization, with exclusive membership, of influential and esteemed individuals from the sciences, business, and civil society that was founded by an Italian industrialist Dr Aurelio Peccei and a Scottish scientist circa 1968 (clubofrome.org). Dr Peccei, an economist and a successful industrialist, was an extensive traveler who had been part of the Italian resistance against Mussolini. During these travels he was disturbed by "what he saw" (Donella Meadows 2007: 191), and that is why initiated the club by bringing together distinguished group of friends who would help determine causes and more importantly solutions to what they identified as the 66 Continuous Critical Problems, which were varied yet interacting on a local and global scale, including problems like poverty, oppression, resource depletion, war, drug addiction, north-south divide and economic instability (ibid).

Jay Forrester, an MIT professor, based on his work in computer modeling, then a relatively new and exciting field, proposed using System Dynamics[3], a field he helped develop at MIT in the 50s, for analyzing and integrating complex interactions between the various elements of the problem (Limits to Growth 1972). The club welcomed the idea. Forrester applied this new technology to 'nonlinear, complex systems' the fundamentals of which were 'stocks, flows, and feedbacks' (ibid). Based on this very Systems Framework, he started work on a

[2] Named thus because the group first assembled at Accademia dei Lincei in Rome.
[3] System Dynamics is mathematical modeling applied to "dynamic problems arising in complex dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality" (systemdynamics.org).

"world famous and trend setting" (Randers 2000: 214) global model prototype that might help explain humankind's predicament or the world problematique[4].

The 60s in America was the time of the anti-establishment counterculture movement which included uprisings against poverty, war, and segregation as well as growing concerns about the environment, especially with Rachel Carson's publishing of *Silent Spring* in 1962. In 1970 Dennis Meadows had returned to MIT after being away on a road trip with Donella which took them from London to Sri Lanka (Donella Meadows 2007). Meadows writes that while on this trip they too were confronted with similar thoughts, insights and 'connections' as what Forrester was working on at MIT and that's why, after attending a seminar organized by Forrester for the Club of Rome, they both eagerly volunteered to join the project (ibid). Dennis Meadows selected and directed a team of 16 scientists, from six[5] countries with varied backgrounds, to work on the project based on the worldview or vantage point of *Systems* (Meadows et al. 2004). The World3 computer model they designed took possibilities like new institutions, technological innovation and increased energy sources into account besides positive and negative feedback loops, interacting stocks and flows, and non-linear relationships built into it to show how "complex systems change over time" (Meadows et al 2004: 7-8). Based on these calculations, a little less than a year into the study, Forrester presented to the unsuspecting club the underlying cause of the problem: "growth—exponential growth of energy use, material flows, and population against the world's physical limits" (Donella Meadows 2007: 193).

The results of this study were published in 1972 as the book The Limits to Growth (LtG) written by Donalla Meadows, an American biophysicist, Jorgen Randers, Norwegian professor of climate strategy, Bill Behrens, American resource expert, and Dennis Meadows, professor and Director of mathematics, engineering and social sciences at MIT and other institutes. This report presented to the world 12 scenarios or 'possible futures', from 1900 until 2100, based on interactions between five economic subsystems: agriculture, industrial production, consumption of non-renewable resources, persistent pollution, and population (Meadows et al. 2004). The main premise was if exponential rise in population and industrial growth continue in an environmentally finite system, humanity is bound to run into trouble like natural disasters, increasing food scarcity, or 'gross inequalities' (ibid: xii) the costs of managing which in terms of 'capital and manpower' required might prove catastrophic for the society. The ten scenarios from the latest book, sans their accompanying graphs and tables can be found in Appendix II.

[4] "Project on the Predicament of Mankind: The intent of the project is to examine the complex of problems troubling men of all nations: poverty in the midst of plenty; degradation of the environment; loss of faith in institutions; uncontrolled urban spread; insecurity of employment; alienation of youth; rejection of traditional values; and inflation and other monetary and economic disruptions" (The Limits to Growth 1972).

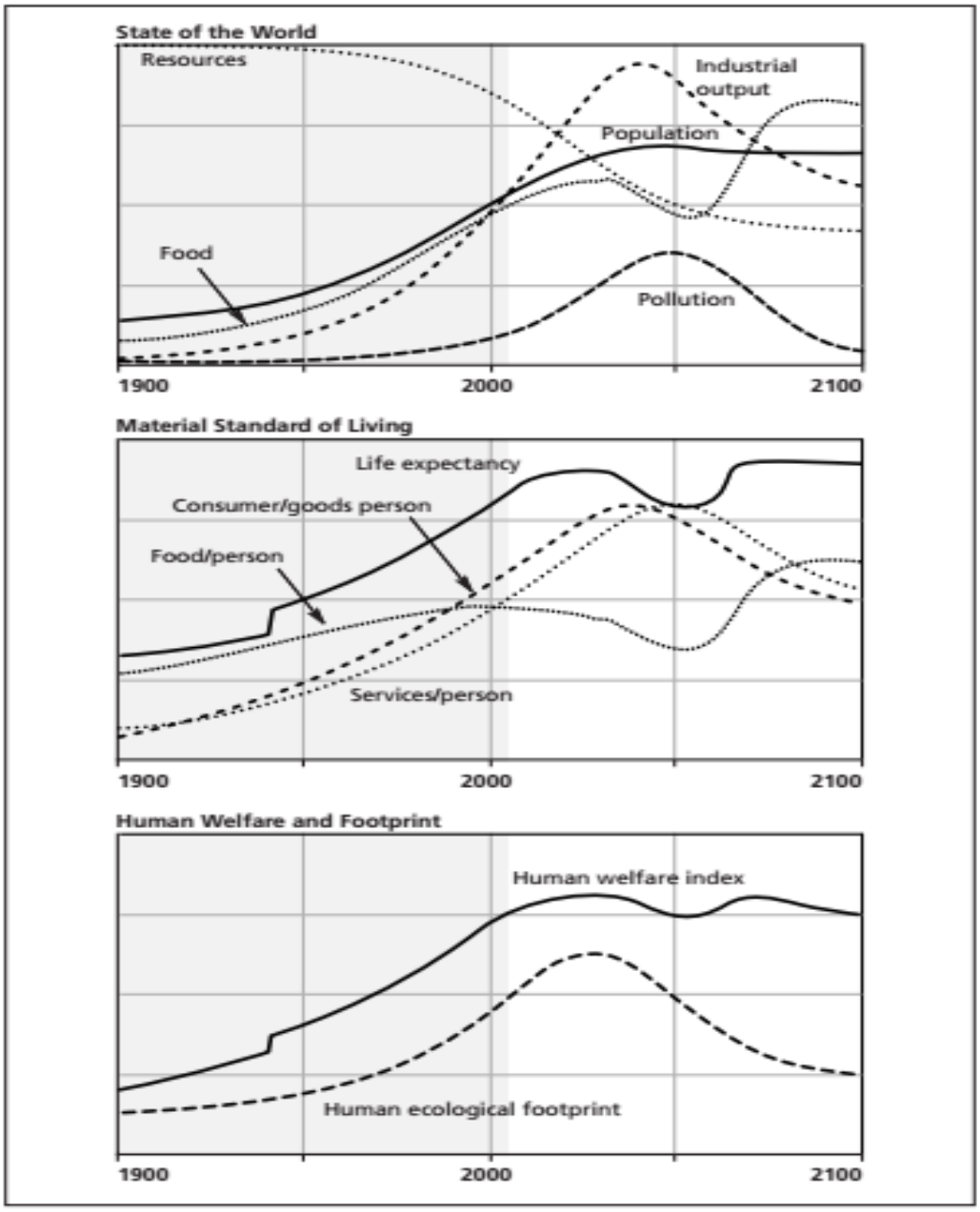
[5] United Sates, India, Iran, Turkey, Germany and Norway.

The study's main message was that humanity must reduce its ecological footprint[6]; that we must pay heed to the exponential character, and the dangers therein, of population combined with industrial growth; that if nothing is done and 'limits to throughput' (ibid: 8), i.e., rate of extraction and emissions, ignored, we could overshoot the planetary limits leading to forced contraction and collapse of the economy and society; and that that is why we had to define and choose the limits ourselves to avoid nature or markets choosing it for us by responding as soon as possible with global policy and institutional change (Meadows et al. 2004; Randers 2012). They also discussed solutions and recommendations, which are detailed in chapter 4, to correct the course that would well keep humanity from going beyond limits while meeting everyone's basic needs and promoting wellbeing.

Their book was translated into 30 languages, sold millions of copies and was a bestseller gaining staunch supporters across communities. This was the beginning of a critical intellectual debate that continues 40 years on and a precursor to many such scientific studies and schools of thought today (Victor 2013; Ekins 1992). Yet at that time, a time of immense confidence in technology and economic growth (Randers 2012: 105), the period of deregulation and liberalization and unfettered progress (Meadows et al. 2004), this was a controversial issue and the book was attacked by economists and some academics like Beckerman, Solow, Shubik, and Wallich; by politicians, industrialists, leading media outlets, including an article by well-known economists Passel, Roberts, and Ross in NYT (Bardi 2011); as well as Science, Newsweek and The Economist (Randers 2000). In addition, although the Meadows and team had explicitly stated that these were probabilities and tendencies only, not predictions or exact values and in fact included six positive scenarios that showed a world in equilibrium or sustainable state, an article in NYT said it was all about doom and collapse.

[6] Meadows et al write that in 1972 lack of basic data, concepts, and simple vocabulary related to for instance overshoot, ecological footprint, carrying capacity, and sustainability made it more difficult to have 'an intelligent conversation' (2004: xiii-xiv).

Fig 1: Scenario 6 from Limits to Growth (2004)



Scenario 6: More Accessible Nonrenewable Resources, Pollution Control Technology, Land Yield Enhancement, Land Erosion Protection, and Resource Efficiency Technology
Now the simulated world is developing powerful technologies for pollution abatement, land yield enhancement, land protection, and conservation of nonrenewable resources all at once. All these technologies are assumed to involve costs and to take 20 years to be fully implemented. In combination they permit a fairly large and prosperous simulated world, until the bliss starts declining in response to the accumulated cost of the technologies.

This complex world system was subsequently tested by modelers across the world who reacted favorably to it (Bardi 2011). The team has since published *Beyond the Limits* in 1992 and *Limits to Growth: The 30-year Update* in 2004. Graham Turner, a physicist from CSIRO, in 2008 published a paper comparing the LtG results 'with 30 years of reality' and

concluded that for many variables like climate change, peak oil and food and water security the current data resonates with the business as usual scenario depicted in LtG (Turner 2008). Hall and Day writing for American Scientist state "the original projections of the limits-to-growth model … up to the current time are largely accurate" (2009: 235). Today, based on examples like depleting fisheries, growing inequality, rising sea levels, rate of soil degradation, and constantly falling per capita GDP in some countries the scientists say the world is in a state of overshoot and urgently needs to prepare for the consequences to 'soften the impact'.

Fig2: Real-world data comparison, 1970-2000, Graham Turner

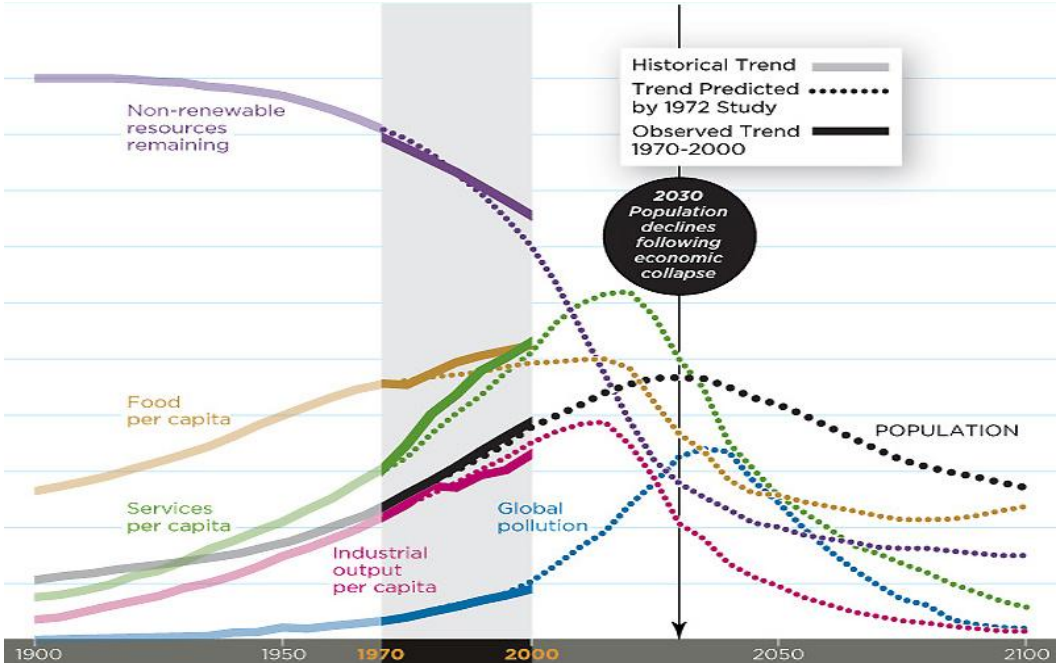
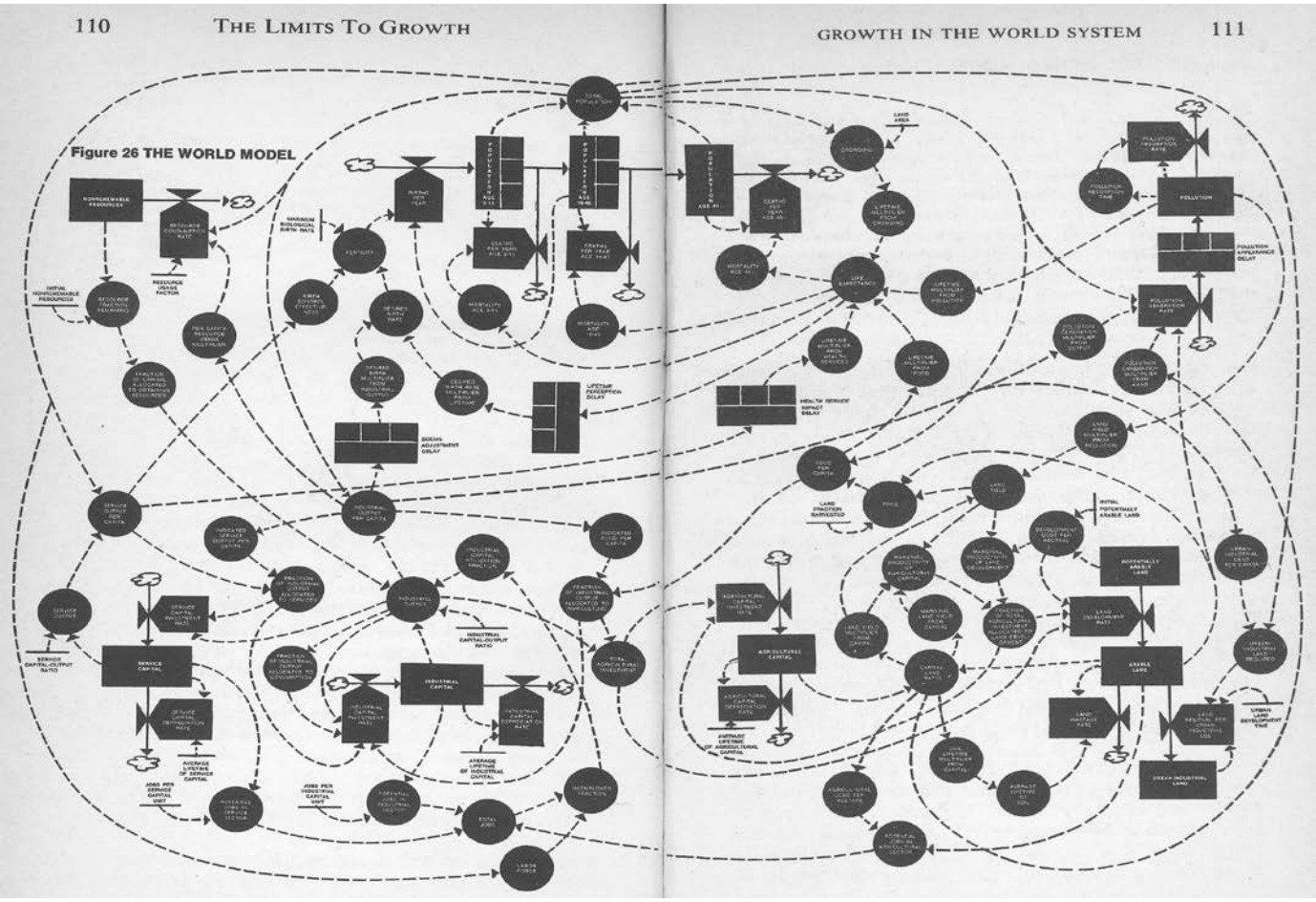


Chart Sources: Meadows, D.H., Meadows, D.L., Randers, J. and Behrens III, W.W. (1972) (Linda Eckstein)
Source: Smithsonianmag.org 20

Fig 3: The World Model Source: Limits to Growth, 1972, page 102



The entire world model is represented here by a flow diagram in formal System Dynamics notation. Levels, or physical quantities that can be measured directly, are indicated by rectangles, rates that influence those levels by valves, and auxiliary variables that influence the rate equations by circles. Time delays are indicated by sections within rectangles. Real flows of people, goods, money, etc. are shown by solid arrows and causal relationships by broken arrows. Clouds represent sources or sinks that are not important to the model behavior.

2.2 Planetary Boundaries

Scandinavian countries are considered the leaders in policy and institution innovation regarding environmental issues (Dryzek 2005). The first UN Conference on Environment, held in Stockholm in 1972, was due to Sweden's initiative. Because of the good reputation enjoyed by the Nordic countries in international and domestic environmental arena, write Naess and Hoyer, it was 'natural' for UN to choose Norwegian prime minister G H Brundtland to head the 1987 Commission (2009: 83). Sweden is often ranked, although critics find the system of ranking flawed, by independent agencies like the Yale Environmental Performance Index as one of the most sustainable countries in the world. This 'success', writes Dryzek, can be attributed to

Ecological Modernization, a reform-oriented system that enables "economic development and environmental protection (to) proceed hand-in-hand" (2005: 169). In line with these aspirations the Stockholm Resilience Center (SRC) was instituted on January 1st, 2007. Their purpose was to better understand the complex socio-ecological system and facilitate sustainable human-biosphere co-evolution through quality governance and management of the Earth System (stockholmresilience.org). Resilience[7] is defined as "the capacity to deal with change and continue to develop" (ibid) and the focus of SRC is "sustainability science for biosphere stewardship in the Anthropocene" (ibid). It was during one of the conferences held here on sustainability that the idea of quantifying boundaries came into being.

In 2009, a team of 29 renowned earth system and environmental scientists published from SRC the now famous paper *Planetary Boundaries: Exploring the Safe Operating Space for Humanity* in Ecology & Society and subsequently in Nature in which they introduced the Planetary Boundaries framework. Their primary endeavor was and remains providing a scientific framework and advance empirical evidence of the risks and tipping points facing the Earth System[8] functioning in the hope of guiding development that's sustainable and helps in resilience building (Rockstrom et al. 2009). This team of researchers, hailing from Europe, America and Australia was led by Johan Rockstrom, executive director of the SRC who is a well known environmental scientist and an expert in water related issues. The group included primarily earth scientists like Nobel laureate Paul Crutzen; 'climate guru' and the former head of NASA's Goddard Institute for Space Studies, James Hansen; theoretical physicist and Chair of the German Advisory Council on Global Change, Hans Schellnhuber; executive director of IGBP and a widely published author on global climate change, Will Steffen; and the Executive Director of the California Academy of Sciences, Jonathan Foley amongst others.

This research was well received by the media, in policy circles, and embraced by UNEP, IPCC, NGOs like Oxfam and WWF (Nordhaus et al 2012: 4), and ESDN[9] and has now become the "leading framework for thinking about global environmental problems" (ibid). Since then the model and data have been advanced and critiqued by researchers from around the world and in 2015, drawing from these and their own continued research, Stockholm Resilience Center published the latest development in their updated paper *Planetary Boundaries: Guiding human development on a changing planet* in 2015 (Science).

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[7] Resilience is a controversial scientific concept, a critical appraisal of this can be read in *The Construct of Resilience: A Critical Evaluation and Guidelines for Future Work* by Luthar et al (2007)

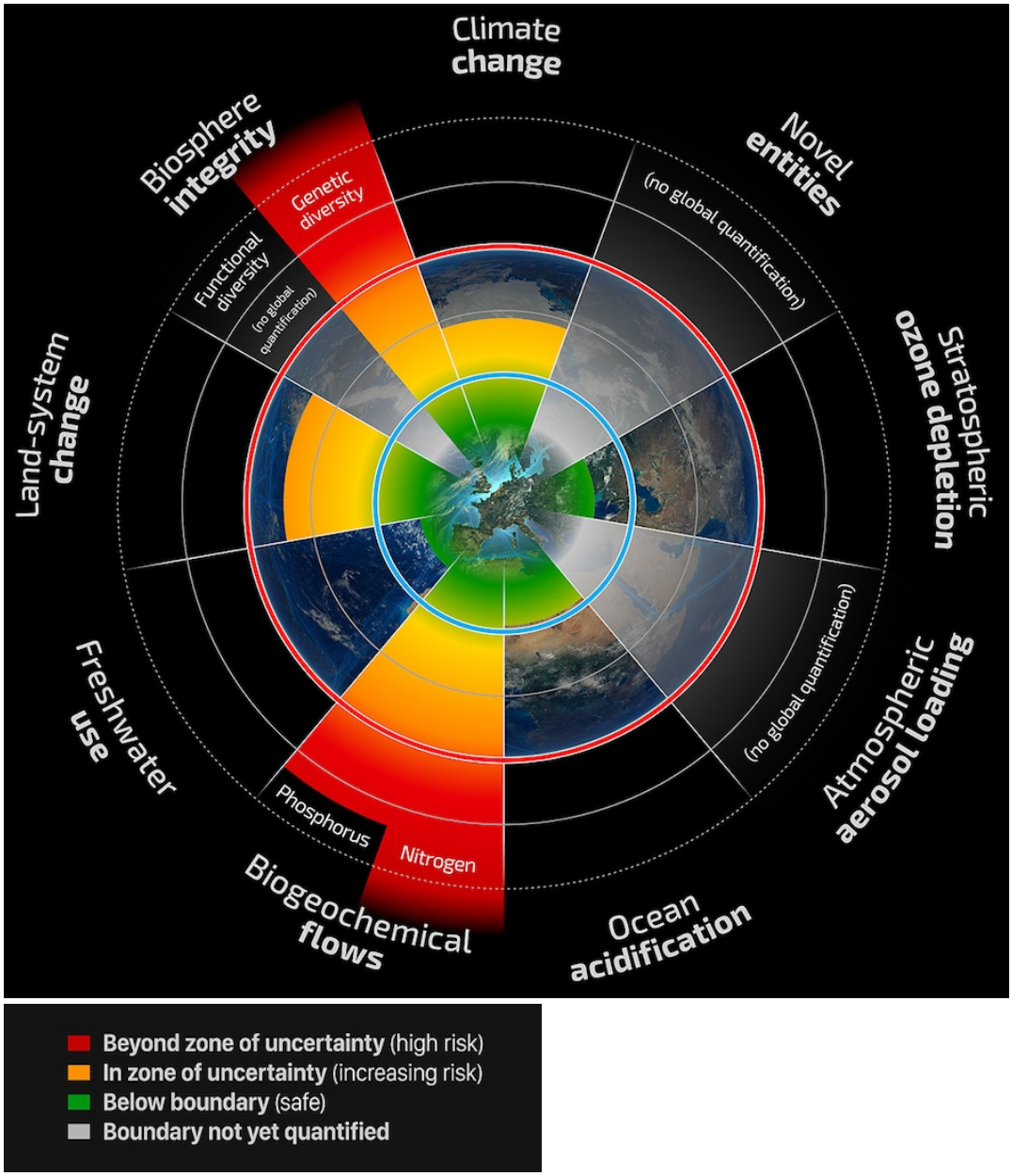
[8] "The Earth System is defined as the integrated biophysical and socioeconomic processes and interactions (cycles) among the atmosphere, hydrosphere, biosphere, geosphere, and anthroposphere (human enterprise) in both spatial—from local to global—and temporal scales, which determine the environmental state of the planet within its current position in the universe' (Rockstrom et al 2009).

[9] For example, the UNEP 2010 yearbook has a chapter dedicated to PB under Ecosystem Management, the Environmental Limits; European Commission is said to refer to the study; and Rockstrom and others are on the advisory boards of governments and other global governance institutions.

Not unlike LtG, the main premise of this study is that human enterprise has significantly altered the stable and desired Holocene[10] like state of the planet and therefore risks crossing 'tipping points' after which it becomes difficult to predict how the system would react. That's why they proposed nine "boundaries for anthropogenic perturbation of critical Earth-system processes" (Steffen et al 2015: 737), which humanity must not transgress if the aim is to avoid destabilizing the environmental system that we know is crucial for humanity's continued wellbeing. The boundaries and their thresholds are listed in the figure below. Out of these climate change and biosphere integrity are considered 'core' boundaries, those if regularly crossed have the potential to break the resilience of the system well on their own. It is now believed four of these climate change (atmospheric CO_2 concentration and energy balance at top-of-atmosphere), biosphere integrity (extinction rates), land use change and global nitrogen cycle (industrial and intentional biological fixation of N) have been infringed. They also stress the importance of accounting for nature's nonlinear response that could drive us rather abruptly and irreversibly over the threshold. Therefore, says the study, these are all interconnected boundaries that cannot be held to singular thresholds (Steffen et al 2015). For example, weakening carbon sequestration capacity affects the climate system as a whole. This in turn leads to melting of sea ice, which now because of the colour change experiences reduced albedo reflectivity thus turning ice caps from natural coolers to heaters since now more heat is retained in turn driving the system at an accelerated pace, through positive feedback, towards the global threshold or tipping points (Rockstrom et al 2009; 2015).

[10] Interglacial period that began 11,700 years ago till today, long epoch that we know for certain can support contemporary human societies (Steffen et al).

Fig4: Planetary Boundaries, SRC, 2015



They believe people have yet to grasp the gravity of the tremendous pressure humans have exerted and continue to exert on the biosphere and that the current socio-economic organization, especially since the industrial revolution, is on a "violent collision course with nature" (Wijkman and Rockstrom 2012:2).

Fellow scientists have been the chief critics of the PB framework who essentially question the science of boundary allocation to Earth's processes as well as its policy relevance. Blomqvist, Nordhaus, and Shellenberger of The Breakthrough Institute in an elaborate report point out that the boundaries are rather arbitrary since at least six of them cannot have a global biophysical threshold, like freshwater use, and therefore the theory lacks evidence of a net negative effect or tipping over if crossed (2012). Instead they believe setting a planetary boundary for Nitrogen while overlooking its connection to welfare and

place specific pollution is misleading. Rockstrom et al. have acknowledged some of these shortcomings. Blomqvist et al. (2012) also believe that by defining these issues with 'scientific authority' the team is depoliticizing an essentially political question of the uneven distribution of costs and benefits and therefore need to talk more about the tradeoffs. Some believe the boundaries are rather indulgent, for example for phosphorus and fresh water use (Schlesinger 2009) or carbon dioxide (Allen 2009), thus might actually lulling policy makers into inaction and encouraging this dangerous behavior to persist (Scientific American 2009). Supporters and critics alike agree though that this study has brought back into focus the science of the complex interconnected and interacting Earth processes and talk of resilience building (Nature 2013).

2.3 Degrowth

The term or idea of degrowth, *decroissance* in French, is said to have originated and gained prominence in France in the early 70s. This was after the 1966-67 recession marked by rising unemployment and drop in growth rates towards the end of *trente glorieuses*, when America under the Marshall plan had helped finance economic growth in France leading to a respectable rise in GDP and 30 years of prosperity. In 1968 there was a student uprising against *dirigisme*—state control of social and economic matters while still following the capitalist model of production and consumption. Borrowing from the French term *nouvelle gauche* of the 50s, socio-politically the 60s and 70s was also the time of the emergence of the New Left in Europe. These were intellectual movements that were called socialist Marxism, and were in addition associated with the student counterculture movements including gay rights, anti consumer-society, environmentalism, feminism and civil rights.

Decroissance was first used in 1972 by Andre Gorz (D'Alisa et al. 2015), a social philosopher, an intellectual and one of the theorists of the New Left who cofounded the left-leaning magazine *Le Nouvel Observateur*. Gorz questioned material production and consumption practices, growth and the economic reason under the capitalist system in relation to the 'earth's balance' and stressed on its detrimental effect on ecological conservation and equality (ibid:1-2). Gorz was inspired by Georgescu-Roegen, a Romanian mathematician and economist who published the seminal *The Entropy Law and the Economic Process* in 1971. Georgescu-Roegen first and 'radically' questioned the repercussions of bringing together physics and biology with economics, and was instrumental in laying the ground for ecological economics and bioeconomics (Bonaiuti 2015: 25). He elaborated on the irreversible economic processes and exosomatic mode of evolution that depends on limited and unevenly distributed energy and resources and the dangers arising from this (Mayumi 2009). He also talks about harmful waste accumulation, the space and energy required to store or recycle it, and the fact that the harm done to life forms, whether recycled or not, is 'irreparable' (Goergescu-Roegen 1975). Two professors from Geneva, Grinevald and Rens, subsequently edited and translated into French Roegen's writings and published this as *Demain la decroissance* in

1979. Other francophone scholars continued using the term inspired by LtG after its publication in 1972 (D'Alisa et al 2015). Georgescu-Roegen defended the LtG school, specially against fellow economists who he said used the exact same assumptions they were criticizing Meadows and team for using, thus creating an unfounded argument (Goergescu-Roegen 1975). But during the 80s and the 90s across the world there was strong opposition to anyone challenging the idea of growth and development, not only by economists but also developing and developed countries alike, since globalization and free markets were called upon to solve many of society's ailments including poverty, inequality, food production and pollution (Stiglitz 2002; Meadows et al. 2004). Here the LtG and Degrowth actors will assert the very cause of these crises, i.e. growth, was lamentably called upon to solve it. Thus for most of these two decades talk of degrowth or limits was largely and deliberately ignored.

Along with Georgescu-Roegen's bioeconomics, Latouche and Alier and other scholars count the works of post development thinkers in particular that of Ivan Illich, Jacques Ellul, and Francois Partant as having a major influence on today's DG framework. Degrowth scholars attribute the origin of the current movement, intellectually and as a group of activists, to a few events in Lyon in the early 2000. In 2001 Bruno Clementin and Vincent Cheynet used the term 'sustainable degrowth' (D'Alisa et al. 2015: 2) and edited a special issue of the magazine *Silence* dedicated to Georgescu-Roegen which sold thousands of copies and "was probably the starting point" (ibid) of the public debate on degrowth. This happened around the same time as the protests like anti-advertisement activities, campaigns for car-free cities and communal meals, and formation of food and agriculture cooperatives were taking place in Lyon (Demaria et al. 2013: 195). Then the first international colloquium on DG was organized in Lyon in 2003, by the institute on Sustainable Degrowth that was founded in 2002. The first international conference on degrowth was held in Paris in 2008 organized by Francois Schneider, founder of Research and Degrowth[11]. Meanwhile DG had gained following in Italy, Catalonia and Spain. In 2010 ICTA, Environmental science and technology institute, Barcelona, hosted the second conference with which the movement now took off outside France, with conferences regularly held across Europe, East Europe, South America, and Canada. Degrowth entered the academic world, through ICTA's links with ecological economics and their "Latin American networks of political ecology and environmental justice" (D'Alisa et al. 2015: 2). Today degrowth enjoys an ever-growing number of published articles in peer reviewed journals, and perhaps because of the financial crisis and resulting recession of 2008, degrowth also received attention from the media including coverage by Le Monde, The Guardian, El Pais, Financial Times, Frankfurter Rundschau (degrowth.de) and some politicians in France as well as Italy.

[11] Research & Degrowth, (R&D) is an academic association dedicated to research, awareness raising, and events organization around the topic of degrowth.

Fig 5: Francois Schneider and his donkey jujube (2005) on a year-long walking donkey tour in France to propagate DG

Some of the prominent DG researchers include the 'DG prophet' (Kerschner 2010: 546) Serge Latouche, professor of economics at University of Paris-sud; Joan Martinez Alier, ecological economist and professor at Barcelona autonomous University and FLACSO; Giorgos Kallis, an ecological economist and environmental engineer who is a professor at Barcelona autonomous University; and Christian Kerschner also from ICTA. Today leading degrowth thinkers and actors are mainly from the ecological economics and environmental science background but also independent scholars and researchers with varied specializations like in sociology, feminist economy, politics, history, activism and communication.

Fig 6: Monthly newspaper printed in Lyon. Publishing Director: Vincent Cheynet Director: Bruno Clémentin

"Degrowth is not a concept" writes Latouche, but a "political slogan with theoretical implications" (2010: 519). According to the definition from Research & Degrowth "sustainable degrowth is a downscaling of production and consumption that increases human well-being and enhances ecological conditions and equity on the planet." And all 'voluntarily', this is an important point for them. The degrowth activists and scholars believe DG is and should be about the way of life, about saying 'enough' irrespective of access to and availability of resources, about definition of wellbeing that is independent of possessions or commodities. Theirs is a different approach because it certainly is about producing and consuming less but not simply "doing less of the same" (D'Alisa et al. 2015: 4), rather doing everything differently, that is imagining societies where development is not equal to growth which is in turn equal to efficiency and progress that translates to wellbeing or happiness. They are opposed to SD that depoliticizes the issue and instead "renders environmental problems technical" (Kallis et al. 2015: 9). In their model, definitions and understandings have to change, as do relationships amongst each

other and with nature. Their goal is to focus on qualitative aspects of production and service sectors rather than their quantitative 'growing' aspect, where accumulation and profit will no more be the driving forces of the socio-economic organization (ibid: 5), which the way it is now promotes inequality, injustice and ecological degradation. So it is not only about resolving technical issues of sources and sinks but rethinking the very nature and origin of how societies have reached this point and then not simply reducing the ecological footprint to get back within the boundary but living with different principles, like conviviality, care, simplicity, respecting the intrinsic value of nature and questioning the ethics of a system in which the market reason rules more or less every aspect of our existence. In order to avoid a reductionist understanding, say Demaria et al. (2013: 206) it is important to take into account all sources of DG like meaning of life, justice, democracy, wellbeing, and critique of development. The next two chapters have more in-depth information on the DG philosophy, theoretical framework, their alliances, and their sources.

This chapter was about understanding the intellectual origins and an overview of the schools' concepts, that's why it does not go into details of the criticisms, a healthy dose of which exists in academia related to science and action/policy potential of the theories. Having traced the origins of these schools we now look at what and where specifically they believe the complication lies, and if there's a difference in their positions. So the next chapter shows how the three schools problematize economic growth.

3 Growth, environment and prosperity

Economist E.J. Mishan in 1967 published *The Costs of Economic Growth* in which he talks about social and ecological costs of growth and draws attention to the paradox of the prevailing pro-growth dogma in the political discourse despite, he says of England at the time, "the fact that bringing the Jerusalem of growth to England's green and pleasant land has so far conspicuously reduced both the greenness and the pleasantness" (xvii). Other well known economists who early on calculated and wrote about social and natural costs of growth include K.W. Kapp, L. Kohr, Boulding and Georgescu-Roegen. Peter Victor (2013) writes it was perhaps J.S. Mill who was the first economist to raise questions about the adverse effects of economic growth in his writings as early as in 1884. Critics of free-market and politically sanctioned exploitation under capitalist relations and its structures like accumulation include Marx, 1887, (ibid) and Polanyi (Andreucci and McDonough 2015). As for natural scientists who have been warning the world for decades, despite their repeated assertions, for examples by E.O. Wilson or James Hansen about catastrophes in store most people outside this field remain unconvinced. Some believe scientists are speaking in hyperbole. Thus economic growth remains the ultimate hope to and for some, and to others the ultimate destructor of nature, society and human values.

Here we see how the three schools based on their conceptualization provide evidence to show contradictions and dysfunction at various levels of the current socio-economic system. It appears that the problems they point to are not very different, i.e., their basic views on where capitalism fails the society and the environment are, despite what one would have imagined considering the differences in scientific methods and intellectual background, quite similar. Of course, as we shall see, there is a fundamental difference in perspective and therefore in how much importance to what aspect each school gives. This finding informs the evolving meanings and knowledge of limits, or more precisely in this case the fact that the diagnosis has not changed.

3.1 Economic growth[12]

The *growth imperative* is an essential feature of Capitalism (Kallis et al 2015). In their study Meadows et al demonstrate how striving for exponential growth, not simply growth, has been a dominant characteristic of the current socioeconomic system. And although the rate of growth may vary, capital ultimately does have the inherent structure to grow exponentially (Meadows et al. 2004). Degrowth scholars note the growth dynamic to be a result of Capitalism's dependence on surplus creation or accumulation (Andreucci and McDonough 2015), for its own sake and as reinvestment. Thus, say Meadows et al., the doubling of resource extraction, food production or pollution is not because they themselves grow exponentially but because the growth economy and increase in population demand that they do so. This is where, they warn, the real threat lies. They go

[12] All authors cited here onwards are from one of the three schools.

on to explain how this tendency is particularly dangerous because effects of exponential growth tend to sneak up and in this case are exacerbated due to non-linear responses from the planetary system. Like the example of reduced ice-albedo effect that accelerates energy retention at various levels of the Earth System. Will Steffen's (from PB school) widely known Great Acceleration graphs, on the following page, proves such exponential rise, albeit at varying rates, is occurring in socio-economic and earth-system fields. This is a critical point because it can be calamitous and yet the economy depends on it, warn the schools.

3.2 Accounting issues, environmental problems and infeasibility of accumulation and profit

Economic growth is measured in real gross domestic product (GDP) and defined as per capita increase in goods and services for that particular year. That GDP is a flawed measurement is not contested by many and economists themselves have been trying to fine-tune and verify its underlying assumptions for years (textbook). Besides, GDP does not have discriminatory powers. As O'Neill (2015) explains in *Degrowth: A vocabulary for a new era*, all economic activity irrespective of 'good' or 'bad' such as sale of beer or a bicycle, government investment in education or cleaning up oil spills, contribute to GDP. Picchio (2015: 208-210) adds that this "destructive system" (striving for GDP increase) depends on exploiting the labour force and overlooking the domestic and care giving unpaid economy that constitutes mainly of women.

All three schools stress the importance of focusing on 'physical economy' or the throughput growth, including industrial capital and output (factories and machines), agricultural capital and output, service capital, and consumer goods (Meadows et al 2004) which is bound by limits and not the money or nominal (income) economy that GDP is expressed in. In short, the economy demands continuous material and energy flows. But the concern of the three schools is not regarding depletion of these material or energy sources alone, like peak phosphorus, but also the unsustainable costs required, including managing the waste generated, to keep the flow going: environmental, social, and economical costs (ibid; D'Alisa et al 2015).

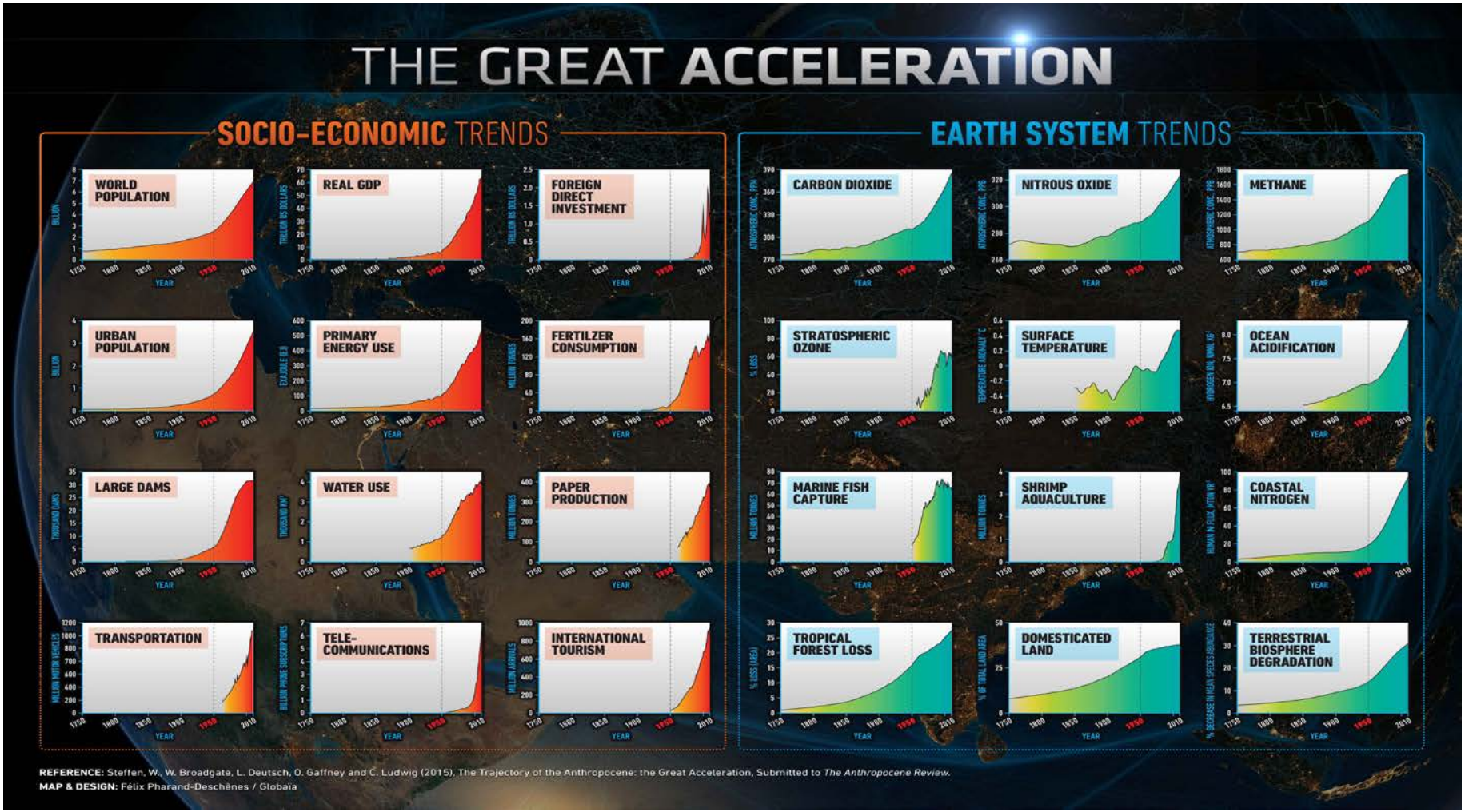


Fig 7 Source: Steffen et al IGB, 2015

In case of the environmental cost or ecological limits of growth, the Meadows team, drawing from global databases and various limits and values determined by scientists around the world, put questions to the global economy based on Herman Daly's three rules which they believe would be amongst the "basic laws of sustainability" were there such laws (Meadows et al 2004: 54-55). These were:

> *For renewable resources: Are they being used faster than they regenerate?* (food, land, soil, water, forests, species and ecosystem services)
>
> *For non-renewable resources: How quickly are the high quality materials being used. What is the course of the true costs in energy and capital required to provide them?* (fossil fuels and materials like steel, zinc, copper, lead, tin, nickel, etc.)
>
> *For pollutants and waste: Are they being rendered harmless at sufficient rates? Or are they accumulating in the environment?* (sinks, greenhouse gas concentration, oxygen level in contaminated waters, etc.)
>
> (ibid.)

They found for the variables studied like soil degradation, rate of tropical deforestation, fish stock depletion, fossil fuel consumption, species extinction, water use, groundwater depletion and pollution, carbon dioxide, nitrous oxide and methane concentration in the atmosphere, biodiversity loss and much more were all at rates clearly unsustainable. Rockstrom et al. (2009; 2015) in their consequent studies show how the related boundaries but particularly threatening at the moment that of climate change is being rapidly transgressed. While abrupt changes are part of the earth system functioning, there is enough scientific evidence to show that changes like global warming and biodiversity loss are human induced. Due to these limits of a finite planet's growth absorption capacity, say Steffen et al., "continued growth of the material economy" cannot go on (2011: 60). It is not a case of few sources or sinks being compromised, report the LtG team, rather all systematically exploited and degraded to serve the economy. As seen in the LtG scenarios in chapter two, the scientists show that none of the purported fixes or solutions like stable population, abundant resource base, or market and technological fixes can resolve on their own this situation unless the nature or structure of economic growth is transformed.

Nevertheless, income increase and related rise in material standard of living and poverty reduction, directly or through the trickle down effect, are the results of economic growth. These "marginal benefits of growth to the poor are immense" (Farley 2015: 51). Thus economic growth is vital for countries that want to develop and for the continued welfare of those that are already developed, or so it is believed by the majority of people, governments, journalists, policy makers and economists. That's why to recover from the great recession Europe and America resorted to austerity measures and public spending respectively but both with the end goal of fueling consumer spending leading to increase in GDP.

Regarding this argument in support of growth Meadows et al. (2004) contend that since 1930 the world has seen a fourteen-fold escalation in industrial output yet we are no closer to ending poverty and that's why there's absolutely no rationale to think that another fourteen-fold increase, which would be physically perilous in any case, ought to do it. All three schools agree economic growth has failed to address inequality and unequal income distribution. In addition, development or growth that has led to affluence or wealth so far depended on cheap energy and material resources which are now scarce, like oil, phosphorus, land, etc., yet in high demand, and this competition over scarce resources is another reason why unsustainable consumption of finite "geophysical resources" cannot be the way out of poverty or pathway to material wellbeing (Steffen et al 2011: 739-740). These very pressures on the Earth System created by this kind of growth has led to the Anthropocene, says the PB team, which in turn is responsible for crisis like wars, including in Syria (Rockstrom), untimely rains in India and hurricanes in the far east, heat waves across Europe, US, and Moscow, animal extinction, diseases and much more.

Meadows and the team identify the poverty and inequality perpetuating structure inherent to this growth model as "social arrangements … that systematically reward the privileged with the power and resources to acquire even more privilege" (2004: 44). Thus this "success to the successful" loop makes it easier for the rich to get top-class education and health services for their children, to save and invest their assets as well as allow better access and control to markets, resources, technology, and political process leading to ever greater capital accumulation. They believe this leads to population growth too since the poor then see children as "one of the few forms of investment available" (2004: 45). Degrowth actors firmly believe, as did economist Joseph Shumpeter they say, that inequality and unequal access and control is essential and not 'incidental' to the workings of capitalism, and hence to growth (Kallis 2015: 139). As for the arguments in favor of technology and markets, LtG report shows through scenario analysis that these are incapable of dealing with the issue. Dematerialization of environment from the economy under current structure, believe LtG and DG actors, is nearly impossible considering growth's unsustainable dependence on environmental exploitation. Meadows and team point out that even service economies are not material and energy independent and are actually pretty throughput intensive producing substantial amounts of waste themselves.

Fig 8: From Limits to Growth, The 30-year Update, 2004, pp 42

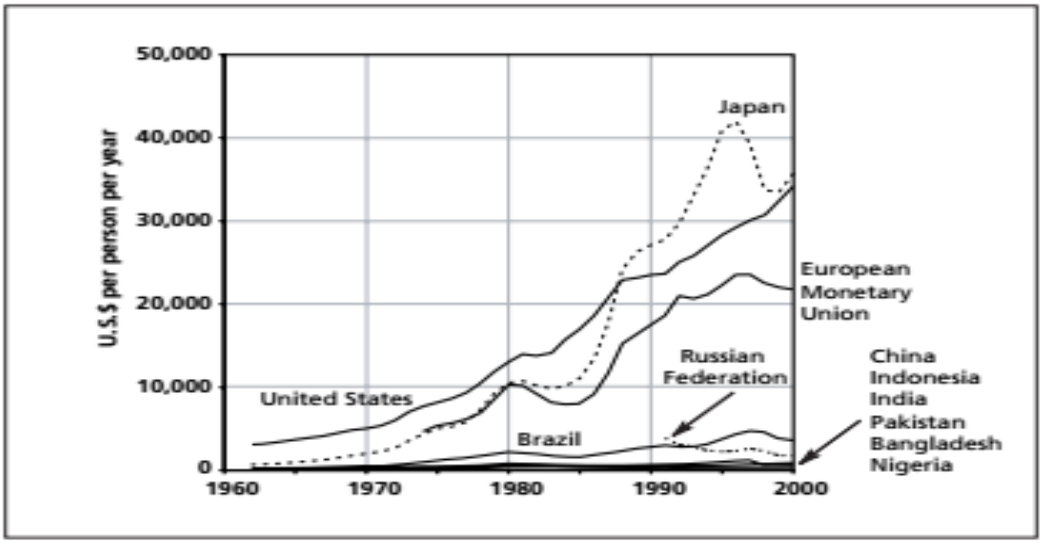


FIGURE 2-10 Per Capita GNI of the Top 10 Most Populous Countries and the European Monetary Union

Economic growth takes place primarily in the nations that are already rich. The 6 countries of Indonesia, China, Pakistan, India, Bangladesh, and Nigeria together contain almost half the world's population. Their per capita GNI barely rises off the axis when plotted together with the GNI per capita of the wealthier nations. (Source: World Bank.)

Fig 9: Global Disparities, from Limits to Growth, The 30-year Update, 2004, pp 43

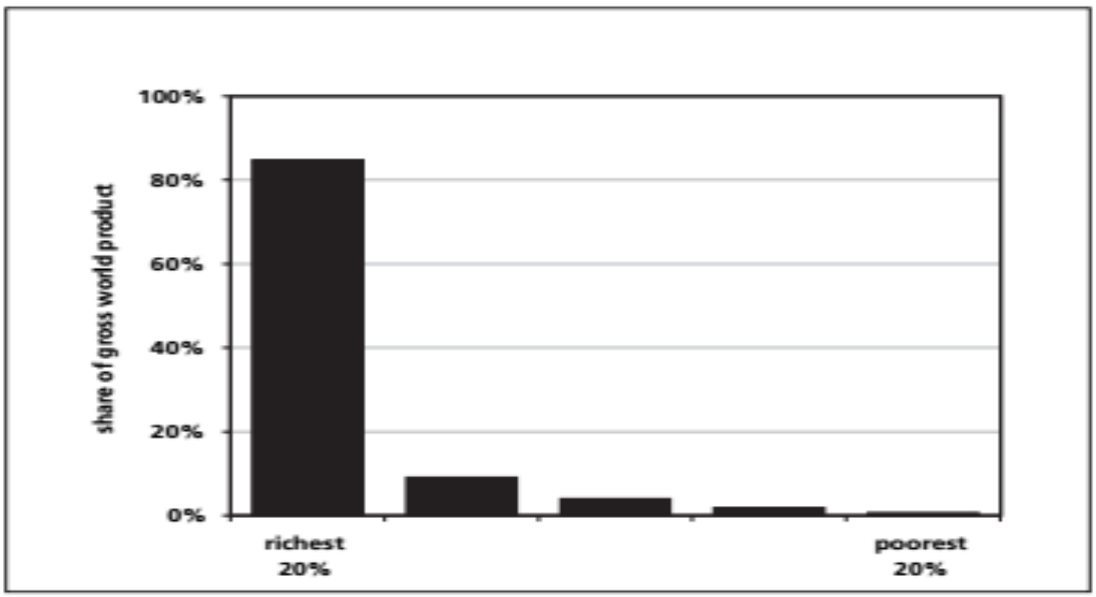


FIGURE 2-11 Global Disparities

The global distribution of wealth and opportunities is extremely skewed. The richest 20 percent of the world's population controls more than 80 percent of the world gross product and uses nearly 60 percent of world commercial energy. (Source: World Bank.)

3.3 Beyond economy and ecology

Because DG sources are varied they criticize growth not only from an ecology and economic perspective but raise questions about the human-nature relationship and capitalism's colonization of all aspects of living, or as Latouche puts it "all the values that underlie consumer society" (2012: 75). Meadows et al. hint towards the same in their book. For the degrowth researchers justice issues are as important and in fact inseparable from environmental issues. Fight for resolving ecological debt aside, economic growth implies further displacement and dispossession, by state or private enterprise, and exploitation of commodity frontiers as well as continued unequal distribution of benefits from resources and harm from the waste generated (Anguelovski 2015). Thus growth they believe will invariably and inevitably perpetuate inequality and injustice. In addition, academics from all three schools when talking about social limits to growth—limits on how much or what growth can deliver (Kallis 2015)—cite research recording how beyond a certain income level excess of it does not contribute to increased wellbeing or happiness. This excess, state DG researchers, is usually spent on acquiring positional goods which is ecologically and morally indefensible. And as mentioned earlier, precisely because any commercial activity can contribute to GDP it tempts people to subject to market exchange goods and services hitherto not in the realm of being a commodity (Gomez-Baggethun 2015).

For Meadows et al. social limits include peace, stability and security since social conditions, along with environmental and physical factors, ultimately determine how resources are deployed for growth (2004). In order to preserve, protect and care for the environment DG actors believe joint community ownership is essential (Demaria et al. 2013). This opposes concentration of resources, or means of production, in the hands of a few rich corporations or monopolies which capitalism reflects. From a post-development perspective they are opposed to growth in the name of development and globalization that leads to the global north thrusting its technology-production-consumption imaginary on the south leading to loss of autonomy and "uniformisation of cultures" (Demaria et al. 2013: 196). Demaria et al., based on Kempf and Veblen's work, add rigorous promotion of consumerism includes propagating comparison, envy and competition for "rich-people lifestyles" (2013: 200). Debt, competition and profit driven investment also implies putting resources into 'wasteful' activities or amoral choices (Kallis 2010: 875) and supporting these with large investments in creating "new needs and limitless wants" (Andreucci and McDonough 2015: 61). For example, more money goes into weapons or cosmetic research than cancer. Regarding the accumulation imperative of economic growth, writes Victor, Keynes acknowledged in his book in 1931 that this trait "was driven by motives and practices that were less than ideal" based on "'pseudo-moral principles … by which we have exalted some of the most distasteful of human qualities into the position of the highest virtues'" (2013: xvii). And precisely in search for new avenues of accumulation and surplus reinvestment, write Andreucci and McDonough, was vigorous privatization and financialization introduced (2015: 61), which further renders the system economically, ecologically and

socially unstable. From an intrinsic value and anti-utilitarian worldview the DG actors are strongly opposed to capitalist principles that view nature only as a provider of goods and services (Demaria et al. 2013), which besides fracturing the human-nature bond clashes with its long term conservation goals as well. According to Latouche (2012) the hegemony of the growth ethic, or the contradictory, unjust and vulgar values of capitalism, undermine pluralism of all aspects of societies including being and doing.

3.4 The bottom line

Economic growth, generally measured in GDP and centrally linked to physical resource use, according to all three schools of thought, is bound to overshoot and collapse if a finite planet's carrying capacity is exceeded, i.e., expansion in physical economy cannot continue forever considering it means unlimited demand of limited natural resources and fast filling up sinks. But "growth economies do not know how to degrow, they collapse" (Kallis et al. 2012: 172). This 'end of growth' can come from hitting one or a combination of limits which are difficult to predict precisely because the colossal 'population-economy-environment' juggernaut is a dynamic, complicated system with complex networks and feedback loops that has the inherent capability to drive off course in a myriad of unexpected ways (Meadows et al. 2004: xi; Rockstrom et al. 2009). That is why these schools are trying to convince and communicate to their respective audiences the need for a transformation, a revolution (LtG), and a paradigm shift (Latouche). In the next chapter we see what these alternatives are, how and who the schools identify as agents of change and what in their opinion should be the course of action.

4 Vision for change

As mentioned before, all schools agree business as usual will lead to an unequal, unstable, and a violent world (Rockstrom et al. 2013; Meadows et al. 2004). Yet prosperity and wellbeing for all is possible, some scientists believe, provided we change our mindsets and transform the underlying structure of growth well in time. Especially, they point out, considering that economic growth itself is in trouble having perhaps entered "a period of prolonged stasis" (Kosoy et al. 2012: 74). Here we see a part of the schools' vision for change and the urgency they give certain actions. These ideas and meanings have many commonalities and often overlap. And sometimes are diametrically opposed.

But all three schools are unanimous on the removal of fossil fuel subsidies, levying carbon taxes, and 100% reserve banking. They all agree material and fossil fuel going into the economy has to be decreased, that the scaling down has to begin in the North (Alier et al. 2010; Steffen and Smith 2013), and that certain regions of the world still need to grow in the conventional sense. Preferably not unsustainably without care for externalities as the North did. Whether convinced of this argument or not, that's exactly what's happening across the world right now, albeit at different rates—relentless pursuit of growth in the name and search for human wellbeing. Martinez-Alier (2014) cites the example of Ecuador where initially president Correa wanted to put a stop to extraction of oil but then decided the way out of an extractive economy was more extraction. Or Rockstrom (2015) on the contradiction in Obama administration which gave new offshore permits in the Arctic despite believing in the urgent need to invest and scale up renewable technologies and transition to a zero-carbon economy by 2050-2070.

4.1 Limits to Growth

Meadows et al. (2004) in their book write that another profound revolution, not unlike the agricultural and the industrial, is required to bring about a paradigm shift and create a sustainable and equitable world singularly different from the one we now inhabit. They recommend, as do the Degrowth scientists, the need to distinguish between growth and development and move away from quantitative expansion. The sustainable world or society for them would be a flexible one that discriminates between types of growth based on questions like "what the growth is for, and who would benefit, and what it would cost, and how long it would last, and whether the growth could be accommodated by the sources and sinks of the earth" (ibid:255). Based on their systems training they identify two critical properties of complex systems that can bring about transformation: transparent information flow, like the Glasnost policy which led to the swift transformation of Eastern Europe (ibid: 270) or transparency in budget allocation, and protecting innovators.

They believe any solution to help move the world towards sustainability should include extending the planning horizon, i.e., thinking beyond immediate market or electoral gratification; improving signals; speeding up response times; minimizing the use of non-

renewable resources; preventing erosion of renewable resources; using all resources with maximum efficiency; and slowing down to eventually stopping exponential growth of population and physical capital (Meadows et al. 2004). Some of their recommendations resonate with what DG actors envision today. Like the idea of "purposeful negative growth" (ibid: 255), or the suggestion of 'sharing', 'sufficiency' and 'solidarity' and diverse ways of self-organization to tackle poverty and unemployment. Although, they write, it is important for an individual to be gratified through work, to feel a sense of responsibility and discipline, their subsistence should not depend on it, specially degrading work. As a critique of the consumer society that finds meaning in commodities and "a system that expects, exhorts and rewards consumerism" (ibid: 270), they emphasize the significance of moving towards moderation and expressing and fulfilling nonmaterial needs like "identity, community, self-esteem, challenge, love, joy" (ibid: 262) in creative non-material ways instead of looking for solutions in 'material things'. Meadows and the team also talk about five other 'tools' that could be helpful but admit that they were hesitant and unsure of how to discuss what could be construed as 'unscientific' concepts. It could be argued that these are similar concepts that DG activists talk about today but they do so unapologetically, and with authority and conviction. The tools being: "visioning, networking, truth-telling, learning, and loving" (ibid:271). The LtG team adds because these 'soft' tools make people uncomfortable and seem inadequate in the face of the massive problem facing civilization, people "turn the conversation to recycling or emissions trading or wildlife preserves" (ibid.), when in fact these very ideas have the potential to revolutionize the system if applied and practiced persistently even if only by a small group of people.

Considering continued rising sea levels, soil degradation, overfished waters, steady declining GDP, and that peak oil has been passed, global ecological footprint is constantly on the rise, in addition to several more factors, say Meadows et al., it clearly proves the SD discourse failed to change the paradigm. That's why Dennis Meadows believes it's a little late to avoid some form of collapse since the system is beyond its carrying capacity unless we make a drastic change to allow the system a "longer time horizon" and therefore suggests putting more emphasis on adaptation measures and resilience building (Smithsonian 2012).

4.2 Degrowth

For the Degrowth school many limits and boundaries have been crossed. Perhaps for them this started when injustices and environmental destruction was deemed alright in the name and pursuit of human wellbeing, that too only for a few. They believe this discrimination was not accidental but deliberate exclusion and therefore transgressed all moral boundaries too. That's why for DG scholars addressing ecological debt is an essential part of the way forward. This debt, says Martinez-Alier (2014), is owed by the rich or global north who like 'pirates' disproportionately occupy the seas and the atmosphere, to the Earth and its many species, the poor, global south, the indigenous people, and future generations. The DG concept can be said to have three aspects or pillars, not necessarily linked: that of theoretical principles elaborated upon by

economists working to device policies that decouple 'wellbeing from growth'; another of activists and social movements that include grassroots and 'everyday transformations'; and the political aspect (Alier et al. 2010) which Kallis (2015) believes should be organized to protect social movements and promote and propagate DG policies. About practicing voluntary simplicity they acknowledge that implementing and adopting such lifestyles will involve more hardships today for the downshifters and that even such eco-communes do rely on the "products and infrastructures provided by the rest of the economy" (Kallis et al. 2012: 174). Thus this transition even if accepted by all will not be a one-sided, straightforward one and will entail, contrary to what some might imagine the DG principle to be, combining degrowth with technology or 'efficiency improvement' as in the case of carbon emissions reduction (ibid.). Latouche, on the lines of Georgescu-Roegen's opposition to SD, argues capital accumulation and profit remain the centerpieces of these green growth projects thus "*good* capitalism characterized by *good* (or *green* or *sustainable*) exploitation of nature" (2012: 76) renders real change or leaving the 'religion' of economy impossible by once again promoting economic growth, in different guises, as the means and end or the ultimate goal.

Kallis et al. write economic DG is probably inevitable considering the economy is running into one or the other limit continuously and so the question of the hour becomes how to make it "socially sustainable" (2012: 172) or how to manage and prosper without growth (Victor 2007). Since degrowth could imply unemployment and reduced investment in welfare and renewable energy. Bilancini and D'Alessandro (2012) present a solution to this in their paper *Long-run welfare under externalities in consumption, leisure, and production*. Basic Income and Work Sharing policies, elaborated upon below, could be one of the solutions to these problems according to the economists. Besides, they do not believe moving to a more equal society is possible without downshifting of lifestyles in the west or 'material sacrifice' (ibid.).

Some specific policy and institutional options, based on work by other ecological economists and environmental economists, discussed in the above mentioned article by kallis, Kerschner, Martinez-Alier (2012) include: cap and share—where permits are sold to a global institution that in turn sells the rights to producers and consumers; non-debt money and regional currencies issued by a non-government authority; zero-interest rates aimed to ultimately achieve zero-growth steady state; new forms of property; and innovative models of local living. The latter is about various forms of non-capitalist communal sharing practices that question the values of capitalism and are in "conscious defiance of the capitalist institutions of private property and wage labour and the logic of exchange-for-profit" (ibid:176).

Degrowth scholars group alternatives to growth from ecological economics perspective into three categories, albeit all dealing with degrowth not all agree on the feasibility and the details of these pathways entirely, namely Steady State Economics, New Economics, and Degrowth (Kallis et al 2012). Kerschner (2010) writes since economic degrowth cannot be "a goal in itself", it should be a means to attaining a globally sustainable steady state using its established macroeconomic theories, namely Daly's "stock-service-

throughput equation[13]" (544) which he says in fact corresponds to Latouche's famous 'Rs'[14].

Their Basic and Maximum Income policy suggestion directly addresses poverty and is aimed at tackling the difficult task of redistributing wealth (Alexander 2015). Here the state would assure every individual an 'unconditional' basic income along with welfare services and supplies necessary for a dignified existence. Alexander suggests this could begin with Negative Income Tax system which issues tax-credit only to those living below the 'subsistence level'. This, the DG proponents believe, would give people some power to choose a non-exploitative form of work by eradicating economic insecurity and finally acknowledge unpaid work outside the formal economy. And as for working towards creating an equitable society, they advocate a 'ceiling' for incomes or a Maximum Income realized through a progressively increasing tax rate leading up to a 100 per cent tax beyond a certain income level. Besides, with the rationale that excess income and happiness are not directly related, this would also avoid 'wasteful consumption' while contributing towards the basic fund (ibid).

Work Sharing (Schor 2015): Research shows reduced working hours translates to lesser pollution and a lower ecological footprint. The concept is similar to what usually transpires during economic downturns, i.e., unemployment or reduced working hours corresponding to reduced demand and production. The deliberate cutbacks though, say the DG economists, would need to be accompanied by some sort of insurance or financing so that the wages remain constant, along with provision to voluntarily trade "income for time" (ibid. 196), probably employment in sectors like the service sector or "eco-efficient production" (ibid) sector, in combination with other DG policy options like basic income and innovative provisioning of goods and services.

Since degrowth is an interpretive framework and the activists believe in diversity and in the possibility of the idea of degrowth being expressed and practiced in various different ways, they see their beliefs reflected in the philosophies of societies trying to live innovatively outside the economic paradigm. These alliances include Buen Vivir which means living well, from south America, Sumak Kawsay from Ecuador, economy of permanence from India, and Ubuntu from Bantu speaking part of Africa.

4.3 Planetary Boundaries

The planetary boundaries school based on decades of earth system research believes human enterprise is shaping the biosphere pushing Earth System limits in unknown ways and risking its irreversible tipping over. That's why they set out to identify and quantify key planetary processes that regulate the Holocene epoch so that humanity

[13] Service/throughput = service/stock x stock/throughput (thus "service is the ultimate benefit of economic activity and should be maximized while throughput is the ultimate cost of this service and should be minimzed.") C Kerschner 2009: 546

[14] 8Rs for socio-economic transformations or drastic reduction in consumption and production to exit growth economies: Re-evaluate, Reconceptualize, Restructure, Redistribute, Relocalize, Reduce, Re-use, Recycle.

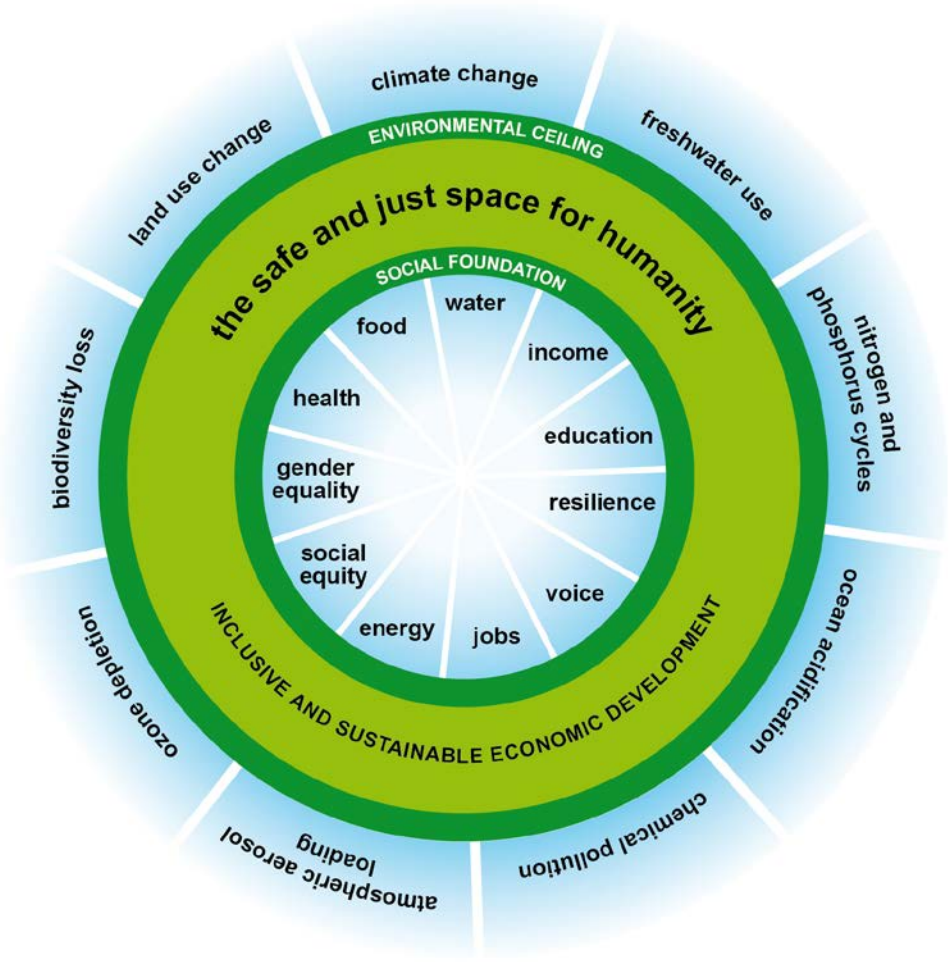
could essentially back off and ease the pressure on these limits and be guaranteed a 'safe operating space'. Steffen, Rockstrom, and Costanza (2011) acknowledge that staying within the 'planetary playing field' does not automatically guarantee human wellbeing. Social factors, like the ones raised by LtG and DG scientists, most importantly that of *distribution* play a crucial role in determining wellbeing for all. One of the ways out they say is facilitating equal access to natural capital. But 'straying' beyond the boundaries will bear calamitous results, of that they are certain. So governance and management of environmental issues although very important at local and regional scales, they believe, must be superseded by a body acting as the "ultimate arbiter of myriad tradeoffs" (ibid. 65) to ensure nations respect planetary boundaries and adhere to 'new global rules'. For example, by rough estimates the carbon budget by earth system scientists is fixed at 1000 billion tons of emissions to stay below 2°C global mean warming since the late 19th century. Considering 545 billion tons of carbon has already been emitted, that leaves 455 Bt. Discounting for other green house gases further reduces this number thus permitting humanity only 25 years of fossil fuel economy at 2014 level emissions. This budget is then to be shared fairly by everyone, according to their model. That's why a global decision-maker is required. Although they do believe governance ought to be "polycentric and multi-level rather than centralized and hierarchical" (Steffen et al 2011: 757), they stress the urgency of decarbonizing the economy also means we do not have the "luxury of time to rely only on bottom-up innovation" and therefore top down regulation is very much necessary (Rockstrom 2013 The Guardian).

In the report for the High Level Panel on the Post-2015 UN Development Agenda, Rockstrom et al. write convergence, that is all nations and people more or less having a comparable lifestyle, benefits from technology, and a similar income level by 2030 should be "the ethical foundation of sustainable development" (2013: 19). Rockstrom and others from PB school believe development that now resembles a "Mickey Mouse economy", where the social and natural capital work to serve the economy, needs to be redefined such that the economy serves the society while always mindful of planetary boundaries (2015 CIGI). So for them if a zero-carbon energy source in a circular economy, where as far as possible all resources and ecosystem services are recycled, is combined with a measurement that is unlike GDP, and where the "emphasis shifts" away from "selling" (2013) then economic growth or sustainable economic development within limits is possible (Rockstrom 2015 yale.edu). Thus, strictly speaking, contends Rockstrom, there needn't be a limits to growth instead growth within limits. For them growth is not so much a problem as the economic paradigm it operates within.

In the paper *How Defining Planetary Boundaries Can Transform Our Approach to Growth* Steffen, Rockstrom and Costanza identify four problem areas for governance: early-warning systems; taking action despite uncertainties, applying precautionary measures, and protecting scientists; multi level governance; and the capacity of the institutions to assimilate new scientific information. Ecosystem goods and services, they explain, can be categorized into three types: provisioning (food, water, phosphorus, metals, fossil fuels, etc.), supporting (soil formation, nutrient circulation, water storage, etc.), and regulating (ecological pests and disease control, carbon storage, radiation filtering,

temperature regulation by ice sheets, etc.). According to them human induced pressure on these services along with other boundaries contributes to the global crisis and needs to be better understood and dealt with.

Fig 10: The doughnut of social and planetary boundaries, 2016, Kate Raworth



The Draft for Discussion for Sustainable Development vis-à-vis planetary boundaries recommends six key structural transformations for continued economic development within the safe operating space: Energy Transformation, which is about moving to a zero-carbon economy; Food security transformation; Urban sustainability transformation; Population transformation; Biodiversity management transformation for protecting species and their habitats; and finally, Private and public governance transformation. They believe businesses and multinational corporations are one of the "most powerful actors" today, who have the power to mobilize capital, technologies, influence politicians and more. So it is imperative that they employ planetary boundaries framework to guide better practices and set their companies on a sustainable trajectory (Rockstrom et al. 2013).

This chapter showcases how the three schools' recommendations and policy suggestions for sustainable existence are dissimilar. The next chapter explores what these differences in articulation signify, for the debates, the school and the audience.

5 Implications and takeaways

We have seen how the discussion on limits has evolved. How people from various backgrounds talk about boundaries in diverse ways, including quantifying different aspects of it. The notion of limits was present in ideas of moderation in relation to consumption and simplicity since ancient times. Followed by the more recent concerns of resource depletion and environmental degradation the world over since the advent of industrialization. The contemporary academic debate is more north-by-north, i.e., the scientists from the north are talking to and primarily for the audience, governments, laymen and policy makers from the north, hoping the argument is universally accepted. The problem identification and content of which (opposed by neoliberals and neo-classical economists) has remained the same over decades even though the language has changed. The change in language can be attributed to advances in theory aided by ever more sophisticated technology and increasing scientific evidence. Limits remain intrinsically about growth. Nevertheless, the scientists' and activists' arguments and perspectives are different, as is their vision for achieving a transformation in the system and or the individual.

In this chapter we see how these disparities are linked to worldviews, values, ideologies and intellectual origins. Along with how certain framings are more acceptable than others. These differences suggest limits are a co-production and therefore their application and acceptance is as much about power[15], stakeholders, politics and exercising agency as about scientific truths. That is why academics in relation to development raise concerns regarding tradeoffs, resource access and decision making (Vira 2015). Limits are subject to 'interpretive flexibility'[16], meaning different things to different people, in the process becoming a much-contested, even polarizing, concept. Not all limits have the same interpretive flexibility though, besides, one can be used to avoid addressing the other. For example, if the conversation is environmental-limit centric, perhaps less weightage is given to ecological debt or current environmental justice issues, despite being a central part of the prescription by many scientists. Thus the debate on limits is informed and complicated by all of the above.

5.1 Co-production

Environmental boundaries if interpreted using the 'idiom of coproduction' (Jasanoff 2004) signifies they are a product of the natural and the social order, being created simultaneously. Jasanoff explains how in the process of exploring and producing facts, and in an unbiased manner illustrating how the world operates, scientists tend to detach knowledge from meaning, separate "epistemic from the normative" (2010: 236). Here this rendering implies global representation of boundaries that excludes local practices

[15] Power here could include, as Martinez-Alier writes, that of the rich and the decision-makers who exclude other classes from the decision-making process, maintain inequities in resource access and waste disposal; brute power; human power that modifies ecosystems; and "sometimes it is the ability to set the agenda (e.g., 'let's go at least for a green economy and weak sustainability')" (2012: 65).

[16] "Observations are subjet to multiple competing readings" (Jasanoff 2015: 37)

and expertise—how resources are distributed and used (or extracted and imported), how people interact with and are affected by scarcities, how these scarcities are created, how people from different regions and walks of life experience and respond to limits, or rely on their own knowledge systems and science of measurement (Storm 2009). "Co-production" writes Jasanoff, "can therefore be seen as a critique of the realist ideology that persistently separates the domains of nature, facts, objectivity, reason and policy from those of culture, values, subjectivity, emotion and politics" (2004: 3). Thus in a co-productionist framing, explains Jasanoff citing Narain vis-à-vis the carbon pricing scheme, carbon will not be value neutral, instead it will be "more dangerous if it's coming out of overconsumption and less dangerous from subsistence" (2014 futureearth.org).

This logic applies to scientifically framed environmental limits that have gained popularity today. Those meant for a select audience, i.e., academics and decision makers in international and national arena, not so much for the layperson. A natural boundary is not an absolute, fully knowable empirical entity. Besides, giving an exact number for a dynamic and unstable system with multiple thresholds is not possible. The scientists admit this; boundaries is a postnormal[17] science. Nevertheless quantification is necessary[18]. Planetary Boundaries research is disseminated with governance and management in mind, since that is one of the priorities of SRC. For instance, scientists from PB team work with Future Earth initiatives which are about co-producing knowledge with practitioners that leads to socio-political action (Steffen 2015). This kind of science-for-action requires making "knowledge global and consensual" (Hulme 2015: 556) and ends up in the process overlooking pluralities, while tying knowledge to governance and power to achieve a 'unitary vision' (ibid). Another danger in articulating the message of limits for audiences outside the scientific community, like policy makers and businesses, is standardizing or deconstructing information to make it easier to deal with. These 'oversimplifications' (Jasanoff 2004: 77) and interpretive aspects can lead to misuse of the message in policy and practice. Perhaps that is how in the name of sustainability and green growth the world saw an addition in socially and environmentally harmful activities like land grabbing and dispossession due to the biofuels complex which led to "crises in other sectors or areas, like the food sector" (Borras 2016: 4). Thus, communicating and taking decisions based on the science of limits becomes even more complicated because of the uncertainties or ambiguities that can be interpreted selectively and taken advantage of by different interest groups. As in the case of LtG study where the scientists were falsely accused of being depletion-forecasters, anti-progress, communists and ironically, being part of a 'capitalist plot' (Piccioni 2012).

[17] PNS: Scientific framework where 'facts are uncertain, values are in dispute, stakes high and decisions urgent' (Funtowicz and Ravetz, 1993).

[18] Gives an idea and probabilities of scale and hitherto unknown seriousness of some phenomenon, like extent of eutrophication, as well as helps measure change.

Coming back to the question of quantification of limits, although it is imperative, some scholars believe numerical representation is used to convey certainty that belies judgments and choices; it is in a way a game plan for message delivery (Porter 1996). Numerical expression is "synonymous with rigor and universality" (ibid ix) thus the appeal, however it also renders, in this case limits, impersonal and objective. One of the reasons for mathematical representation is the need to provide policy makers with fairly 'certain', indisputable facts and theories. When the LtG or PB schools talk in numbers, albeit differently, they are trying to convey the message across borders which is when quantification comes in handy. A boundary quantification can also be misleading because what's harmful or helpful at the local level can be exactly the opposite globally (Ellis et al. 2015). That is why, add Ellis and team, it is more important to study the trade-offs and boundaries locally, in the environment and human wellbeing context, and not calculated on a global scale.

Limits are a human creation. Rather, as Moore, Narain or all three schools will point out, the creation of a small minority, even if not always mentioned in framings and conversations on boundaries. Akin to scarcity that is real yet created by some and thrust upon others. Thus it is a social construct. Which signifies limits are as much about stakeholders as about the environment; about experiences and practical application; about asking who is responsible for the transgressions, who takes the decisions for resolving these issues, and who is the judge of the right way forward. The point being, some scholars do and some do not address all the above based on their intentions, attitudes, and the studies' priorities or goals.

5.2 Ideology, worldview and values

Politico-economically the DG movement has roots in the New Left as seen in chapter two. They are vociferous in siding with radical environmentalists, mobilizing community to repoliticize ecology and development, and criticizing market economy and consumer capitalism (Kallis 2010), along with imploring the radical Left and the new Left to not give in to the demands of global capitalism and instead support the cause of degrowth (Kallis and Research & Degrowth 2015). Stockholm Research Centre on the other hand is more a Centre-leaning institution, therefore their faith in institutional reform, since Sweden has had social democracy for almost a century where centralized labor unions exist alongside the corporate sector and by and large credited to have achieved a 'positive' outcome with "institutionalized social solidarity" (Milner 1990: 17). This capital in the Social Democratic corporatist model, though, is strong capital not 'passive', writes Swenson (1991), that along with the state worked aggressively to "harness labor unions to the capitalist wagon" (ibid: 516). The corporatist system then is governed by the "essential characteristics of capitalism" (Keynes as cited in Schmitter 1974: 109) including resource accumulation, productivism, efficiency and mass consumption (Schmitter 1974). This could explain the belief of SRC in 'growth within limits' and the backing and recognition they are said to get from powerful agents, definitely more than the left does, in this case the DG movement, much like in the 80s and 90s. The Meadows team perhaps can be identified as social-liberals (centre-centre

left). These ideologies inform and are reflected in, as evidenced in previous chapters, the scientists' conceptualizations and affiliations as well as associations. For instance, Donella Meadows' involvement with environmental movements and Bill Behrens experiments on simple living with minimal ecological footprint (Beherns 2015). These beliefs or political ideologies also resonate with Sunderlin's (2003) class/managerial/individualist paradigm designed to identify environmental ideologies.

At the heart all debates on limits whether LtG and DG advocates' concerns about materialist, consumerist culture, or PB scientists' suggestion on moving the emphasis from selling to re-circulating, or all three advocating the demise of planned obsolescence and the throwaway culture are about connecting with the 'biosphere' (SRC). About moving to a society that is not defined by possessions and knows the difference between wants and needs. They all believe the issue of distribution and equal access should be foremost in any discourse apropos boundaries. These schools are against the dominant neoliberal paradigm that affirms "to reduce economic inequality is to raise incomes, consumption patterns and technological development of all people in all countries towards levels currently enjoyed by most people in North America, Europe or Australasia" (Steffen and Smith 2013: 407).

However, is there a difference in what they mean by connecting with the biosphere? Yes. For many Earth System scientists resilience building and planetary stewardship is about "keeping the Earth's environment in a state conducive for further human development" (Steffen et al 2011: 741). The DG school's anti-utilitarian ethic and critique of development stands in opposition to this view. This depicts how differences in worldviews are reflected in academics' positions. Or the weightage they give certain aspect. For example, we have seen how limits are an interrelated concept with strong correlation between social, ecological and growth limits. Hirsch in 1976, writes Ekins, criticized the focus on "'distant and uncertain physical limits'" instead of "'the immediate if less apocalyptic presence of social limits to growth'" (1993: 274). Today on the other hand some scientists are more focused on imminent dangers and threats posed by environmental limits while cognizant of social limits, and yet others believe all the above can only be dealt with if addressed simultaneously.

Many PB scholars are actively involved and believe in the ability of SD to deliver, while Degrowth actors believe SD is merely a 'green wash'. Recently Dennis Meadows (2015) in an interview said he too had changed his mind about sustainable development and agreed it was rather an oxymoron. Most PB scientists believe through innovation, 'perfect substitution' (for energy, not resources) and sustainable and efficient use of resources and energy, economy can grow in a manner that helps eradicate poverty and provide plenty for all. However, the LtG scenarios show that even if everything worked perfectly, that is the markets, technology and resource base, and nothing else changed, after a while humanity still hits the tipping point (see scenarios 3-6 in Appendix II). Dennis Meadows explains the affinity or belief in growth is because "if you don't have the idea that growth is desirable or possible then you don't have economics" (Documentary 2015). Degrowth school on the other hand affirms even if infinite

resources were available they would be against growth since it "destroys the human in ourselves, because it destroys beauty" (Decourt in Demaria et al. 2013: 206). This major division over SD, and visions of sustainable futures, is to do with fundamental belief in whether one sees growth and environmental preservation as compatible or irreconcilable. Whether one blames the ethics of growth for social ills and injustices or only the paradigm within which it operates but not the fundamental principle and structures. Similarly the DG school probably will not use Anthropocene since the term homogenizes humanity thereby overlooking justice issues, unfairly placing the blame on all humans and their economic activity alike. Not that the PB scholars don't recognize this, from their point of view though the concept helps explain the aggregate effect of human enterprise on the Holocene. Thus it can be argued the method of study appears to shape the worldview to some extent, although in the first place "methods-choices may stem from value-choices" (Gasper 2009: 12).

The selection of focuses then "depend partly on choices of values" (ibid. 11). This could be one of the reasons why the PB team chose to study boundaries in this manner. Or the very different audiences these schools engage with. Rockstrom and others do believe to a certain extent[19] in the ability of geoengineering and scaling up of wind and solar farms to deliver, if done sustainably, the DG school on the other hand is opposed to mechanized, big scale alternatives. This skepticism can be traced to their value-tradition that includes Ellul's opposition to 'gigantism' and domination of 'technique'. The PB scientists find solutions stemming from post-environmentalist or ecomodernist principles more appealing, while the other schools disagree because ecological modernization pushes into the background limits to growth (Dryzek 2005). Planetary Boundary vision includes steady state and circular economy as well as decarbonization and dematerialization of the economy for continued growth. Limits to Growth and DG scientists believe this is akin to having and eating your cake (Latour 2015), an impossibility in practice and a delusional endeavor. The reason could be that PB framework originated in an institution focused on resilience building, governance and management. Their background is related to resolving issues through reforming institutions in countries where corporate and government policies are formulated with environmental issues at the forefront (Dryzek 2005), and for most part appear to work[20]. That's why in their opinion equal access and fair distribution is possible within a circular and fossil-fuel free economy that includes growth provided right governance and management policies are in place.

The DG proponents do not believe continued growth is an option even with right policies in place. In addition they believe in collective caring of the commons or 'commoning' (Helfrich and Bollier 2015) and autonomy, that is why are opposed to global regulatory authority or governance (for emissions permits or resource distribution that PB advocates propose) even though admit some global action, state intervention

[19] They acknowledge the risks associated with geoengineering such as carbon capture and storage and similar techniques.

[20] As mentioned before, these countries top the SD and environmental friendly rankings, but perhaps don't account for debt and externalities.

and regulation will be necessary initially, especially for redistribution purposes ("of burdens and resources") (Kallis 2015). Their policy suggestions are egalitarian and collectivist. They believe the only way out is in opposing power structures that promote growth. The DG scholars have a completely different approach to dealing with limits. This could be a function of differing origins and problem identification. One school looks at boundaries from a global phenomenon and S&T angle; they look at what causes disturbances in the earth system functioning and then work towards identifying and restoring the processes that sustain the mechanism which is essential, in their opinion, for human wellbeing. Another school begins with the world problematique, which includes analyzing real-world data based interactions between all aspects of the earth system processes and the human enterprise to understand how the system works and reacts and then proposes changing the feed; they have the numbers to prove their claims. And yet another is rooted in the discordance observed by economists and thinkers in capitalism and its elements, appreciating this as a single-issue problem—growth that leads to transgression of social and ecological limits. They have been pointing at the 'naked emperor' (Naess and Hoyer, Barry) so to say right from the beginning.

An important point of reference for the DG scholars, that the LtG team do mention in their book, and perhaps one of the reasons they are called idealists, is the non-material or spiritual one. This is about the relationship indigenous and other communities have with nature and ideals and values of sharing, caring, giving, and preserving that they organize their existence around. Where nature is seen as a living entity, an integral inseparable part of being. This can be attributed to their 'alliances' like buen vivir and Kumarappa's economy of permanence. Some scientists though would probably be uncomfortable talking about this. Maybe because as Steven Yearly writes in the STS handbook, "conceptualizations of 'nature' and 'the natural' sit uneasily in mainstream Western culture" (2008: 937) and that the environmental discourses usually reflect this nature-culture dichotomy (ibid 938). Or "'nature' isolated from its twin sister 'culture' is a phantom of Western anthropology"(Latour 2015: 221). Therefore the absence in most discussions on intrinsic value. The DG discourse though doesn't echo this division; on the contrary their argument and activism includes bringing attention to and displaying solidarity with cultures that make no distinction between the two.

5.3 Environmental and social limits, yes, growth limits, not so much

One can argue in certain circles, such as policy and industrial, acceptance or rejection of LtG has changed little with time. This signifies, as many scholars have expounded, achieving credibility had nothing to do with the soundness of science, rather its interference with capitalist ideals and desired direction the societies were on, political goals, which were at stake. The study's implication, as that of the concepts of ecological economists before them, were about considering restrictions (imposed by the environment) and self-limitation (behavioral choices). That meant questioning and acknowledging the defects of the economic model and questioning the all-pervasive neoliberal ethics. The language of restrictions was unpopular and remains so today. It

was associated with failed communist and oppressive regimes. Thus values of 'individualism' and 'self-expression' gained another dimension: opposite of whatever communist regimes were thought to imply including moderation and limits of any kind. This argument was also contradictory to 'full speed ahead' trajectory economic growth was on at the time. Today in light of financial crisis in the US and Europe, austerity measures, Brexit and related investment uncertainties perhaps moderation and self-limitation is not that much of an anathema. Maybe that's why the resurgence of limits and re-evaluating meanings of *enough* or *sufficiency* vis-à-vis both production and consumption, not limits to growth directly per se, more its sister arguments.

The above inference is related to politicians and the industrial sector not indulging LtG, though increasingly entertaining and concerned about environmental boundaries. Nor are the LtG and Degrowth discourses for most part considered by UN agencies or the EU Commission or global governance institutions, probably because of its exiting-growth casting. On the other hand, PB framework has been fairly quickly accepted by all of the above. What could be the reason? Perhaps because the articulation as well as the terms *Limits to Growth* and *Degrowth* are still more political and therefore less palatable than *Planetary Boundaries*. The term PB sounds like it represents objectively the science of Earth in isolation from subjective realities, thus does not directly attach meaning or pique reflection, instead leaves it to people to do so. Where as the reason it was left out of the Rio+20 statement was precisely because it was thought to have the power to oppose growth by signaling resource and emissions constraint (Steffen 2012). This is proof despite ample evidence of rampant inequality, injustices, and ravaging weather events, people are uncomfortable confronting faults in the philosophy and values of the socio-economic system that permeates every aspect of how life is organized today, from the educational system to socializing to personal goals to what achievement or success has come to represent. For the rich and the powerful acknowledging these limits would imply acknowledging redistribution and access issues in the here and now, not as Martinez-Alier et al. say, trusting and hoping the trickle-down to take effect sometime in the future (2010).

The planetary boundary framework, not the discourse that Leach (2014) says is a truth regime which is a co-construct of power, knowledge and institution, rather the scientific framework by virtue of being a co-production, does lend itself to different interpretations as we have seen earlier. While it can be employed in the service of conventional SD, it can also, at the same time, be used to construct arguments in favor of degrowth or guide the 'right' kind of development, starting with the global North. For instance, Kallis and Research & Degrowth's (2015) suggestion in Spain to initiate environmental limits such as declining emissions caps, and caps for material, water and land usage, including licenses for tourist operations in high stress areas or Australia's increasing marine protected zones or the Swiss footprints based on PB. The point being, even if framings on limits are not orchestrated to promote a certain viewpoint by scientists, they can lend themselves to those very viewpoints that the all pervading, all powerful neoliberal, capitalist agenda aided by mainstream economists and policy makers can selectively choose and interpret to suit their pursuits, or otherwise.

6 In closing

The aim of this paper was to understand how the meaning of environmental limits and boundaries evolves, the manners in which it is conceptualized and explore the reason for the different shapes and forms the conversation takes. Conception of limits, as seen in the previous chapters, is closely linked to the time, atmosphere and place of origin, as well as the method, background and problem identification. It appears though the meaning, or rather the critical aspects of limits, has not changed. What has evolved is how schools and scholars argue about their point of view borrowing from increased empirical data and additional cross-disciplinary theories and techniques, from both natural and social sciences. Some scientists, as in the case of the Meadows team, have tweaked their calculations based on advances in scientific theories and reviewed their expectations in light of the reaction or inaction observed over time. Another aspect to the evolution could be a case of increased acceptance of aggregate, intensified effects of climate change making it difficult to ignore the environmental boundaries conversation. Nevertheless, one of the most sellable and popular argument about limits today is if environmental boundaries are not addressed this can jeopardize the future of economic growth, which is coupled to human wellbeing, development and welfare and therefore to be safeguarded.

On that note it's important to clarify limits are not about the environment, limits are first about *what* humans do, what the certain minority, including us, are doing. For some scholars it is the *way* they are doing it, but by and large for most scientists it is the *what* first, followed by the how or way it's done (for instance, when a scientist says 'growth without regard for environment', the issue still begins with *what*). These different aspects of what and why and how are used to frame warnings about physical repercussions, social injustices and moral compromises based on the goals of the scholars, activists, institutions or the study. For instance, one could propagate *growth with regard for environment* or *limited growth with highest regard for environment* or *unlimited growth… no growth…* and so on. Therefore, as pointed out in the last chapter, by not acknowledging limits for what they really are, which is human action and aspiration, businesses and markets are able to take advantage of the situation, making it more difficult to protect as Martinez-Alier stresses the extractive frontiers, as well as avoids devising policies for regulating the industry where most of the capital and power is concentrated, and continues to accumulate. Such conversation succeeds in skirting the issue to avoid confrontation vis-à-vis capitalism in policy circles. Perhaps that is why the lesser inconvenient of the truths gets more traction. Hence the very popular yet grossly ineffective sustainable development or greening of the economy concepts (Gomez-Baggethun and Naredo 2015). If we accept though that the environmental or the natural comes long after the human action, perhaps then the conversation can begin on the right note.

The question is can action taken simply from fear of crossing a boundary be long-lasting and transformational. That is, only concentrating on the environmental limits and

marginally adjusting growth and social limits to appease the environment could land humanity in the exact same spot a while later. The LtG scenarios demonstrate this. That is why the DG school's insistence on exiting the growth imaginary and linking the conceptualization of limits back to its origins, as mentioned in chapter one, back to questioning human action and aspirations. Thus their concerns stem from, and so are their solutions rooted in, values and philosophies that delineate humans from themselves (excessive use of technology for example), each other (individualism, accumulation, competition), and nature (utilitarian worldview, disregarding intrinsic value). This means going back further to the origins that talked about limits first and foremost in the context of action stemming from desires and ambitions, greed, lack of vision, selfishness, lack of control and carelessness resulting in moral depravation, environmental degradation and societal injustices. The DG school is asking for a societal transformation stemming from these concerns.

Jorgen Randers (2016), one of the writers of LtG, claims transferring 1-2% of labor and capital from dirty sectors to clean sectors, like fossil fuel to renewables or gas cars to electric cars, could make a big difference ecologically within a short duration, the industries though won't do it for fear of losing profits and the democratic process will not allow heavy regulation to facilitate this action. That is why, he writes, perhaps out of frustration, along with capitalism it's time to rethink democracy too. It transpires then that the best solution would be to change the underlying ideology, and therefore the structures of 'power and knowledge' of capitalism as suggested by the DG proponents. The DG scholar-activists who aim to bring about this change aspire to create such a space by advocating voluntary simplicity, changing individual values and building alternatives in practice. Because of their varied origins and interpretive framework this school of 'activist-led science' includes all three categories of scholar-activists that Jun Borras (2016) writes about, i.e., able to carry out independent research, indulge in both academic and political rigor, continue fighting for justice through academics, experiment, draw from others and their own experiences, organize politically, participate in resistance movements, and inform research and policy suggestions based on all of the above.

This kind of revolution might take time though that's why all schools have policy suggestions and plans for the here and now. Yet introducing such policies proves difficult because of the "elite capture of the policy space" (Arsel and Dasgupta 2015: 661) and the voters who are uncomfortable with the idea. Then the question is why? Amitav Ghosh believes more than lifestyles it is about power equations, about "change in relationships between classes and nations" (Interview NDTV 2016). Thus it would seem the various limits and boundaries mentioned here, at an individual as well as collective level, are ultimately a human creation that is about power and values and how we view ourselves, our worlds, and choose and measure and act upon what matters. That is why, when engaged in a conversation on environmental limits to bring about a change in the individual or the collective, it is necessary to acknowledge and consider the origins and all related aspects of limits.

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APPENDIX I

COMAPRATIVE TABLE

These are not to be seen as hard and fast divisions since there are often overlaps amongst schools, besides, their ideas and policy recommendations evolve over time, so it is difficult to write, interpret, and attribute these comparative points with hundred percent accuracy, thus the following is to be viewed as tendencies only.

Criterion	Limits to Growth	Degrowth	Planetary Boundaries
1. Origin of the schools			
Year	1972	1970, 2001, 2008	2009
Place of birth (all Global North)	America (+ Europe)	France	Sweden
Institution	MIT	Barcelona / France	SRC
Intellectual background	System Dynamics	Ecological Economics + social movements	Earth System Science
Focus (determined in part by value priority says D Gasper)	Human enterprise, Environment, population interaction	Health of people and nature	Earth as a complex system, ES processes and functioning
Aim	Prevent overshoot and collapse of global society by changing the system dynamics	Change growth paradigm, decolonize minds of growth fetishism to achieve more ecologically and socially just futures	Scientifically define ecological limits fro the society to avoid its tipping over
Socio-political scene (origins)	Environmental movements, counter culture	New Left, anti-consumerism, Lyon-first socialist mayor in 130 years, Great Recession	Great Recession (not sure if there is a direct connection)
Other circumstantial and influential factors	State of the world, Advancement in Computer modeling	Environmental justice + Ecological economists saying for a long time that costs far exceed benefits of growth, against conventional development	Advances in their field and interest shown by governments and institutions in their work + SD initiatives in their countries
Scope	Academicians and General public	Academicians, academics (changing the content of economics syllabus), activists, politicians because state has a role to play, practitioners	Academicians and policy makers, businesses,

Criterion	Limits to Growth	Degrowth	Planetary Boundaries
Assumptions	Natural limits exist	Economic growth has surpassed many limits. Degrowth is necessary to regain a desirable future.	Holocene desirable state
Values	Reformist and egalitarian and collectivist	Radical, egalitarian, collectivist	Reformist, individualist
2. Economic Growth			
GDP as indicator and GDP increase as goal	Problem	Problem	Problem as an indicator but not so much as a goal as long as it is achieved sustainably
Accumulation and profit	Unsustainable	Unacceptable and unsustainable in the business sense	
Ecological degradation	Need to Address (NtA)	NtA	NtA (Carbon free economy main goal for now + 3 other boundaries)
Inequality	NtA	NtA (main goal)	NtA
Unequal access	NtA	NtA (main goal)	NtA
Redistribution	NtA (imp)	NtA (main goal)	NtA (imp)
Social limits	NtA	NtA (main goal)	NtA
Morals/values	NtA	NtA (main goal)	NtA
Materialism	anti	anti	To some extent
Markets	Markets not the solution	Markets cannot do it; on the contrary they are part of the problem	Might continue to need them (regulated?)
Decoupling/ dematerialization	The extent to which it's possible is not enough to change the feed, service economies carbon intensive too	Highly unlikely	Possible (for dirty energy, material not mentioned)
3. Recommendations for socio-economic transformations			
Goal	Wellbeing	Wellbeing, Fair distribution, social transformation through voluntary DG	Wellbeing, Convergence (between low, middle and high income countries)
Growth	Limit growth, only what's deemed necessary, negative growth if need be	No further growth, DG in the North (some e.g., Kerschner argue that the South still can grow)	Growth within ecological limits, economic development

Criterion	Limits to Growth	Degrowth	Planetary Boundaries
Alternate Economy	SSE and circular economy	SSE (some are skeptical) (not through usual economic reforms), DG and New Economy, and alternative economy based on cooperative management and sharing	SSE and circular economy
Development	Sustainability, equilibrium	Anti SD or green growth	Sustainable Development
Action	Everyone, i.e., from top governance level to grassroots movements, profound changes in consumption preferences,	Grassroots mobilization, consensus building, bottom up	Convince policy makers and businesses, top down
Scale of action	Similar to DG	Focus on local and regional participatory governance, individual behavior and some global action	Global rules, governance, and institutions + local bottom-up innovation
Technology	Important but only if employed for the right reasons, efficiency of resource use	Efficiency and some technological small scale knowledge based innovation and technology but not to serve the economy	New sustainable technologies, geoengineering (but acknowledge its limits)
Alternative energy/material	Not rigid, whatever it takes, transition to renewable energy systems, closed-loop material system	Not large scale technical intervention (Latouche)	Large scale wind farms, solar-energy facilities
Global commons	Both, global and local level collective management and governance	Could be a worldview, has its own community, local level governance through collective action	Govern jointly but with an international arbiter, global governance
Democracy/ autonomy		French DG (Latouche): autonomy most imp, all economic questions are political questions	
4. Criticism			
Loopholes	Didn't account for technology and decoupling	Degrowth could lead to recession like conditions, transfer to dirty /cheaper industries	Boundaries are partly guesses, Doesn't differentiate properly between local and global variables, elite

Criterion	Limits to Growth	Degrowth	Planetary Boundaries
			institutions defining and drawing limits
Argument lacking in that		Too many approaches, not a clear framework, lacks clear unequivocal goals. Lacks systemic understanding of society-environment interactions as LtG do.	Privileged knowledge, Not Anthropocene but Anglocene and the same people then drawing boundaries
Values said to be		Idealistic/essentialist	Utilitarian/Anthropocentric
Misunderstood as	Communists/ Making predictions/ advocates of planned economy/ Malthusians	Communist and/or hippies	Libertarian/ hierarchical

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APPENDIX II

THE WORLD3 SCENARIOS, ANALYSIS

World3's core question: *How may the expanding global population and material economy interact with and adapt to the earth's limiting carrying capacity over the coming decades? (2004: 137)*

Scenario 1: A Reference Point*: The world society proceeds in a traditional manner without any major deviations from the policies pursued in the 20th century. Population and production increase until growth is halted by increasingly inaccessible nonrenewable resources. Ever more investment is required to maintain resource flows. Finally, lack of investment funds in the other sectors of the economy leads to declining output of both industrial goods and services. As they fall, food and health services are reduced, decreasing the expectancy and raising average death rates.*

Scenario 2: More Abundant Nonrenewable Resources: *If we double the nonrenewable resource endowment assumed in Scenario 1, and furthermore postulate that advances in resource extraction technologies are capable of postponing the onset of increasing extraction costs, industry can grow 20 years longer. Population peaks at 8 billion in 2040, at much higher consumption levels. But pollution levels soar (outside the graph!), depressing land yields and requiring huge investments in agricultural recovery. The population finally declines because of food shortages and negative health effects from pollution.*

Scenario 3: More Accessible Nonrenewable Resources and Pollution Control Technology
In this scenario we assume the same ample resource supply as in Scenario 2 as well as increasingly effective pollution control technology, which can reduce the amount of pollution generated per unit of output by up to 4 percent per year, starting in 2002. This allows much higher welfare for more people after 2040 because of fewer negative effects from pollution. But food production does ultimately decline, drawing capital from the industrial sector and triggering a collapse.

Scenario 4: More Accessible Nonrenewable Resources, Pollution Control Technology, and Land Yield Enhancement: *If the model world adds to its pollution control technology a set of technologies to increase greatly the food yield per unit of land, the high agricultural intensity speeds up land loss. The world's farmers end up trying to squeeze more and more food output from less and less land. This proves unsustainable.*

Scenario 5: More Accessible Nonrenewable Resources, Pollution Control Technology, Land Yield Enhancement, and Land Erosion Protection: *Now a technology of land preservation is added to the agricultural yield-enhancing and pollution-reducing measures already in place. The result is a slight postponement of the collapse at the end of the twenty-first century.*

Scenario 6: More Accessible Nonrenewable Resources, Pollution Control Technology, Land Yield Enhancement, Land Erosion Protection, and Resource Efficiency Technology: *Now the simulated world is developing powerful technologies for pollution abatement, land yield enhancement, land protection, and conservation of nonrenewable resources all at once. All these technologies are assumed to involve costs and to take 20 years to be fully implemented. In combination they permit a fairly large and prosperous simulated world, until the bliss starts declining in response to the accumulated cost of the technologies.*

Scenario 7: World Seeks Stable Population from 2002: *This scenario supposes that after 2002 all couples decide to limit their family size to 2 children and that they have access to effective birth control technologies. Because of age structure momentum, the population continues to grow for another generation. But the slower population growth permits industrial output to rise faster, until it is stopped by the cost of dealing with rising pollution—as in Scenario 2.*

Scenario 8: World Seeks Stable Population and Stable Industrial Output per Person from 2002: *If the model society both adopts a desired family size of 2 children and sets a fixed goal for industrial output per capita, it can extend somewhat the "golden period" of fairly high human welfare between 2020 and 2040 in Scenario 7. But pollution increasingly stresses agricultural resources. Per capita food production declines, eventually bringing down life expectancy and population.*

Scenario 9: World Seeks Stable Population and Stable Industrial Output per Person, and Adds Pollution, Resource, and Agricultural Technologies from 2002: *In this scenario population and industrial output are limited as in the previous run, and in addition technologies are added to abate pollution, conserve resources, increase land yield, and protect agricultural land. The resulting society is sustainable: Nearly 8 billion people live with high human welfare and a continuously declining ecological footprint.*

Scenario 10: The Sustainability Policies of Scenario 9 Introduced 20 Years Earlier, in 1982: *This simulation includes all the changes that were incorporated in Scenario 9, but the policies are implemented in the year 1982 instead of in 2002. Moving toward sustainability 20 years sooner would have meant a lower final population, less pollution, more nonrenewable resources, and a slightly higher average welfare for all.*

Source: Limits to Growth, the 30 year update (2004)