Limits and Beyond

50 years on from *The Limits to Growth*, what did we learn and what's next?

Edited by Ugo Bardi and Carlos Alvarez Pereira

A report to the Club of Rome

Exapt Press
www.exapt.press

First published in 2022 by Exapt Press

Edited by Rob Worth, Editor-in-Chief, Exapt Press
Cover design by Andrew Brown, DesignForWriters.com

Suggested citation: Bardi, U. & Alvarez Pereira, C. (2022). *Limits and Beyond: 50 years on from The Limits to Growth, what did we learn and what's next?* A Report to the Club of Rome. Exapt Press.

A CIP catalogue for this book is available from the British Library.

ISBN: 978-1-914549-03-8 (paperback)
ISBN: 978-1-914549-04-5 (eBook)

www.exapt.press

Dedicated to Donella Meadows and Lynn Margulis,
and to all the persons, past and present, struggling
to open the space of possibilities.

Contents

Foreword

Mamphela Ramphele and Sandrine Dixson-Declève

Co-Presidents of the Club of Rome

The universe is conspiring to bring humanity to its inescapable destiny – being inextricably interconnected and interdependent within the web of life. Humanity's attempts at escaping into a make-believe world of me, myself, and I have hit a dead end.

Limits and Beyond is a celebration of hard lessons learnt from 50 years of humanity's resistance to the central message of *The Limits to Growth* report. It is our responsibility as the Club of Rome to remind global decision makers that we have collectively wasted 50 years of valuable time. As a consequence the book is also a reminder that humanity needs to move beyond the limits we set for ourselves to learn what we need to learn, and learn it, as we were invited to do in another report to the Club of Rome, *No Limits to Learning*, published in 1979.

This book is a rich compilation of deep reflections by members of the Club of Rome, as well as other partners who share a vision of a world characterized by wellbeing for all within an equitable global order for a healthy planet. It includes an updated perspective by two of the co-authors of *The Limits to Growth* and other prominent thinkers about what the book actually said, how it was received, what happened next and its relevance today.

One of the central lessons of past decades is that public and private agendas were captured by a particular school of economic thought, neoliberalism, obsessed with uneconomic growth at all costs. As several of the co-authors

suggest, it is more than time to overcome this and adopt transformational economic models that embrace a systemic perspective to address humanity's challenges.

Moreover, we need a rich diversity of perspectives if we want to liberate ourselves from the constraints we have created. As exposed in several chapters of this book, new lenses are required to imagine different and more desirable futures. Voices from Most of the World and from alternative perspectives are here included to show that we can reconnect with our humanity, provided we inquire on our blind spots. This book is coming out shortly after the publication of the IPCC Sixth Assessment Report. For the first time, the IPCC goes beyond reliance on so-called "natural scientists" as the sources of data and analysis, and included "social scientists", indigenous knowledge experts and community leaders, as well as voices of young people.

This led to the acknowledgement that colonialism was a root cause of the climate crises. The report went further to recognize the impact of colonial history as an ongoing impediment to appropriate responses by humanity to adapt and transform their destructive lifestyles. In addition, vulnerable communities whose ecosystems were captured for the benefit of colonial conquerors and their post-colonial successors do not have the resources nor the capacity to respond appropriately to planetary emergencies.

In its last chapters, *Limits and Beyond* also reminds us that there are *No Limits to Learning*. There is a growing evidence of the huge untapped innate capacity in all humans to learn and come to grips with how complex living systems change. Work done in the most challenging environments has demonstrated the innate capacity of people to adapt. Its most important enabler is the encouragement for each to travel inwards to liberate themselves from a sense of worthlessness and fear of failure. Self-liberating education and learning environments tap into the innate capacity of even the poorest – young and old – and unleash enormous energy and creativity.

Contrary to some widely held views, human beings are wired to be connected. We are happiest when we are surrounded by loved ones who affirm and support us. And the 50th anniversary of the publication of *The Limits to Growth* coincides with a growing awareness by humanity at various levels that we are part of nature and that nature has infinitely more intelligence than we do. The Covid-19 pandemic has proven most effective in demonstrating our inextricable interconnectedness and interdependence. It has exposed the vulnerabilities of health, social, economic, financial, and political systems across the world and propelled us to a critical juncture that provides the opportunity and necessity to reshape our future, placing a value on what

truly matters. Healing the legacy of brokenness imposed by dominant ways of thinking and relating to others and to nature is essential for all of us. Healing this brokenness is the opportunity awaiting humanity to become open to return to the essence of what it means to be human.

This book is a feast. It provides the reader with a rich variety of views on the critical issues facing us. It provides encouragement to all changemakers that change is not only possible, but underway. Look around you – change is hiding in plain sight. Let us reclaim our humanity and celebrate Mother Nature in her full splendour.

Introduction

Ugo Bardi and Carlos Alvarez Pereira

The editors

This book originates in another one, published 50 years ago, which intended to open the space of possibilities for humanity to decide on its course. Many did not, and still do not, perceive *The Limits to Growth*, the 1972 report to the Club of Rome, as doing exactly that. What was mostly taken from the book was its strong warning of how dire the fate of humanity would be if we did not change what we understand as "development". And to many this was not good news. It was rejected as a first step. And many ignored the book entirely as well as the endeavour behind it.

The Club of Rome had been founded in April 1968, as a space for open debate among personalities from different backgrounds – business, science, politics, civil society – equally committed to examine the future of humanity as a whole with a systemic, long-term, global lens. At the time no other organization was daring to ask some essential questions. One of them is now even more critical than in 1968: Can we achieve equitable wellbeing for all within a healthy planet?

Within the logic tying human development to the unlimited growth in consumption of material resources, one must ask how much is feasible within a finite planet, a question that traditional schools of economic thinking have been reluctant to consider. *The Limits to Growth* addressed it by using early computer modelling to produce a simulation tool and build a variety of future scenarios. Unfortunately, the simulation showed that in most of the

scenarios, human civilizations would face collapse during the first half of the 21st century.

This finding shocked the world.

The Limits to Growth disrupted the conviction that conventional "development" and its expansion to the whole globe, as a programme of modernization and industrialization under Western hegemony, was necessary and legitimate for the sake of the progress of humanity.

The disruption was not appreciated by many in the established powers of the time. The possibility of scenarios in which human development would be redefined to fit within the boundaries of a finite planet was simply ignored. And when the concept of "sustainable development" was coined in 1987, it only questioned the nature of "development" inasmuch its negative effects could be considered as "collateral" issues to be addressed by more development of the same kind.

Humanity's situation has changed a lot since 1972, and we are in worse trouble than anyone related to *The Limits to Growth* would have liked to see. The financial crisis started in 2008, the Covid-19 pandemic since 2020 and the many ongoing conflicts including the war in Ukraine in 2022 are brutal signals that everyone sees. They emerge from a larger background of unfolding existential threats. To name just a few: the growth of inequity and fractures within and between nations; climate warming; the destruction of ecosystems and species; and the use of finance and technology to segregate people instead of nurturing healthy societies.

At the same time, women are emancipating themselves everywhere. In many places, people are overcoming the helplessness derived from colonial and neocolonial rules and mindsets. Young generations are more aware of the failures of economic and political systems that are reducing possibilities in the future. And achievements of science and technology are breaking barriers, but also accelerating the possibility of dystopian futures with deeper divisions between winners and losers. All in all, it seems that humanity is thriving and committing suicide at the same time. We might be living in the brightest moment of humanity and be closest to the abyss of our self-induced extinction.

How can we deal with that fundamental contradiction? What we already know about how Life works might help. Living systems evolve all the time and occasionally enter critical zones from which they could emerge with completely new patterns. But "could" is not "will". At critical points, the future is truly unknown. Jorge Luis Borges claimed that "time forks perpetually towards innumerable futures". Erich Jantsch (co-founder of the Club

of Rome) and Ilya Prigogine (member of the Club in the 1970s, and Nobel Laureate in Chemistry) would have agreed with that literary expression, so well aligned with their own investigations on the self-organizing nature of the universe. Criticality might lead to emergence, but the process cannot be planned beforehand, and natural imagination and creativity play the leading role in giving birth to unexpected patterns unfolding into new harmonies within the larger web of Life.

This is where the expansion of the space of possibilities comes in. *The Limits to Growth* was an optimistic bet on collective intelligence to learn from the exploration of possible futures. Nowadays, the situation is even more critical than it was. We have to renew the bet on the humanity and capacities of everybody to create the conditions for a collective emergence from emergency.

This is the general context in which we (the co-editors) started imagining this book on occasion of the 50th anniversary of *The Limits to Growth*. In 2011, Ugo Bardi had already written a book to revisit the original report. Building upon that experience, we decided to explore further by asking 21 authors (including ourselves) to submit original contributions synthetizing their insights, perspectives, and feelings. We did not give them precise instructions on what topics we would like to see covered by whom, but the magic of emergence saw to it that there is very little overlap between the different contributions, which also reflects the diversity of backgrounds, disciplines, geographies, and cultures of the authors involved. We limited our task to organize the flow of contributions, combining the timeline (what did the book mean in its time? and later? and now? and for the future?) with the type of approach (from science, politics, economics, culture, and more). As you might expect, that diversity is also reflected in the wide variety of approaches, voices and styles of the different pieces, which we decided to respect. Life tells us that radical diversity is a must.

In the first section, "Echoes of a great book", Ugo Bardi sets the scene with a detailed and in-depth examination of the original report, how it was received at the time, and how it could still be useful and relevant for our reflections today. Bringing in two of the original authors from the 1972 book, Dennis Meadows and Jorgen Randers, we have the privilege to better understand what that book actually said and answer the most common questions that people have asked about it over the years. Unfortunately, we cannot have the voice of Donella Meadows, who played a prominent role in the crafting and impact of *The Limits to Growth*, and in the subsequent development of the whole domain of systems thinking. She left this world in 2002,

not without writing a last piece titled "Dancing with Systems", a brilliant evocation claiming for the mobilization of all our capacities, the rational as well as the embodied, to reconnect with the harmonies of living systems. This book is also a tribute to her invaluable work.

Sviatoslav Zabelin then follows with an insightful piece revisiting the collapse of the Soviet Union with the hypothesis that it had actually reached its own limits to growth. In the light of recent events, this line of thinking would certainly deserve further research. Ernst von Weizsäcker, for several years co-president of the Club of Rome, gives his impressions of the outstanding personality of Aurelio Peccei, the reception of the bestselling report in the political context of the 1970s and 1980s, and the attempt to promote the decoupling of wellbeing from the consumption of material resources. He also evokes *Come On!*, another collective report to the Club of Rome, published on its 50th anniversary in 2018. Gianfranco Bologna summarizes the evolution of scientific thinking inspired by *The Limits to Growth*, and particularly the work on climate change, biodiversity loss, and other ecosystemic issues, ultimately leading to the current concept of Planetary Boundaries, crafted in 2009.

In response to our generic invitation, several authors decided to focus their reflections on economic thinking and how limited its dominant schools are to grasp properly the challenges of humanity. To start the section titled "Still the economy, but what kind?", Wouter van Dieren revisits his own involvement in the launch and initial impact of *The Limits to Growth* to sharply criticize the obsession of orthodox economics with growth at all costs. Following the line, Hunter Lovins goes further into a detailed, radical and well-documented deconstruction of the shortcomings of neoliberal economics. Ndidi Nnoli-Edozien even dares to explore the value of "solidarity capitalism", an oxymoron she proposes to go beyond the limits to growth, by blending corporate social responsibility with elements of African cultures and decentralized digitalization. Next, building upon her experience with the philosophy and practice of Gross National Happiness in Bhutan, Julia Kim advocates for the emergence of wellbeing economies as an alternative paradigm to reconcile human welfare with the care of the ecosystems on which our lives depend.

In the "New lenses for a different future" section, thinkers from continents and cultures across the globe bring in their unique experiences and perspectives to imagine elements of the shift(s) required. Sirkka Heinonen emphasizes the value of learning, de-learning and re-learning and of futures thinking if we are to navigate the crises and shocks of a volatile, uncertain, complex and ambiguous (VUCA) world. Nature is our ultimate teacher, she

concludes. Yury Sayamov relates the intellectual reception of *The Limits to Growth* in the Soviet Union, where it was taken more seriously than in most Western contexts, with ongoing research on global social transformations and civilizational prospects.

Sandrine Dixson-Declève (co-president of the Club of Rome) builds upon the tragedy of the Covid-19 pandemic to claim that transformational economics is not only urgent but also possible. The convergence of multiple tipping points creates a complex emergency, but it is also the threshold to address the challenges of humanity through a systemic lens. The elaboration of a Systems Change Compass for the implementation of the European Green Deal in the EU context, in which the Club of Rome has been involved, is an example of such an endeavour.

Reflecting on what has changed since *The Limits to Growth*, Mamphela Ramphele (co-president of the Club of Rome) invites us to explore some fundamentals. What does it take to shift mindsets out of tensions between change and resistance? What role will the cultural shift, that is becoming evident in younger generations, play? And not least, what should we expect from diverging visions of Most of the World and the dominant Global North? The responses to these questions will deeply influence our future. The Club of Rome can have a catalytic role at the crossroads of these issues by better understanding how living systems change.

Petra Kuenkel proposes a feminist perspective, in the hope that a much stronger participation of women in how and what decisions are taken could lead to a shift from patriarchal blind spots to a collective stewardship for better futures. On his side, Chandran Nair proposes to label the 21st as the century of Asia, building on the evidence that the most populated continent is also quickly recovering its prominence in a multipolar world. From Asian perspectives, achieving "Global Equity for a Healthy Planet", the motto adopted by the Club of Rome for this 50th anniversary of *The Limits to Growth*, requires a strong role for the state facilitating a combination of shared prosperity and moderate consumption, quite a divergent approach from that followed in the West in the last decades. To continue with alternative worldviews, Yi-Heng Cheng engages in the appealing exercise of weaving Chinese traditional wisdom with requisites for prosperity in resilience. Acting as metaphors, the five traditional elements (water, wood, fire, earth, and metal) signal societal values for a new balance of opposing characteristics, that he connects with the five variables of *The Limits to Growth*.

Last, but not least, the "Did we learn? Will we?" section ponders where we go from here. Has humanity taken in the lessons of *The Limits to Growth*?

What have we learned in the meantime? And, most importantly, what can we do about it now? Gaya Herrington compares the scenarios simulated in the 1972 book with the factual evolution since then and elaborates how these could be used as references for an essential debate among different societal priorities. Doomsday prophecies are not the appropriate framing for that debate to be effective, and humanity has better chances if we follow our own instincts since, as she says, "we love life more than growth". Chuck Pezeshki puts empathy at the centre of how we could grow socially, a way out of our addiction to material growth. The path he proposes, inspired by network science, implies redefining evolution by getting rid of its exploitative and non-cooperative interpretation, in order to develop the capacities of everybody.

Nora Bateson proposes a deep dive into ecological interdependencies to learn from the complexity of living systems. She delves into the relationality of all human societies, whatever the attempts to split reality into separate boxes. Though framed in a "what's in it for me?" mode, relationships can become actually devitalized. But giving them again a central role, they can also lead to "an ultimate unifying beauty". To conclude the book, Carlos Alvarez Pereira (vice president of the Club of Rome) proposes to "learn what we already know". Learning only happens when we change. We did not learn in the last 50 years, but we identified that the use of an inadequate lens to understand the world and our role in it is a major obstacle. Our relationship to time, and with it the current concept of capital, are framed by the past and present distribution of power and hinder the potential of future generations. As Aurelio Peccei said in 1984, a Human Revolution is needed "to live at peace with nature".

If you opened this book looking only for responses, it might disappoint you. Its purpose is to open the space of possibilities, which can only happen by asking better questions. And good questions open minds, unveil blind spots and lead to responses leading to other questions rather than to closed "solutions". The endless flow of questions and responses is Life itself.

In his foreword to *No Limits to Learning*, another seminal report of the Club of Rome published in 1979, Aurelio Peccei formulated our challenge as a riddle: "What we all need at this point in human evolution is to learn what it takes to learn what we should learn – and learn it." This book is an invitation to share the excitement of this learning adventure, for our own sake and of the generations to come.

Echoes of a great book

1

The Limits To Growth: The story of an idea

Ugo Bardi

Faculty Member, University of Florence

Summary

In 1972, the Club of Rome sponsored the publication of a study titled *The Limits to Growth* (*LtG*). It was not the first to examine the long-term trends of modern civilization, but among the first to do that quantitatively by means of models. A robust feature of the model results was that the global economic system was going to collapse at some moment during the first decades of the 21st century. The study was initially praised, then it went through a barrage of demonization that consigned it to the dustbin of wrong scientific ideas. Only with the new century a reappraisal started and, in 2011, I published a book titled *The Limits to Growth Revisited*,[1] one of the first studies aimed at a comprehensive review of the validity of the 1972 book. Today, in 2022, the Club of Rome is publishing a new book that aims to tell the story of the first 50 years of the study. The present section of this new book is based on my 2011 book, but it is a completely new revisitation of the subject and tells the story of how the idea of civilization growth and collapse fared in history and how it was interpreted by the *LtG* study.

There will come the The Day of the Lord, like a thief in the night.
— Paul's first letter to the Thessalonians (5,2)

The Cycles of Civilizations

Some five thousand years ago, the first human civilizations appeared over an arc of land that spanned the whole of Eurasia, from the fertile crescent of the Near East to the Yangtze valley, in China. Over the years, new civilizations were born and spread all over the world, building cities and roads, increasing their population, and conquering their neighbors. They all had one thing in common. First they flared up, then declined and disappeared leaving only ruins, tombs, and sometimes inscriptions on rocks where one or other great ruler stated that his glory would never end. But few empires lasted more than a thousand years, and most disappeared after just a few centuries. Our modern civilization, the one we sometimes call "The West" or "Globalization," had its origins in Europe about a half millennium ago, in the great expansion period that we call "The Renaissance." Now, it is old enough that it may be facing its demise.

But why do civilizations follow this cycle of growth and collapse? It is a question that never made those who asked it popular, especially if they concluded that collapse was coming soon. Nevertheless, the ups and downs of ancient civilizations were noticed, and, in some cases, we can still follow ancient discussions on this subject. Perhaps the first mention of a collapse comes from the Sumerian priestess Enheduanna, the first author of texts whose name we know. In one of her hymns to the Goddess Inanna, written some 4,500 years ago, she described an epic battle between the goddess and a mountain, a story in which we can recognize the collapse of the fertile land caused by erosion.[2,3]

Much later, the Roman Empire became one of the largest empires ever seen in history, but it had to face decline, too. The first hints that something was not going well for Rome appeared during the 1st century AD, when Lucius Annaeus Seneca noted in one of his letters that "the way to ruin is rapid."[4] During the same period, the early Christians interpreted the trend in religious terms as related to the coming *parousia*, the manifestation of God, that would end not just the Roman Empire, but also the human experience in the material world. Later, this view was called "Millenarianism," typical of religious sects.

But the Romans, just like most historical civilizations, went through collapse nearly completely unaware of the reasons for what was happening to

them. We have a chilling report from the 5th century AD, the last century of the Empire, written by a Roman patrician, Rutilius Namatianus. He could see the ruin of the world around him, but he couldn't understand that he was witnessing the last gasps of the Roman state. Everything he saw, he understood as a temporary setback, and he fully expected Rome to soon return to its ancient glory. This idea persisted for a long time in history and perhaps the last attempt to recreate the Roman Empire was when Benito Mussolini engaged in creating what was perhaps the shortest-lived empire in history: the "Italian Empire" that only lasted from 1936 to 1943.

In our times, recreating the Roman Empire seems to have gone out of fashion, yet, as late as in 1989, Francis Fukuyama wrote a paper titled "The End of History?"[5] where he described the dominance of Western civilization as equivalent to the *Pax Romana* during the Roman Empire, destined to last, if not forever, at least for a long, long time. The events that followed showed the limits of Fukuyama's ideas, but we still seem to be stuck with a view that sees collapse as unthinkable or, at least, unspeakable. The troubles of Western civilization are evident, but most people tend to see the situation as a temporary setback, to be corrected, at most, with minor adjustments. Then, the "*Pax Occidentalis*" will be the rule forever.

This optimistic view may be the result of the expectation generated by the "golden decades," from the 1950s to the 1970s, when the world's economy experienced a growth rate probably never seen before in history. And it was not just the economy growing, technological progress appeared as an unstoppable force leading to continuous growth all the way to the foreseeable future. With cheap and abundant nuclear energy, all problems could be solved, including that of "running out" of mineral resources. That was not to be feared according to a concept that was grandly described by the physicists Goeller and Weinberg as the "Principle of Infinite Substitutability."[6]

The central idea of those years was the control of nuclear fusion, the energy that powers stars. With that, the wildest dreams would have been possible. In 1974, the physicist Gerard O'Neill, proposed a grand scheme of space colonization based on gigantic artificial habitats capable of housing millions, perhaps even billions, of people.[7] An even grander scheme had been proposed earlier on by Freeman Dyson[8] with the ultimate limits of humankind being reached by creating an immense solid sphere (the "Dyson Sphere") around the sun. Flying cars? Those were just toys. What we really wanted were starships to reach other stars and colonize the whole galaxy!

But, despite the optimism of those years, there also existed also a thread of reflections that went in the opposite direction. Perhaps the first in modern

times to discuss civilization collapse was Edward Gibbon in his *The History of the Decline and Fall of the Roman Empire* (1776–1789). Gibbon's book was a detailed description of the fate of the Roman Empire that clearly reflected the preoccupation that the same destiny could befall the modern civilization. Gibbon denied that possibility but, clearly, he had identified a line of thought that was starting to penetrate the discussion: if the Roman Empire, glorious as it had been, had disappeared, what was in store for the modern civilization?

Not much later, in 1798, Thomas Malthus published his book *An Essay on the Principle of Population* where he noted, perhaps for the first time in history, that there were physical limits to the expansion of the human population. Curiously, and contrary to the common perception, Malthus was never a "catastrophist." That is, he never predicted collapses of any kind. He only noted that famines and wars would necessarily limit human growth to a certain level. And he didn't even say that it would have been a static level: he saw it growing, although not as fast as the population. Nevertheless, he was demonized and sneered at for having made wrong predictions to the point that, today, being defined as "Malthusian" is understood as an insult. That was to be a common destiny for many later catastrophists.

In time, others examined the problem of the limitation of natural resources. William Stanley Jevons published *The Coal Question* in 1865.[9] He was pessimistic (and correctly so) about the capability of England to keep extracting and burning coal for more than a century or so, but he never predicted an economic collapse. On the same line of thought, although one century later, the geologist Marion King Hubbert was the first to examine the long-term cycle of oil extraction,[10] predicting that it would reach its limits by the start of the 21st century. Hubbert was later described as a catastrophist and a Malthusian, but he, like Malthus, never mentioned collapse. He saw crude oil smoothly replaced by nuclear energy and the human civilization continuing to thrive.

It was only in the second half of the 20th century that the view we sometimes call "catastrophism" appeared. It may have been a consequence of the disaster of the two world wars, or maybe an effect of the specter of the nuclear holocaust. In any case, the idea of a negative future appeared first in science fiction. It was a genre that had started before the war as a generally optimistic depiction of the conquest of space and of technological wonders of the future. But, after World War II, it became affected by a dark streak, with the "post-holocaust" genre describing the survivors of a nuclear war trying to rebuild their lives in a ruined world. This harsh future did not even need a nuclear war to materialize and, in the 1950s, Isaac Asimov

told the story of a galactic-scale collapse, patterning his *Foundation* cycle of novels using Edward Gibbon's grandiose description of the fall of the Roman Empire. In 1968, George A. Romero started the "zombie" genre in movies with his *Night of the Living Dead*. The movie generated innumerable sequels and gave a visual shape to an unimaginably horrible future patterned on ancient fears of death, not unlike the "Triumph of Death" of medieval times.

During those years, people were reflecting on the future of our civilization and sometimes saw it as a nightmare rather than as a dream. But it was a subterranean way of thinking, never taken seriously in the mainstream debate. That was to change in the late 1960s when the catastrophist line of thought started to surface.

Perhaps the first scientist who rocked the boat of orthodox optimism was Rachel Carson with her book, *Silent Spring* (1962), where she criticized the indiscriminate use of pesticides and noted their damage to human health and to the ecosystem. Arriving in a world where the standard slogan of the chemical industry was "Better Life Through Chemistry," the book had an enormous resonance and Carson is correctly credited as having started what we call today the "environmental movement." As usual for catastrophists, she was widely insulted and demonized, but her ideas had a profound impact.

Another sacred cow that some deemed worth slaughtering was the growth of the human population. Up to then, growth had always been seen as a good thing; more people meant more customers, more workers, more soldiers, and more wealth for everybody. But, in the 1960s, the number of human beings on earth had passed the three billion mark. It was growing exponentially, and it was nightmarish to extrapolate the trend to future decades.

In 1968, Paul Ehrlich published *The Population Bomb*. It was seen as a return of Malthusian views but, if that is the case, Ehrlich was Malthus on steroids. Unlike Malthus, who had predicted a stabilization or a slow increase of the population, Ehrlich predicted widespread famines that would bring a rapid population collapse all over the world in the coming decades. Ehrlich's worries turned out to be misplaced or, perhaps, just premature. As a result, he was insulted and demonized according to the established pattern of catastrophist-bashing. But, again, the problem he had raised could not be ignored.

Finally, the fateful year of 1968 saw the publication of a paper that rocked the foundations of economics as they had been understood up to then. It was "The Tragedy of the Commons" by the biologist Garrett Hardin.[11] It soon became a classic.

Hardin exposed his ideas in the form of a story, considering a pasture managed as a "commons," that is, free for all shepherds to bring their sheep to feed. Imagine that the land can support at most, say, 100 sheep. More sheep than that would eat too much grass and leave bare land that would be rapidly eroded. So, 10 shepherds can have 10 sheep each and, as long as things stay that way, nothing bad happens. But place yourself in a shepherd's wooden clogs: for you, more sheep mean more wealth. So, if you could have 11 sheep instead of 10, you would be richer. But you also know that one more sheep in your herd would damage the pasture. You scratch your head a little and then you reason that the money you make with the extra sheep is yours to keep, while the damage it does to the pasture affects all the shepherds in the same way. After all, 101 sheep is not very different from 100; the damage is small. Accordingly, you go ahead and add one more sheep to your herd.

The problem is that every shepherd reasons in the same way and each one adds one more sheep to his herd. Now we have 110 sheep grazing pasture that can't feed more than 100. And the effects start being seen: the green pasture is becoming less green, with dark patches appearing where sheep have overgrazed the grass.

And it is not over. If one more sheep gives you an advantage, why not add two? That will at least compensate you for the damage done to the land by the extra sheep that the other shepherds are keeping. And you do that, just like everybody else does. So, the population of sheep increases and the final result, according to Hardin, is the destruction of the pasture by overgrazing. At that point, the sheep die, and the shepherd must migrate to seek a living, if they can. Note that the disaster is the result of everyone reasoning in a perfectly reasonable manner to increase his economic revenues. Using the economists' jargon, every shepherd does his best to increase his personal "utility function." A good idea at the individual level, but a very bad one at the collective level.

Hardin's model was purely theoretical, but it did hit a sore spot in the debate on the exploitation of natural resources. It demolished at its basis the concept of the "invisible hand" as proposed by Adam Smith (1723–1790). It was one of the first clear expressions of the concept that later would be called "overexploitation," a term popularized in the 1980s by William Catton.[12] We will see later that the "tragedy" is not a necessary consequence of the limits of resources,[13] but also that it does take place in real-world systems.[14]

This series of studies was a symptom of the profound change to the way of thinking of those times and it was going to surface in full with the publication of *The Limits to Growth* in 1972.

1972: The beginning of world modeling

When *The Limits to Growth* appeared in print in 1972, it gained enormous attention and it sold perhaps three million copies, having been translated into at least 30 languages. Several factors contributed to this success: the innovative approach using computers, the fact that it was written with the aim to be understandable by everyone, and, above all, the dire predictions of collapse it was understood to describe. The scenarios developed by the study showed that if nothing was done to change the policies of the time the human industrial civilization would collapse during the first decades of the 21st century.

It was a shock that, for many, truly arrived from the blue, but it had a story. It originated with an Italian intellectual, Aurelio Peccei (1908–1984). Peccei was neither a scientist nor a philosopher; he was a man of action, an expert in managing large-scale projects. He was endowed with foresight, entrepreneurial vision, and knowledge of several languages.

In the atmosphere of optimism of the 1960s, it didn't seem far-fetched to Peccei to think that humankind could reflect on itself and take decisions on its own future on the basis of the advice of some of its enlightened members. In a sense, Peccei aimed at endowing humankind with a consciousness.

Peccei's early ideas can be found in a speech he gave to the financial consortium ADELA in Buenos Aires in 1965. It is surprising how that speech looks to us in contrast with the way the ideas of the Club of Rome are perceived nowadays. Peccei was as far as anyone could be from "catastrophism," he saw no collapse on the horizon, he never mentioned – and probably couldn't even conceive – such a thing as "limits to growth." He did mention overpopulation but, of course, he couldn't even imagine that humankind was facing unsolvable problems with the depletion of natural resources, nor with pollution and overpopulation. At that time, the concept of "anthropogenic global warming" existed only as a hypothesis in some specialized scientific publications. Nobody could know that in a few decades it would become an existential threat for the whole of humankind. On the contrary, Peccei's ideas were aligned with the prevalent ones of the time: technological progress was pushing economic growth onward and bringing prosperity to humankind for the foreseeable future.

Yet, it was also clear to Peccei that something was wrong with this bright picture. Don't forget that the world was still reeling from the disaster of World War II, and that it was facing an even more tragic possibility: that of a nuclear

holocaust. At that time, the world was divided into three different sectors: the first, second, and third world. The first was that of the "developed" nations, the second that of the communist countries, the third of the poor nations, at that time still called "underdeveloped." Whereas the first and the second world were menacing each other with nuclear obliteration, the third world was not catching up with the increasing prosperity of the others. Starting to call the third-world nations "developing" instead of "underdeveloped," as it became fashionable at that time, was a sleight of hand that didn't change anything.

So, Peccei saw the challenge ahead was to make sure that everybody would profit from the bounty that growth and progress were bringing. He clearly saw that inequality and divisions among people would bring only disasters, if not the dreaded specter of an all-out nuclear war. It was necessary to improve collaboration among states if the worst were to be avoided.

Peccei's ADELA speech was a huge success that led Peccei to expand his ideas in a book titled *The Chasm Ahead*, published in 1969, and to gain international renown, and he started thinking about how he could put his ideas into practice. Peccei collected a group of people who had similar ideas: intellectuals, scientists, and politicians, all persons of international renown. The group met for the first time in Rome in 1968, and one of their first decisions was to call themselves "The Club of Rome."

The document titled "The Predicament of Mankind," published by the Club in 1970, followed Peccei's ideas. The main concern of the members at that time was finding practical ways to improve the conditions of life of all humankind, in particular by reducing wealth inequality. So, the question that the Club faced soon became to quantify the world's resources in order to act on their distribution.

It was not an easy task. In the 1960s, global quantitative data were still scant and scattered. Nevertheless, progress was being made: the concept of "Gross National Product" (GNP) – later to become a slightly different unit called "Gross Domestic Product" (GDP) – had become widespread after World War II. Governments started collecting data on industrial and agricultural production; for the first time it was possible to evaluate the size of the economy at the global level.

Economists were fascinated by the new tool they had in their hands. They noted that the GNP (and the GDP) tended to grow as a function of time. That was seen by most as a good thing, but there remained the nagging fact that wealth differences between rich countries and poor countries were

increasing instead of diminishing. What caused this perverse effect? Could it be reversed?

During this phase of evaluation, in 1968, Peccei attended a meeting on urban development on the shores of Lake Como, in Italy. The conference was also attended by another engineer, a young professor from the Massachusetts Institute of Technology (MIT), Jay Wright Forrester.

Forrester was another remarkable personality of the mid 20th century. He was fascinated by automation, and he saw the world as a system of interconnected elements acting on each other. The crucial element of automation, according to Forrester, was the concept of "feedback," a term originally developed in the field of signal processing. "Feedback" implies that an element of a system reacts to the status of another element and, in some cases, can cause the other element to change its status as well. Forrester's first application of this idea was with an automatic anti-aircraft gun that he developed for the US Navy during World War II. The gun received a signal from radar and it had to react to this signal by modifying its aim to follow the aircraft's trajectory. Forrester sailed with the US fleet to test his gun in action and his ship was torpedoed by the Japanese. Surely an interesting experience that most university researchers nowadays miss.

Back in the US and having become professor at MIT, in Boston, Forrester didn't limit himself to conventional engineering systems, soon moving his interest to social and economic systems. Those systems were beyond the capability of an engineer to test in a laboratory, but that didn't deter Forrester. He could always work on simulated systems where he could change the input parameters at will and see the effects without having to shoot down enemy airplanes.

This was another remarkable advance for the time. The concept of simulating a complex system by means of models was already known, but not commonplace. The only field where simulations were a standard procedure was in the military, which had been using them extensively from Napoleonic times. These early simulations took the form of "wargames" played sometimes on an elaborated diorama or just a cardboard map, where military units, in the form of counters, moved and fought each other according to complicated rules. If you have ever played wargames as a hobby, you know how slow the progress of the game is. Every turn, the counters move according to laborious measurements made with rulers, then fights are resolved according to the roll of dice. It is a slow, sometimes glacial, pace and endless discussions and bickering among players are commonplace.

Forrester, as a good engineer, could not be satisfied by an approach so slow and so limited. Engineers are known to be problem solvers and Forrester surely was one. He managed to be not only the founder of modern simulation modeling but also the designer of one of the first solid-state memories for digital computers that he developed and built expressly to use for his models.

Considering this and other feats, Forrester may well remind you of one of those fictional scientists, such as Dr Zarkov of the *Flash Gordon* series, who builds a spaceship in his basement. You may also wish to compare Forrester to another fictional scientist, Hari Seldon, one of the protagonists of Isaac Asimov's *Foundation* cycle of the galactic empire. We have no proof that Asimov ever met Forrester or knew of his work, but it is not impossible that Asimov was directly inspired by one of the talks that Forrester gave at MIT in the 1960s.

Surely, Forrester was a creative scientist and he was not afraid to move along unexplored paths. Here is how he explained the way he saw the field he was developing.[15]

> People are reluctant to believe physical systems and human systems are of the same kind. Although social systems are more complex than physical systems, they belong to the same class of high-order, nonlinear, feedback systems as do physical systems. The idea of a social system implies that relationships between its parts strongly influence human behavior. A social system strongly confines behavior of individual people. In other words, the concept of a system contradicts the belief that people are entirely free agents. Instead, people are substantially responsive to their changing surroundings.

With his new computers, Forrester was able to perform simulations better than anyone had ever done before. He could take a complex system, such as a whole city, a battlefield, or an economic field, and simulate it inside the memory of a computer. No human mind could ever do that; we just cannot keep track of so many parameters at once, and we tend to select those that look like the most important ones. Then, humans are often emotionally driven and may deceive themselves by bending the rules or ignoring the factors that would lead to an outcome they don't like. There is a well-known story that tells how the Japanese Imperial Navy used a wargame to simulate the battle of Midway before fighting it. When the simulation seemed to lead to a Japanese defeat, it is said that Admiral Yamamoto himself, the commander of the Japanese forces, ordered that the Japanese aircraft carriers that had been sunk in the game were to be "refloated." In

this way, the wargame ended with a Japanese victory. Of course, the result was completely different in the real world. This story may be in large part a legend,[16] but it does illustrate the emotional attitude that affects people when trying to predict the future.

The digital computer, in contrast, doesn't use anything like intuition, it is not affected by ideology, it has no idea about what patriotism is, and couldn't care less about who wins or loses a battle. It just crunches numbers, methodically and inexorably, moving virtual counters in its virtual memory until the end of the simulation. The human programmer may not like the outcome, but that's exactly the point.

So, in the early 1960s, Forrester had in his hands a tool for simulating complex socioeconomic systems. He dubbed the new fields "urban dynamics" and "industrial dynamics." Later, the term "system dynamics" became commonplace. The method could be used to simulate business situations and socioeconomic systems such as entire cities. From there, another step forward was clear for Forrester: simulate the world's entire economic system. He developed his first world models in the mid 1960s, when his computers had become powerful enough.

When Peccei and Forrester met on the shore of Lake Como, they rapidly understood that they had similar goals. Forrester needed Peccei in order to gather the data he needed. Peccei needed Forrester in order to interpret the data and understand the world's trends in the future. It is said that luck is what happens when chance meets preparedness. The meeting of Peccei and Forrester in Italy in 1968 was the start of a series of events that would change the intellectual landscape of the world.

In 1970, Forrester met the members of the Club of Rome in a reunion they held in Bern, Switzerland, and started developing his first world model, called "World1." In the meantime, with the help of Aurelio Peccei and Eduard Pestel, a German member of the executive committee of the Club of Rome, the Volkswagen Foundation provided the financing for a major study on world dynamics that was to be performed at MIT. The group charged to perform the study was led by Dennis Meadows, one of Forrester's former students, then assistant professor at MIT.

Jay Forrester did not directly participate in the study led by Dennis Meadows. His personality was more like that of the individual scientist, and he preferred to work alone using a model that he had dubbed "World2." The result was that two studies on world dynamics were performed between 1970 and 1972 at MIT. One by Jay Forrester, the other by the Meadows group, who had developed their own model, called "World3."

The two studies were different in the details but based on the same concepts and methods. Forrester's study was published in 1971 as a book with the title *World Dynamics*. The work of the Meadows team was published in 1972 with the title of *The Limits to Growth* (*LtG*), which had as its subtitle *A Report to the Club of Rome*. Later, there was much confusion about what the role of the members of the Club had been in the study, but it is sure that Forrester and Meadows' MIT group were completely free from any influence from the Club, ideological or any other kind. Indeed, for some members of the Club, and perhaps for Peccei himself, the results of these studies were a surprise.

Both studies arrived at the same conclusion: *The world's economy tends to cease growing and then to collapse as the result of a combination of reduced resource availability, overpopulation, and pollution.* The calculations were not meant to determine when exactly the collapse was to start but, using the best available data, both studies indicated that it could happen within the first decades of the 21st century, which was about half a century into the future.

Both Forrester and the *LtG* team performed their calculations for a variety of possible assumptions, including radical technological innovations or that population could be stabilized by policy actions at the global level. In most cases, even for very optimistic assumptions, collapse could not be avoided but only delayed. In many cases, apparently optimistic assumptions turned out to be counterproductive. If the available natural resources were assumed to be more abundant than the estimates of the time, the result was that the economy kept growing for a longer time, but that collapse arrived anyway and it was even more catastrophic than in the more conservative scenarios. If pollution was assumed to be controlled, then overpopulation would bring the system down. Stopping population growth alone was not sufficient to stabilize the system. Only a carefully chosen set of world policies designed to stop population growth, stabilize material consumption, and control pollution could avoid collapse and generate a stable state of the world's economy.

Forrester's book sold about 100,000 copies, a remarkable result for a technical text full of equations and diagrams. But the real impact came with the *LtG* study, which was aimed from the beginning at the general public and the number of copies sold was probably of the order of a few million. Evidently, the book gave voice to something that was deeply felt all over the world: that the limits to the planetary resources could not be ignored for long. The Club of Rome became famous for this study, even though not all its members approved of it. But Peccei understood the importance of these results and integrated them in his worldview, thinking that the specter of future collapse made it even more urgent to build up the tools needed for the

governance of the global commons. He never abandoned his position that it was important that the poor of the world would have a chance to grow and reach the same level of wealth as those in the rich nations. In a speech he gave in New York in 1976,[17] he explicitly rejected the idea of "zero growth" that would have locked the poor countries in their subordinate conditions.

But it would take time for the results of the *LtG* study to sink into the world's consciousness. The story had just begun.

The basic ideas of *The Limits to Growth*

When the "scientific method" was developed, mainly with the work of Galileo Galilei (1564–1642), the idea was that scientists should use laboratory or field experiments to determine the "laws" governing a certain phenomenon. It is typical of science that some "laws" are truly universal. Think of the universal gravitation law. The story goes that Newton thought of it by observing an apple falling from a tree and then applying the law to the Moon orbiting around Earth. For us, it is obvious but, at the time, it was a remarkable leap of imagination to think that two objects so different as an apple and the Moon would behave according to the same "law," an innovative concept at the time. And not just apples and orbiting bodies; once you know the universal gravitation law, you can use it to determine the trajectory of a cannonball, and do your best to make it land on the heads of your enemies. You can also use it to determine the trajectory of a space probe aimed to land on another planet. And you can do much more. Not for nothing Newton's gravitational law is said to be "universal."

The idea of "universal laws" was a huge success and it led to impressive scientific developments. But it was not possible to use simple laws to describe complicated or "complex" systems. Even for just three bodies orbiting around each other there are no simple equations that can exactly describe their movement. In practice, most real-world systems are impossible to describe using equations. For instance, there are no equations describing the trajectory of a cat chasing a mouse, just as there are no equations describing one person falling in love with another. In both cases, there is no equivalent of Newton's "universal" law, although it is not impossible to model human love using equations (J. C. Sprott did exactly that for the case of Giulietta and Romeo,[18] but it was just for fun).

Complex systems are a different kind of science. There are several definitions for these systems but, in general, we can say that they are all those

systems dominated by "feedback effects." "Feedback" is an intuitive term that we use when something reacts proportionally to something else. To stay with the example of falling in love, the target of your romantic attention may react symmetrically, falling in love with you. In this case, we have an "enhancing" or "positive" feedback. But the person you desire may react to your advances in the opposite way: the more you try to woo him or her, the more he or she tends to move away – eventually your efforts become stalking and you'd better realize it before your love interest calls the police. This is an effect we can see as a "negative" or "damping" feedback. Then, your attitude may also be affected by the reaction of your love, with their reactions enhancing or damping your attitude. In short, the system will oscillate or stabilize, but always in ways difficult to predict and surely not describable by simple equations.

In the 20th century, science started noting complex systems. That led to the development of a completely new set of methods of investigation. One of these methods, perhaps the most common one nowadays, is called "system dynamics," a field created mainly by Jay Forrester. Models developed using system dynamics are designed to describe how feedback affects the flows from one stock to another in the system. Stocks are defined as amounts of something that the model takes into account. A stock could be the number of individuals in a biological population, the balance of a bank account, or the number of fishing vessels in a fishery. Flows, instead, define how a stock varies with time. In a biological system it may be the growth (or decrease) of a population, in a bank account there is an inflow (deposits) and an outflow (expenses).

These elements are the essential features of complex systems, also called "complex adaptive systems" (CAS) to emphasize the fact that their internal feedback system tends to react to external perturbations in such a way to maintain the system status. It is a fundamental characteristic called "homeostasis."

System dynamics models quantify these factors to describe the behavior of CAS. There are many examples in the field of socioeconomic systems, but one of the first models to be proposed in this field is known as the Lotka–Volterra model, also called the "predator–prey" or the "foxes and rabbits" model.[14] In the model, the stock of the predators and the stock of the prey interact with each other causing the two populations (predators and prey) to oscillate forever. The Lotka–Volterra model is not just theoretical and in a slightly modified version it can describe how the fishing industry may destroy itself with overfishing.[19] The idea of destroying the resources that

make one live is surely stupid, but it is also very common. It is an effect that Bardi and Perissi dubbed "The 6th law of stupidity" in a paper inspired by the "5 laws of stupidity" proposed earlier by Carlo M. Cipolla.[20]

Of course, describing the whole world's economic system, as Forrester and the *LtG* team aimed to do, required something more complex than a simple predator–prey system, while still remaining within the capabilities of the computers available at the time. For this reason, many elements of the world system were "aggregated," that is considered as a single entity. That was not in itself a disadvantage. An aggregated model is affected by lower uncertainties and it may be more reliable than models that attempt to follow the behavior of many elements whose values are not certain.

For the models underlying *World Dynamics* and *The Limits to Growth*, the world was divided into a limited number of subsystems: agriculture, industry, population, etc., and the relations among the elements of the subsystems were described by a set of equations to be solved iteratively as a function of time. In the first published *LtG* report, in 1972, the model used was called "World3" and involved hundreds of parameters. But the "core" of the model was relatively simple: it was based on five main sectors:

- Human population
- Nonrenewable resources (minerals)
- Renewable resources (agriculture)
- Capital resources
- Pollution

The interaction of these subsystems can often be described in relatively simple ways. As an example, the paragraph below describes the "core" of the World3 model in terms of the interactions of the industrial capital element with the other elements of the model (from the 2004 edition of *LtG*[21]):

> The industrial capital stock grows to a level that requires an enormous input of resources. In the very process of that growth it depletes a large fraction of the resources available. As resource prices rise and mines are depleted, more and more capital must be used for obtaining resources, leaving less to be invested for future growth. Finally investment cannot keep up with depreciation, and the industrial base collapses, taking with it the service and agricultural systems, which have become dependent on industrial inputs.

Note the feedback relations involved in these relations. It is a condition that reminds us of how "predators" and "prey" behave in the Lotka–Volterra model in biology. In other words, with "capital" playing the role of the predator and "natural resources" taking the role of the prey. Of course, this subsystem was not alone in the model that also took into account that population growth is not simply proportional to the availability of services and food. Growth tends to slow and then, once a certain level of wealth is reached, the population starts to fall as a result of the concomitant decline of the birth rate and growth of the death rate. It is a phenomenon known as "demographic transition," observed nowadays in most of the relatively wealthy regions of the world.

The authors of the *LtG* study used their model to explore several different possibilities depending on the input parameters: the availability of natural resources, the effects of pollution, external human interventions, and more. The scenarios based on the concept of BAU (business as usual) showed that, at the beginning of the simulation, the availability of abundant natural resources led to a rapid, nearly exponential, growth of agricultural and industrial production. At this stage, pollution poses no problems and capital grows in the form of equipment, resources, and human knowledge.

But, in time, natural resources are gradually exhausted and therefore become more expensive to produce, while pollution becomes a significant damping factor affecting growth. More and more capital is needed to maintain growth and, eventually, both agricultural and industrial production stop growing, reach a peak, and start declining. Afterward, the accumulated capital also shows a peak and starts to decline. The population goes in parallel with the other sectors of the economy. It stops growing some years after the peak of industrial and agricultural production because of the reduced food and services available.

This behavior is most evident in the simulation that the authors call the "standard run" or the "base case" model. In Figure 1, we see the basic results obtained in 1972.

In all three versions of *LtG*, (1972,[22] 1992,[23] and 2004[21]) this scenario was based on the data that were, according to the authors, the most reliable available. The results were basically the same for all the parameters, except for population. In fact, there was an evident problem with the 1972 scenario: population continued growing for at least two decades after agriculture had peaked and was declining. It looked at least unlikely, but it was the result of the assumption that the demographic transition of the mid 20th century would "go in reverse" after the collapse of the system. That is, people would

react to the declining availability of services and industrial products by having more children, provided that sufficient food was still available. That assumption was abandoned in later calculations, replaced with another one that saw people reducing the number of offspring in a period of crisis. In any case, the behavior of the human population after the global peak remains impossible to predict, but this uncertainty does not change the main results of the *LtG* report.

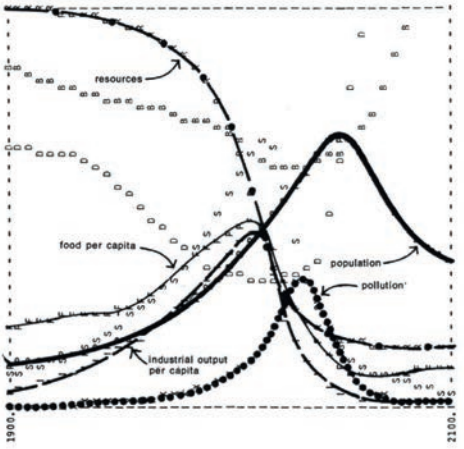


Figure 1. Base Case Model, the results of the 1972 LtG study

So, the future of civilization was to collapse. But what did that mean? Is collapse a prediction, a prophecy, or what? Can collapse be avoided? And, if so, how?

From the beginning of the story, there was much confusion on these points. One of the main problems was with people who took the base case scenario as a prediction (or even as prophecy). But that was not, and could not, be the purpose of the study: no model can predict the future over a time span of more than a century. The *LtG* report was intended from the beginning to provide a range of scenarios describing the outcomes of different assumptions and policy choices. What if natural resources are more abundant than we think? What if there is a technological breakthrough in energy production? What if humans were able to stop population growth?

Over three different books on the same subject that used the same methods, it is impossible to describe all the details, but the main results can be summarized as:

1. Collapse is a robust feature of all scenarios that involve reasonable assumptions for the parameters and also that the exploitation of natural resources would continue with economic growth as objective.
2. Technology can remove collapse from the results only with extremely optimistic assumptions, such as assuming, at the same time, infinite energy and zero pollution. This is an approach that the *LtG* authors called "infinite in-infinite out" (IFI-IFO).
3. Pollution is an important factor in causing collapse, but its effects usually arrive after resource depletion has already set the world economy toward a declining trajectory.
4. Human population is also an important factor, but its decline normally starts after the whole system has already started its decline.
5. The system can be stabilized and the collapse prevented during the 21st century only by specific interventions aimed at stopping population growth, reducing resource consumption, and curbing pollution.
6. Decline is usually faster than growth. It is a point that was not emphasized by the authors of the *LtG* studies, but that was later identified and termed the "Seneca Effect" by Ugo Bardi.[24]

The two reports, the one by Forrester and the other by the *LtG* group were not the only ones arriving at these results, but their work was the most detailed and exhaustive at the time. Later, other authors examined world collapse using a variety of methods. Joseph Tainter exposed the viewpoint of the historian with his well-known book *The Collapse of Complex Societies* in 1988.[25] Among others, Hall and his coworkers correlated the growth and the decline of civilizations to a parameter called energy return on energy invested (EROI) and proposed that the progressively reduced EROI caused by depletion was going to cause a decline of the whole human civilization.[26] Today, if you look for the term "civilization collapse" on Google Scholar, a database of scientific papers, you find that 237,000 studies on the subject were published after 1972, and nearly 23,000 just in 2020. Clearly, the impact of the idea is growing.

Despite the many studies in this field, however, the idea that collapse is an expected feature of Western civilization is not accepted with enthusiasm in the mainstream debate and often generates various accusations of "Malthusianism," "Catastrophism," or "Millenarianism." One of the reasons

for this may be the denigration campaign that had successfully presented the *LtG* study as wrong or flawed. It is a subject that needs to be examined in some detail to understand the trajectory of the ideas about collapse in the debate during the past 50 years.

The reaction: To the dustbin of bad science

During the 1990s, it became commonplace to say that the *LtG* study was immediately laughed off by everyone as obviously flawed. It was not so. The first, immediate reaction was favorable, sometimes enthusiastic. As an example, Robert Townsend, author of *Up the Organization* (1970) (cited in Simmons 2000) wrote that:

> The *Limits to Growth* has made headlines the world over. Its shock waves have caused our most cherished assumptions to come crashing down. It is a book that we can ignore only at our peril.
>
> If this book does not blow everybody's mind who can read without moving his lips, then the earth is kaput.

But it is true that the *LtG* book generated a heated debate. In several respects, it was a normal reaction. Science is itself a complex adaptive system and it tends to react to external perturbations by maintaining its homeostasis. When faced with a new, revolutionary idea, the first reaction may be enthusiastic, but if previously cherished assumptions are challenged, then a rejection may follow. It is not a bug of science; it is a feature. It is a pattern that filters out the many bogus ideas that periodically emerge out of scientific research. Already by the time of Darwin, in the mid 19th century, Thomas Huxley (who liked to be defined as "Darwin's bulldog") said, "It is the customary fate of new truths to begin as heresies and to end as superstitions."

The problem is, what is a genuine innovation (truth) and what is a fad (heresy) that will soon disappear? Errors are always possible, and the job of the scientific debate is to discover and correct them. And the problem is not just that of bona fide mistakes. Falsified data and other scams are a plague in some fields of science. Reading a book such as *Science Fictions* by Stuart Ritchie (2020) gives you some idea of how bad the situation is, especially in medicine, where large financial losses or gains are at stake.

Scientists are human beings and data are not a gospel of truth. Data are always incomplete, affected by uncertainties, and need to be selected. Try to

develop Newton's law of universal gravitation without ignoring all the data about feathers, paper sheets, and birds, and you'll see the problem. In practice, science is a fine-tuned consensus-building machine. It has evolved exactly for the purpose of smoothly absorbing new data in a gradual process that does not lead (normally) to the kind of partisan division that's typical of politics.

Science uses a procedure derived from an ancient method that in Medieval times was called *disputatio*, and that has its roots in the art of rhetoric of classical times. The idea is to debate issues by having champions of the different theses squaring off against each other, trying to convince an informed audience using the best arguments they can muster. The Medieval *disputatio* could be very sophisticated although, as you may imagine, theological *disputationes* normally failed to harmonize truly incompatible positions, say, convincing Jews to become Christians. It was tried more than once, but you won't be surprised by the results. But sometimes these debates lead to good compromises, and they kept the confrontation to the verbal level (at least for a while).

In modern science, the rules have changed in several ways, but the idea remains the same: experts try to convince their opponents using the best arguments they can muster. It is supposed to be a discussion, not a fight. Good manners are to be maintained and the fundamental feature is being able to speak a mutually understandable language. And not just that, the discussants need to agree on some basic tenets of the frame of the discussion. During the Middle Ages, theologians debated in Latin and agreed that the discussion was to be based on the Christian scriptures. Today, scientists debate in English and agree that the discussion is to be based on the scientific method.

In the early days of science, one-to-one debates were used (such as the famous debate in 1860 about Darwin's ideas involving Thomas Huxley and Archbishop Wilberforce). But, nowadays, that is rare. The debate takes place at scientific conferences and seminars where several scientists participate, gaining or losing "prestige points" depending on how good they are at presenting their views. Occasionally, a presenter, especially a young scientist, may be "grilled" by the audience in a small re-enactment of the coming-of-age ceremonies of Native Americans. But, most important of all, informal discussions take place all over the conference. These meetings are not supposed to be vacations, they are functional to the face-to-face exchange of ideas. Scientists are human beings, and they need to look each other in the face to understand each other. A lot of scientific innovations are generated in cafeterias over a few glasses of beer. No one, it seems, was ever struck by a ray of light from heaven while watching a PowerPoint presentation.

It would be hard to maintain that scientists are more adept at changing their views than Medieval theologians, and older scientists tend to stick to old ideas. Sometimes you hear that science advances one funeral at a time; it is not wrong, but surely an exaggeration. Scientific views do change, even without having to wait for the old guard to die. The debate at a conference can decisively tilt toward one side based on the brilliance of a scientist, the availability of good data, and the overall competence demonstrated.

So, after the presentation of the *LtG* study, the consensus machine should have worked as it was supposed to and led to a consensus, or at least to a compromise on the points of disagreement. It didn't happen.

The *LtG* study was so revolutionary and interdisciplinary in its methods and results that most scientists who commented on it simply couldn't understand what it was about, to say nothing about the methods and the details of the model.

A paradigmatic example of total incomprehension is the review of the *LtG* book that John Koheler wrote in 1973 in the *Journal of Politics*[27]: "If the point of this book is simply to observe that as t becomes large with the passage of time, ae^t becomes large, then some significant portion of its 205 pages are unnecessary." With this, Koheler demonstrated that not only he had understood nothing of the book's methods and aims, but that he had not even bothered to read more than just the first two chapters, which dealt with (and rejected) exponential growth as a viable model for the world's economy.

Reviewed 50 years later, the debate completely failed to address the important points about the study, as noted, among others, by Magne Myrtveit in one of the first reappraisals of the study after the demonization period.[28] Most of the criticism, and especially criticism in its most scathing form, arrived in the form of personal opinions published either in the mainstream press or on the "opinion" sections of scientific journals. In most cases, the critics didn't do much better than John Koheler. Most of the criticism arrived either in the form of statements of disbelief or of observations based on misunderstandings of the *LtG* study.

Typical examples of the latter kind of criticism were the common statements that the initial assumptions of the study were "too pessimistic," in the sense that the authors had been too conservative with their estimates of natural resources, or didn't take into account technological progress. But if you understand the aims and the methods of the study, you can immediately see how these statements are widely off the mark. The *LtG* study did take into account the possibility that natural resources were more abundant than estimated, and also the effects of technological progress. The latter

was simulated even in forms that would change everything, in terms, for instance, of the availability of abundant cheap energy. The authors of the study were very clear in their minds that the future was not, and could not be, fixed but it depended on the choices that humankind would make and on the possibility of technological improvements. But those who used this kind of argument seemed to be unable to understand the basic concepts of the study.

Unfortunately, in the great noise that the *LtG* study generated, there was little space for the kind of criticism needed for a serious scientific debate. A detailed discussion of this point is out of place here, and the reader is directed to *The Limits to Growth Revisited* for a complete discussion.[1] Nevertheless, we may try to summarize here some main points that we may call "scientific."

One of the few studies that examined the model of the *LtG* study can be found in the book *Models of Doom* published in 1973 by the Science Policy Research Unit of the University of Sussex.[29] It was a multiauthored book that examined the *LtG* study from several viewpoints. Mostly, we read of misunderstandings, statements of disbelief, and also, of political attacks. But the book contained a chapter written by the editors, H.S.D. Cole and R.C. Curnow, which remains to this date one of the few in-depth critical examinations of the "World3" model at the basis of the *LtG* study.

Cole and Curnow made several interesting observations about possible shortcomings of the model. Their work is also remarkable because they tried to determine how sensitive the model was to the variables it contained. It was part of a trend that would lead to the modern concept of "sensitivity analysis," believed to be a necessary part of all studies by multiparameter dynamic models.[30] Although their overall evaluation of the *LtG* study was negative, they could not report having found serious inconsistencies or shortcomings in the model. Other examinations also concluded that the World2 and World3 models were basically correct in their internal structure (e.g., see Cuypers and Rademaker[31]).

The other author who attempted to deconstruct the *LtG* world model was William Nordhaus, best known today as the recipient of the 2018 Nobel Memorial Prize in Economic Sciences for his work on integrating climate change models with macroeconomic models. In 1972, Nordhaus was a young economist at Yale University and he didn't wait long before presenting his criticism in a paper that was published in 1973 in *The Journal of Economics*.[32] This paper was dedicated to discuss Forrester's *World Dynamics* book, but it also broadly targeted the *LtG* study.

Nordhaus didn't mince words in his attacks, for instance accusing Forrester of Malthusianism, presumption, lack of humility, and general neglect of the basic principles of scientific research. The central point of Nordhaus's criticism was in the subtitle of the paper: "measurements without data." Nordhaus stated that "simulation models […] that have not been subjected to empirical validation *are void of meaning*." (italics in the original). Surely not a minor kind of criticism. If Forrester was really making "measurements without data," then it was not just a question of errors in the model or of the need to change the input parameters. The whole story of world modeling was an exercise in futility performed by a group of incompetent researchers.

Nordhaus's aggressiveness was somewhat extreme, but not unusual in the scientific debate. In science, a researcher normally gains "prestige points" by publishing new ideas and new results. But "points" can also be gained by demolishing a colleague's results or interpretations. If that happens, scientists may behave in very unrefined ways and, when they attack a colleague's work, they often take no prisoners. That was the case with Nordhaus's attack on Forrester, but, of course, the important point is not the wording, but whether the accusations are justified or not. Was Forrester really so careless as Nordhaus had described him?

Obviously, Nordhaus needed to substantiate his accusation of "measurements without data." He had the possibility of examining Forrester's complete World2 model since it had been published in full in Forrester's book *World Dynamics*. From the model, Nordhaus chose the equations about birth rates as a function of GDP, he plotted it, and he claimed that, indeed, the equation produced results that could not even remotely match the historical data. Q.E.D. then?

Unfortunately, this procedure was the result of a complete misunderstanding of how a complex system works and how it is modeled. A single equation of the model of a complex system is useless unless you take into account the effects of all the other equations. Imagine testing a plane engine on a test bench and finding that it does not fly, then concluding that planes cannot fly, either. An unjustified leap of logic, to say the least.

Forrester himself explained this point in a rebuttal to Nordhaus,[33] showing that, if the equation was properly used within the model, it did reproduce the historical data. Surely, neither Forrester nor the *LtG* authors ignored the real-world data. Unfortunately, the journal that had published Nordhaus's paper refused to publish Forrester's rebuttal. That was an indication that the debate on the *LtG* study was eschewing the accepted rules of the scientific debate, not so much because of the vehemence of Nordhaus's attack, but for

not giving to the attacked person a chance to respond. Forrester's rebuttal was published in a scarcely known journal (*Policy Sciences*) and the result was that many people thought that Nordhaus's paper had demolished once and forever the system dynamics approach to modeling.

Later, Nordhaus again targeted system dynamics in a 1992 paper published in *Brookings Papers on Economic Activity*.[34] This time, he was less aggressive, but he still accused the World3 model of being "lethal," in the sense that the assumption of economic collapse was built into the model and therefore it was not surprising, and not useful either, that the model predicted collapse. This idea is debatable, to say the least. Nowhere in the equations of the "World3" model are there parameters or equations specifically constructed to generate collapse. Instead, the rapid decline of the industrial system is the result of a well-known assumption in economics: diminishing returns. That doesn't mean that the model cannot be criticized, but saying that it is no good because it is "lethal" is a superficial criticism that doesn't go to the core of the matter.

Nordhaus contrasted the *LtG* model with a model of his which did not generate collapse. But that was no demonstration that the *LtG* model was wrong, just that it was possible to conceive of different models that would produce different results. In 1996, a paper by Robert Costanza[35] examined Nordhaus's papers noting that "Nordhaus has fallen in the same traps he so vehemently criticized Forrester for." In criticizing the Nordhaus's "DICE" model, Costanza listed five several fundamental defects, including the fact that parameters such as "Population growth and technological change are exogenous and natural capital is completely missing," and "in DICE, the economy goes on in its merry way with no real feedback from the natural world."

Clearly there were strong points of disagreement in this debate, but that was not the real problem; it was that the authors of the *LtG* study were not given a chance to respond to the criticism. On the contrary, Nordhaus's 1992 paper contained a section titled "Comments and Perspectives" written by other economists which may be best described as an academic version of a "feeding frenzy" by sharks.

From this brief review, you can see how poor the scientific debate on *The Limits to Growth* was. Instead of discussing the validity of the model, scientists soon found themselves divided in two camps: those who completely rejected the *LtG* approach, and those who adopted it enthusiastically. There was little or no connection between these two camps. When the members of the two groups happened to cross each other, they reacted like enemy battleships

encountering each other on the open sea. They exchanged broadsides before disappearing into the fog.

It was, mainly, the result of the incompatible approaches used by economists versus those of practitioners in the field that would be later called "biophysical economics." The economists were completely convinced that the economy is dominated by factors related to prices and markets, while physical factors, such as depletion or pollution, have only minor effects. In an extreme version of this approach, it is sometimes stated that mineral resources are not even limited at all. As an example, in 1981, Julian Simon wrote a book titled *The Ultimate Resource* conceived as a direct rebuttal to *The Limits to Growth* where he concluded that the worldwide mineral resources are "infinite" on the basis of five price trends. Another example is a rather famous statement pronounced by the Nobel Prize-winning economist Robert Solow at the annual meeting of the American Economic Association in 1974: "… the world can, in effect, get along without natural resources." The statement is not as absurd as it looks if examined in the context of the whole text of Solow's paper. But it is more evidence of how economists give much more importance to market factors than to physical ones.

Overall, it is certain that prices affect the economics of mineral extraction, but it is hard to maintain that a purely virtual entity, "money," can create a physical entity, mineral resources. Emphasizing the role of prices and markets led many economists to claim that the *LtG* model was flawed because, "it did not take prices into account." This is true in the sense of prices as an explicit parameter in the early versions of the model. But that's not the point. The question pivots around how some parameters are represented, rather than whether they are represented or not. The *LtG* model was built in such a way as to be able to simulate the transfer of capital from one sector of the economy to another when the need to produce a commodity became critical – this transfer simulated the effects of prices without needing to explicitly have prices as parameters of the model. It was exactly this process of capital transfer that eventually led to the collapse of the whole system.

As you see, initially there were attempts to set up a scientific debate on the *LtG* results, but the idea was lost from the late 1980s, when the *LtG* study was subjected to a barrage of criticism that completely engulfed it, consigning it to the dustbin of wrong scientific theories. The avalanche started in 1989, when Ronald Bailey published, in Forbes,[36] an all-out attack against Jay Forrester, whom he called "Dr Doom." In the article, Bailey also criticized *The Limits to Growth* study, accusing it of "wrong predictions" saying that it "predicted that at 1972 rates of growth the world would run out of gold

by 1981, mercury by 1985, tin by 1987, zinc by 1990, petroleum by 1992, copper, lead and natural gas by 1993." Later, in 1993, Bailey reiterated his accusations in a book titled *Ecoscam*. This time he could claim that none of the "predictions" of *LtG* had come true.

Bailey's criticism was simply the result of a misinterpretation of the *LtG* study. He had picked up an early criticism made by a group of economists in 1972.[37] In the heat of the initial debate, they had completely misunderstood the meaning of one of the tables in the second chapter of the *LtG* book that used data provided by the US government to estimate the duration of some mineral resources in the hypothesis of a continuous exponential growth. It was a hypothesis that the authors themselves defined as "nonrealistic."

The economists, instead, blithely took the numbers of the table as "predictions" and proceeded to criticize the authors of the *LtG* study for having been "nonrealistic" with numbers that the authors themselves had defined as "nonrealistic." It was simply absurd and that was perhaps the reason why that attack went unnoticed in the early debate.

But, nearly 20 years later, when Bailey picked up these numbers again, his criticism had an extraordinary success. Mainly because by the late 1980s people had mostly forgotten what the *LtG* study was about and also because nearly two decades had passed, the "nonrealistic" exhaustion dates had become much closer, and the contrast with reality appeared starker. From then on, the dam gave way and everyone in science or in the mainstream media started repeating that *The Limits to Growth* had made "wrong predictions."

It mattered little that the study had made no predictions, and surely no wrong predictions. No one seemed to be interested in checking whether the story of these wrong predictions was true or not. Most people seemed to be content to repeat Bailey's statement verbatim. Then, when everybody repeats the same thing over and over, it becomes the accepted truth. In this case, the documented and detailed *LtG* study was transformed into a caricature of itself: a series of naive statements created by a group of scientists who, like Chicken Little, really believed the sky was falling.

One question that was asked later about these events is whether the attacks on the *LtG* study may have been orchestrated by some industrial or political lobby that saw the *LtG* ideas as damaging their financial interests. The question is not far-fetched. We know that "spin campaigns" exist not just in politics but have also been used in scientific debates to denigrate and demolish a scientific thesis. In the Soviet Union, scientists who didn't follow the party line were demonized and marginalized by the government-dominated press. In the West, the origin of demonization campaigns was normally

hidden but, in some cases, their inner mechanisms saw the light because of government investigations. This was the case in the attempts of the American tobacco industry to disparage and demonize scientific research showing the adverse health effects of tobacco smoking. It was a covert spin campaign that started in the 1960s and went through its peak in the 1980s as described in some later studies.[38,39,40] A financed spin campaign was also used by the US chemical industry to discredit Rachel Carson's 1962 book *Silent Spring*.[41] It is possible that similar methods are being used nowadays to discredit climate science.[42]

In the case of *The Limits to Growth*, we have no proof of an orchestrated and financed campaign against the study, but we can't exclude it either. Overall, however, it seems more likely that the denigration campaign was mostly spontaneous. It was the result of the human tendency to believe what one wants to believe and disbelieving what one does not like to believe. In the end, the debate was political from the beginning, no matter how it was disguised as a scientific debate.

But, if the *LtG* study had a deep political significance, then it was perfectly legitimate to discuss it in political terms. It was the result of the imprint that Aurelio Peccei had given to the Club of Rome from the beginning. The idea of managing the world system for the common good implied a profound attention to people's needs and their dignity. For Peccei, "politics" had the original Greek meaning of *politiká*, "affairs of the cities." He saw the world as a single, large *polis*, a city that belonged to everyone and that had to be managed with the consensus of everyone. This was, and remains, the approach of the Club of Rome.

Of course, not everybody agreed with these views. For some, Peccei was just a dreamer, for others, a dangerous revolutionary. His ideas were often in contrast with views that saw politics as a competition among nations, ideologies, and religions. The reviews by Giorgio Nebbia[43] and by Mauricio Schoijet[44] tell us how different political attitudes shaped the worldwide reaction to the positions of the Club of Rome. In the Soviet Union, the official reaction was that the *LtG* book might have well described the collapse of capitalism, but that it had nothing to do with communist societies, which would avoid collapse by means of their planned economies. In many poor countries, the scenarios of future collapse were seen as a scam designed to perpetuate the dominance of the rich West, or a fraud to impose population reductions on the poor, or even the harbinger of a return to colonialism. In the Western world, different political orientations often determined the reaction to the *LtG* results. The left often saw the future threats as an attempt to

justify the subordinate position of the working class while the right saw it as incompatible with their vision of free markets and economic growth. Positive political reactions to *LtG* came most often from moderate liberal positions.[45]

The story was more complex than it may appear from these general lines. In the communist world, although the official reaction was negative, the *LtG* study left an important impression. In the 1980s, Viktor Gelovani and some colleagues adapted the *LtG* model to the Soviet Union and he published their results in a book titled *Soviet Union and Russia in the global system* (1985). The results were, as you would have expected, that the Soviet Union was following its own trajectory toward collapse for the same reasons that affected the world economy. According to a story told by Dennis Meadows, Gelovani "went to the leadership of the country and he said, 'my forecast shows that you don't have any possibility. You have to change your policies.' And the leader answered, 'No, we have another possibility: you can change your forecast.'"

Meadows' anecdote is a personal recollection, but it is basically confirmed by a study performed by Egle Rindzeviciute on the collapse of the Soviet Union.[46] It turns out that it is not true that *The Limits to Growth* was ignored. The book was translated into Russian, although it was distributed only to very limited circles (generating, by the way, a brisk black market). Several Soviet scientists knew of the study, they had contacts with its authors, and a number of them made an effort to warn the Union's leadership that the system was going to collapse, but they didn't have much of an impact. In general, the Soviet leadership was aware of the economic difficulties that their country was experiencing, but they were completely unable to take action against collapse. It may be argued that some of their actions, such as the invasion of Afghanistan in 1979, hastened the demise of the Union. We may also argue that exactly the same situation exists nowadays in more than one region of the world. The similarity of the trajectories of the Soviet and Western societies has been noted and described by, among others, Dmitri Orlov in a series of books such as *Reinventing Collapse* (2011).[47]

In another region of the world behind the iron curtain, in China, the *LtG* book may have had more success. It is often stated that the study was the origin of the "one-child" policy the Chinese government implemented from the 1970s to 2015 and that may have been effective in reducing birth rates, although it might well be that China just went through its demographic transition. There is no proof that the decisions of the Chinese government were influenced by the *LtG* study, but that is often taken as self-evident.[48]

In the West, we can say that the *LtG* study had little or no direct political effects. Even though at the beginning some Western leaders were sympathetic, no attempt seems to have been made to implement the policies that the study recommended. Soon, the denigration campaign launched against the scientific validity of the *LtG* study spilled over to its political contents. That led to a thorough demonization, and the study and its promoters became politically unmentionable, at least in the mainstream debate. They were accused of having hidden motives, of being part of a world conspiracy, even of planning the extermination of the "darker races." They were also accused of "escapism" because they thought that the availability of natural resources was a factor that needed to be considered if one was to discuss their fair distribution. The Club of Rome was described as a dark and secret organization whose purpose was the extermination of humankind (you can still find this kind of accusation in the current social media). The Club was said to be linked to legendary evil groups such as the "Illuminati" or others.

By the end of the 20th century, the victory of the critics of *LtG* seemed to be complete, and the study appeared to be both irrelevant and discredited. But the debate was far from being settled.

The reappraisal

With the coming of the 21st century, the negative attitude of the public toward the *LtG* study remained prevalent, but there also appeared signs of reappraisal. One factor may have been the "peak oil movement." The concept that crude oil production was going to reach a worldwide peak and then decline originated with the work of Marion King Hubbert in the 1950s.[10] In 1998, Hubbert's ideas were re-examined by Colin Campbell and Jean Laherrère in an article published in *Scientific American* with the title "The End of Cheap Oil."[49] Subsequently, Campbell and Laherrère created the Association for the Study of Peak Oil and Gas (ASPO), dedicated to the study of global oil production and its consequences on human society. The basic idea the association explored was that the peak of oil production was to be a momentous event in the history of Western civilization and that reaching the peak would have had dark and dire consequences. ASPO engaged in an attempt to spread the concept of peak oil in the hope that something would be done by governments to prevent the crisis that was supposed to occur within the first two decades of the 21st century.

The peak oil movement followed a relatively short cycle of about 20 years, peaking around 2008 when the production peak of conventional oil was probably reached.[50] Then, the discussion was mostly abandoned, in part because of the enthusiasm about "shale oil," in part, also, because it was understood that there was little that could be done to avoid peaking and decline. Nevertheless, the concept of peak oil was never attacked so strongly and so thoroughly as the *LtG* study. So, the spread of studies on oil depletion helped in changing the acceptance of the concept of economic decline caused by physical factors such as depletion.

In a sense, the ASPO views were similar to those of the *LtG* study; both saw the depletion of mineral resources as a fundamental factor in the world economy. It was also argued that the theory at the basis of the peak oil concept was a simplified version of the *LtG* model.[51] Nevertheless, the contacts among the two groups remained sporadic. But some people understood both the ASPO and the *LtG* viewpoints and saw their common elements. Indeed, one of the first reappraisals of the *LtG* study in the 21st century was the work of Matthew Simmons,[52] a member of ASPO. Simmons saw the trends of decline caused by depletion taking place in his field. He went to review the 1972 *LtG* book and found that – surprisingly – it had made none of the mistakes commonly attributed to it. On the contrary, it was still valid in describing the world's situation.

With the new century, a revisitation of the *LtG* study was published in 2004 by some of the original authors of the first study with the subtitle of "The 30-year update."[21] Several other researchers favorably re-examined the *LtG* study. Myrtveit[28] reviewed the debate that had taken place in the 1970s, finding that it was far from settled against the *LtG*. In 2011, Bardi revisited some of the common misperceptions about the results of the study.[53] Others also revisited several aspects of the study.[54,55,56,57] A recent paper by Gaya Herrington[58] that compared the *LtG* scenarios with the current situation, gained notable traction in the mainstream media and was widely read.

Perhaps the most comprehensive review of the *LtG* work was the one by Turner[59] who concluded that the "base case" scenario of the study was the one most compatible with the historical evolution of the global economic system. Overall, the scenario data never strayed away from the historical data by more than 15%, a remarkably good result considering that the scenarios covered several decades.

So, *The Limits to Growth* study turned out to have been prescient even beyond what its own authors could have imagined. Indeed, several recent

events can be seen as ominous hints that the collapse of the world's economy foreseen by most *LtG* scenarios may be around the corner.

The other area where the *LtG* study may be turning out to have been prophetic is that of pollution. In 1972, the concept of "anthropogenic global warming" was still a marginal issue in the discussion, and it was barely mentioned in the 1972 version of the *LtG* study. Nevertheless, the authors used an aggregated parameter in their model that would describe pollution without specifying what kind. So, this parameter could be seen, with some caution, as proportional to the excess of carbon dioxide (CO_2) in the atmosphere, the main cause of global warming. Also in this area, the model seems to have described reasonably well the ongoing trends.[59] According to the 1972 "Base Case" scenario, the concentration of CO_2 in the atmosphere will not start declining before around 2040. It doesn't have to be taken as a prophecy, but it seems to agree with most "business as usual" climate models and, indeed, despite all the attempts to cap CO_2 emissions, the concentration in the atmosphere continues to increase.

In recent years, global warming and climate change have become the main focus of the environmental movement. That may have led to the importance of resource depletion being neglected – more evidence of the importance of an integrated approach, such as the one developed for the *LtG* study. In any case, climate modelers have found their position turning into one similar to that of the *LtG* authors. Their models were widely disbelieved outside the scientific environment and the attempt to move the results of modeling into the political arena was a global failure. Climate science has not been consigned to the dustbin of failed scientific theories, not yet, at least, but we may not discount this development as a possibility for the future.

Another global issue which is returning under attention is population. "Population control" had become a subject of discussion even before the *LtG* study, but its popularity followed the same parable. That is, after a phase of strong interest in the 1960s and 1970s, the concept was demonized. Today, there are signs that the population debate is being reopened but overpopulation remains a politically charged term that risks generating the accusation of genocidal intentions for those who express their opinions on it.

The future

And here we stand today, back to where the group of intellectuals united by Aurelio Peccei in the "Club of Rome" had started in 1968. They had ambitious

goals and they sponsored the "Limits to Growth" study with the idea that it would help them in understanding what they called the *world problematique* or "the predicament of mankind." They believed that, based on the results of the *LtG* study, it would have been possible to convince the public and the world's leaders that it was necessary to transform the world's economic system into something that could provide a reasonable level of material prosperity for everyone. But, as it might have been expected, this idea turned out to be very difficult to put into practice.

The first problem encountered was the difficulty of having the message understood. Thus, the *LtG* study was widely misinterpreted. Scenarios were seen as prophecies of doom, the need for concerted action was interpreted as a call for world dictatorship, and the plea for equality as an attempt to impose communism worldwide. Then, of course, policies designed for the common good unavoidably damaged those economic sectors that thrived on nonrenewable resources and produced extensive pollution, for instance, the fossil fuel industry. A strong opposition at the political level was an obvious consequence.

Now, 50 years later, the current world situation indicates that the possibility of a collapse of the world's economy is not a far-fetched form of catastrophism, but a real possibility for a non-remote future. It is a possibility that is being noted by citizens and decision makers alike, despite the facade of official optimism that remains the rule. To say nothing about the worries about the status of the ecosystem. A collapse of the planetary life system would lead not just to an economic disaster, but to the extinction of humans as a species.

But even assuming that an agreement can be found on the fact that the *LtG* analysis of 50 years ago was basically correct, how could the problem be acted upon?

The first point that we may examine is a technological one. Do we have, today, possibilities that didn't exist in the 1970s and later? We do, and there has been remarkable progress in the field of renewable energy in the form of solar photovoltaic and wind. The price of photovoltaic energy is today lower than that of fossil fuels and the current solar technologies do not require rare metals that cannot be recycled. Also in terms of the ratio of energy return to energy investment (EROI),[26] the current values are better than those for the average fossil production.[60] Remarkable progress has also been made with lithium-based batteries that have made possible road vehicles with weight and range comparable to that of vehicles using combustion energy. Electronic data processing technologies allow higher efficiency in many fields that once

required high energy input (see, for instance, the book *Come On!* (2018) by von Weizsäcker and Wijkman). Finally, there are impressive innovations such as "photovoltaic food," using photovoltaic energy to cultivate microbial biomass, which is rich in proteins, as well as other nutrients, and that can be ten times more efficient than any current agricultural process in terms of the required land area.[61]

The problem is that these new technologies are arriving only now, and that renewable energy still represents a minor fraction of the world's energy production. At the same time, the world's infrastructure and the industrial and agricultural systems are still largely based on fossil fuels and on traditional technology. So, the new technologies may well be arriving too late to change the trajectory we are following toward collapse. The problem is especially serious in agriculture, which remains, to this day, a system that transforms fossil energy into food. Turning it back to a truly sustainable process, as it was before the fossil age, is not impossible, as it was argued in some studies[62] but it is a huge and expensive task.

The problem we are facing was termed by Ugo Bardi the "Sower's problem" to be solved using the "Sower's Strategy."[63] Imagine an ancient farmer. They need to save some of the this year's harvest as seed for the next year. If, instead, their family eats all the harvest, they will starve the next year. We are in a similar situation. We need to invest a considerable fraction of our current energy production (the harvest) as "seed" to develop and install a new energy production system (next harvest) fast enough to obtain a smooth replacement of fossil fuels before they become too expensive to extract or do irreversible damage to the earth's climate. In other words, we need fossil fuels to get rid of fossil fuels!

The investment needed for the transition could be quantified using a system dynamics model[64] or even just considerations based on the energy return for energy invested (EROI).[65] The result is that the transition is not impossible, but that to obtain it fast enough would require investments larger than we can reasonably expect will be deployed in the near future. That does not mean that the new generation of renewable technologies cannot soften the coming economic decline and reduce the human impact on the climate. But we can't expect technology to reverse trends that have been ongoing for more than a century. We are still stuck with the problem first identified in the 1970s. We need to manage the planetary commons without destroying them.

The Club of Rome and the *LtG* authors often stated the need for concerted action at the worldwide level to manage the earth's commons, a concern shared by many other actors in the world's decision-making arena. The

general consensus on this seems to have been – and is still today – that global actions designed to fight environmental and overexploitation threats can be obtained by means of international treaties. Easily stated, but not so easy to put into practice.

So far, most of the action has been based on exhortations. A good earth citizen, it is said, should avoid wasting resources, use nonpolluting technologies, consume as little energy as possible, eat local products, and other kinds of virtuous behavior. Many people sincerely tried to put these ideas into practice, but it is impossible for single persons or families to "unplug" themselves from the economy and have a significant impact on an economic exploitation system that gives no value to sustainability.

The problem of the scarce effectiveness of this kind of action is compounded by the so-called "Jevons paradox," or one of its similar versions (e.g. the Khazzoom–Brookes postulate[66]). These concepts state that higher efficiency of an economic process does not lead to a lower consumption of resources. It is not a paradox, but a principle well entrenched in the systemic view of the world. The resources freed by a more efficient or more conscientious consumer are likely to be used by a less efficient one. This is valid not just for individual consumers but even for groups, firms, and entire states. As an example, the decarbonization of some Western economies has been obtained mainly by transferring polluting industries and processes to non-Western countries.

Every project manager knows that a project cannot be managed by exhortations alone. If we want to solve global problems, we need to implement global decision mechanisms and functioning global institutions. Unfortunately, little or no progress has been made in this sense from the time of Aurelio Peccei. It is not that we lack institutions to act on global problems, perhaps we have too many of them. And these institutions have little or no power over national governments, which are supposed to be sovereign in the decisions they take.

National governments have powers that could be used to manage the commons, but they have no firm commitment to that. Consider how the US President Donald Trump decided, in 2017, to formally withdraw from the Paris Climate Accords. Then, four years later, in 2021, the new president, Joe Biden, ordered the US to rejoin the treaty. If you were dealing with individuals or with corporations, this kind of behavior would be illegal. What is a contract for if anyone can decide not to respect it at any moment? But there is no authority that can sanction a sovereign state for not respecting a treaty its representatives signed. The Paris treaty, already weak, has been considerably

weakened by the behavior of the US government, but any sovereign country could decide to behave in the same way at any moment.

Not that it is impossible to act effectively on global environmental problems. A classic case is that of the chlorofluorocarbons (CFCs), compounds that can cause the destruction of the stratospheric ozone layer that protects living beings from ultraviolet radiation. CFCs were banned by an international treaty in 1987. There are other cases of successful global treaties, for instance, the 1963 treaty banning nuclear explosions in the atmosphere, the 1997 Ottawa treaty against anti-personnel mines, and various treaties aimed at limiting overfishing.

Unfortunately, these treaties deal with specific and relatively simple problems, and, even then, creating effective treaties and enforcing them turned out to be frayed with difficulties. It will be enough to cite the title of a 1992 article by Steele et al., "The Managed Commercial Annihilation of the Northern Cod,"[67] to gain some understanding of how treaties can be misused to obtain the exact opposite effect to what they were meant for. More examples on how treaties on marine resources turned out to be counterproductive can be found in the book *The Empty Sea* (2020) by Bardi and Perissi.

If acting on relatively simple problems turned out to be so difficult, we can imagine how difficult it is to act on more complex – and more dangerous – problems such as climate change, correctly defined as "a wicked problem" by Incropera in a 2019 book.[68] The tool used to act on climate change is mainly the series of Conferences of the Parties ("COP") on the subject. COPs are a tool of the United Nations conceived as the governing body of any international convention. That makes a COP the only supranational body able to convene all the parties interested in climate and to establish conventions to mitigate climate change. The first COP on climate, COP 1, was in Berlin in 1995. Since that time, there have been 26 of these conferences, one per year. Most have been concluded with documents agreed by all the parties on the need to reduce the emissions of greenhouse gases.

In practice, the results of these 26 COPs have been modest in terms of reducing emissions. During the past several decades, the emissions of greenhouse gases and their concentration in the atmosphere have been increasing along a smooth curve, apparently unaffected by all attempts to reduce them. The point is not to denigrate the people who did their best, nor to deny that these conferences did a good job in maintaining the interest of the public and of governments about the issue. On the contrary, we could say that the climate problem has been among the most successful cases of global action. At least, some global agreements have been negotiated and implemented.

But do not forget that the systemic view of *LtG* and other dynamic studies was not just focused on climate. The call for action of the Club of Rome also involved action on other factors affecting the ecosystem: resource depletion, pollution, ecosystem disruption, land erosion, deforestation, overpopulation, and more. Global treaties on some of these problems have been implemented, but some have been resistant to all attempts of supranational regulation. That is true especially for mineral resources, where the very concept of "depletion" seems to remain unknown to the industry and to government officials. In this area, an "Oil Protocol" was proposed in 2005 by Colin Campbell,[69] the founder of the Association for the Study of Peak Oil (ASPO). It involved putting a cap on oil extraction with the purpose of making oil last longer. But we live in a world where, for some reason, high levels of mineral production are taken as a sign of abundance, without realizing the obvious fact that the more you produce it, the faster you run out of it. After some initial interest, the Oil Protocol was abandoned.

In terms of natural resources, a better attitude seems to exist about fertile soil, with the Food and Agriculture Organization (FAO) of the UN engaged in an attempt to reduce soil erosion worldwide. Apparently, even here the results are far from being satisfactory since we can read on the current FAO website that "Every 5 seconds, the equivalent of one soccer field is lost due to soil erosion." As for population, the subject remains unmentionable at all levels, at least in the Western world.

So, what can be done? We are stuck in a situation that reminds us very much the description of the mismanagement of the commons that Garrett Hardin had described in his 1968 article "The Tragedy of the Commons." But whereas Hardin was discussing small-scale pastures in England, the modern tragedy involves the planetary commons. In the end, large problems stem from simple causes: a conflict between individual greed and societal good. No need for sophisticated mathematical models to understand that as long as everybody wants to optimize their individual (or group) gains, that will lead to the destruction of the commons.

The effect of Hardin's ideas on the current way of thinking in economics has often been to promote privatization. If every shepherd owns their patch of pasture, it could be reasoned, then they will have no interest in overexploiting it. That may have been one of the reasons for the wave of privatizations that swept the Western world during the past decades. But, in practice, there is no evidence that privatization had any effect in reducing the overexploitation of the commons. One problem is that even when people are personally exposed to the results of their mistakes, they may still overexploit the resources they

control, either because their time horizon is shorter than the perceived arrival of the retribution, or simply because they have insufficient knowledge or understanding of the system to control it effectively. The latter phenomenon has been argued, for instance, in a series of studies by Erling Moxnes.[70]

But the fundamental problem with privatization is that it cannot always be applied. Privatizing may be just too expensive and, of course, you can't fence the ocean or allocate parcels of atmosphere to each state in the world. Not for nothing, at present, the sea and the atmosphere are the most overexploited global commons. You may argue that even without physical fencing it is still possible to allocate separate portions of these commons to different actors. This is the principle of fishing quotas, of carbon credits, and other cases. Yes, but again, these measures have been tried in various forms and in different areas of the world without leading to especially good results. In general, it is extremely difficult to apply quotas in any field and when it is done, the quotas are often too large to prevent exploitation and they generate cheating, black markets, and other negative consequences.

So, are we doomed?

No, but we need a more creative approach. There is a very basic problem here in the very approach to complex systems that Jay Forrester pioneered in the 1960s and that was at the basis of the *LtG* study. Forrester developed his modeling theory, "system dynamics," with the idea of describing the behavior of a system and, within some limits, extrapolating it into the future. It was an extremely innovative approach, but it had a weak point: it was based on a standardized view of the way people behave.

The world models at the basis of Forrester's and *LtG* studies are implicitly based on the same assumption made in most economics models: that people simply act in ways that maximize their immediate advantage (apart from the population sector). That is, people tend to maximize growth and the exploitation of natural resources. At the macroscale of world models, the assumption works, but note that it is not modifiable by the feedback effects that govern the model. It means that the only way to study the effect of changing people's behavior was to assume an external "forcing" (a technical term for parameters that are not contained in the algorithms of the model).

It is understandable that Forrester and his coworkers did not want to embark on the difficult (perhaps impossible) task of embedding people's behavior in the tangle of feedback that make the core of the model. Yet, this approach prevented the model from describing the effects of people learning from experience and what factors could lead them to modify their behavior. This feature made world models extremely sophisticated in *describing* the

system, but told people little, or nothing, about how it would have been possible to *control* the system.

"Control" is a term with a negative ring to it. It seems to imply dictatorship or totalitarian regimes. These are, indeed, about societal control, but they are primitive and expensive methods that usually fail in the long run. If we replace control with "governance," intended as shared responsibility and shared decisions, then the negative ring disappears. And we need governance, otherwise the system may evolve in ways that could be extremely negative for the citizens, such as the rise of oppressive dictatorships, extreme inequality, segregation of minorities, and worse (and we are seeing some of these negative trends appearing right now). But how do we attain governance, especially at the global level?

While Forrester was developing his system dynamics models in the 1960s, another great mind of the 20th century, Norbert Wiener, was laying the foundations of a new field of complex systems that he called "cybernetics," from a Greek word that meant "helmsman." Wiener and others, including Rosenblueth, Ashby, Turing, and von Neumann, were studying exactly the problem that we are facing today: that of controlling (governing, if you prefer) complex systems. Just as for Forrester's system dynamics, the basis of the concept of cybernetics was and remains that of *feedback*.

In time, cybernetics branched into two fields: one we today call "artificial intelligence," whereas the other is still called cybernetics and spreads over several sectors, including biology, sociology, and politics. The idea of being able to "steer" systems is attractive in many fields, but the only known practical example in politics was "Project Cybersyn," tried in Chile from 1971 to 1973 under Salvador Allende's presidency. It was a computer-based system designed to manage the national economy using a simple system dynamics model. The system was destroyed during the coup that deposed Allende in 1973, so we cannot say how well it could have worked in the long run. Later, the idea of central planning of state economies was discredited when the Soviet Union collapsed in 1991.

Nevertheless, artificial-intelligence technologies have been moving onward and they play an important role in many decisional processes and there exists much more sophisticated systems assisting (or perhaps controlling?) governments worldwide. In this field, China has surely the most advanced system. According to China's "new economic thinking," big data combined with AI can manage the economy, shape markets, optimize production chains, control the resource supply, and much more. It is a concept

sometimes termed "techno-utilitarianism" that may replace the traditional decision-making systems.

There is no doubt that China has been doing well, so far, with its technocratic system, which doesn't seem to suffer from the same problems that plagued the old "planned economies" of Soviet times. The Chinese economy has been rapidly growing, but also facing huge problems in recent times. In any case, the Chinese people seem to be happy with technologies of electronic surveillance considered too invasive to be acceptable in the West (at least up to 2020). But can this system manage the commons? And, in particular, can it help us manage the global commons? And can it be done without impacting on the basic privacy rights and on the freedom of citizens?

The answer, at present, is uncertain. China's technocracy remains at the level of a single state and the record of the Chinese government in terms of global environmental issues is not especially shiny. So far, the Chinese societal-control machine seems to have been mainly geared to optimize the country's economic output. Long-term parameters such as sustainability and overshoot do not seem to have played an important role in the system. But things may be changing. China's 14th Five Year Plan (14th FYP), published in March 2021, included energy and carbon intensity reduction targets. In April 2021, President Xi Jinping announced that China will strictly control coal generation until 2025, when the country will start a gradual phase out of coal. China will be an interesting test of how the new Chinese governance system can act on protecting the environment.

Despite the promise, even the most sophisticated cybernetic control system is still based on input parameters that are decided by human minds. So, a worldwide AI system could immensely help humankind if it were programmed with the function of protecting the global commons (imagine that Aurelio Peccei had programmed it). But, as things stand, there is no guarantee that this would happen, and the problem remains human greed, which may well end up programmed into the system. No matter how well the system can be optimized, if the objective is to optimize monetary profits, the system will optimize overexploitation of the natural resources and generate the destruction of the commons. It may also optimize an increasing inequality, the problem that the Club of Rome founder, Aurelio Peccei, was most worried about.

So, we find ourselves back to basics. The human mind is at the same time the problem and the solution. Humans can learn, and often they do. We need to learn how to make humans learn. Even though human learning is not part

of system dynamics models, it is still possible to use heuristic reasoning at least for starting to nudge society in the right direction.

In this field, Jay Forrester was again a great pioneer. Some parts of his research never were translated into quantitative algorithms but can be seen as starting points of a new way of managing human societies. Among these, there shines Forrester's observation on "leverage points" in complex systems. According to Forrester, most often, when dealing with complex systems, people tend to "pull the levers in the wrong direction." That is, decision makers tend to act on the system in such a way to worsen the problem they are trying to solve.

There are many examples of this self-destructive tendency, perhaps the most cogent one in regard to our current situation is how depletion problems are almost always countered with increasing efforts at more efficient exploitation and that, obviously, makes things worse. But Forrester's observation leads to the symmetric possibility that, pulling the levers in the right direction, it would be possible to move the system in the right direction. And we are back to the concept of cybernetics: how to steer the system in the same way a helmsman would steer a trireme or a transatlantic liner?

This chain of thought led Donella Meadows to propose the concept of "Places to intervene in a system"[71] in 1999. It was a series of 12 suggestions that go from changing some of the parameters to "the power to transcend paradigms." Meadows' text is fascinating and inspiring, but it remains qualitative and incomplete. Unfortunately, she died in 2001 and did not have the time to further develop her ideas.

The work by Donella Meadows can be considered as parallel to the work of another remarkable mind of the 20th century, Elinor Ostrom (1933–2012), who was, among other things, the first woman to be awarded the Nobel Memorial Prize in Economic Sciences. Ostrom's contribution to science was to demonstrate that Hardin's "tragedy of the commons" does not always occur and, in particular, it does not occur in the very settings that Hardin had taken as an example to discuss his ideas: pastures and other agricultural settings.

Ostrom's work is incredibly fascinating for its human side: no more abstract "agents" who behave like automatons trying to optimize their "utility function." No, Elinor Ostrom went to study real cases of real people who managed real resources: pastures, fishing waters, forests, and others. She showed that when natural resources are jointly managed by their users, in time, rules are established for how these are to be cared for and used in a way that is both economically and ecologically sustainable.

How is this miracle obtained? Ostrom proposed a series of eight rules for the good management of the commons, but these rules are all connected in a simple way: human-to-human communication. It is a concept that you may also describe with the term "empathy" (or "love," as Donella Meadows used to say). In other words, if people are left free to communicate with each other in a relatively nonhierarchical and egalitarian environment, then they will manage the miracle of governance. They will govern each other and the system without the need of dictators, totalitarian rulers, police forces, and the like.

It may be a surprising result, but it makes sense. It has to do with our heritage as human beings. Commons still exist in our world and if you ever encountered some ancient collective management systems for common resources, you would surely notice how well it was regulated. And the beauty of the concept is that these governance systems were not designed from above, they evolved by discarding what didn't work. In this sense, a well-managed governance system is akin to the concept of "holobiont," initially created by Adolf Meyer-Abich in the 1930s[72] but revised and disseminated in our time[73] by another remarkable mind of the 20th century, Lynn Margulis, (1938–2011). She was, among other things, the co-originator with James Lovelock of the concept of "Gaia" intended as the homeostasis of the planetary ecosystem.[74] Holobionts are widespread biological entities, not created by "the survival of the fittest" in a Darwinian sense, but by the "survival of the good enough," intended as the one which best manages the available resources by collaboration rather than by competition. Forests, fungi, corals, and even human beings are examples of holobionts. We can also see human social systems as holobionts when they are regulated by interactions based on empathy bonds among members. These "social holobionts" can often avoid overexploitation by maintaining a relatively egalitarian structure that prevents excessive competition among members.

So, we are back to what we started from. Can we manage the global commons according to the suggestions from Donella Meadows, Elinor Ostrom, and Lynn Margulis? Maybe the solution lies in recognizing that these three great women of the 20th century were probably endowed with a better understanding of the concept of empathy than their male counterparts of their time. The name of the game is always the same: empathy. If we can inject empathy into the governance of the world, then we can solve the enormous problems we face. Otherwise, they will solve themselves, without caring too much about human suffering.

Conclusion

After a few decades of overoptimism generated by concepts such as the "new economy" or the "end of history," the possibility of civilization collapse, if not the extinction of humankind, is gaining space in the current debate. We are returning to the views of 50 years ago, when the question of the limits of civilization had been asked by the authors of *The Limits to Growth* and by the organization that sponsored the study, the Club of Rome. The difference is that 50 years ago, problems such as the collapse of the industrial economy could be considered as pertaining to a distant future and dismissed, but that's not the case nowadays. It is possible that now we are on the edge of collapse.

The problem we face is still the same that Aurelio Peccei had foreseen when he had started his attempt to change the world, more than 50 years ago. It is not so much a scientific problem but a political one. Peccei correctly saw the task of changing the world as mainly a management problem. He understood that good management is based on good communication and that good communication, in turn, is based on empathy. But the attempt failed; the world was not yet prepared for the kind of negotiations needed to manage the global commons.

Would things be better today? Perhaps yes. We now have a much better understanding of the parameters of the world's climate, of the extent of the world's natural resources, and we have made considerable advances in technologies that may help us negotiate a better future. The problem is that while most of the world's leaders are still bound to obsolete concepts, we need to act fast if we want to avoid the collapse that the *LtG* study foresaw for our times 50 years ago. It may well be too late to avoid a decline, but all we can do now to soften it will be useful to soften the impact of an unavoidable transition to a sustainable world. The future is not a map, but a path that we discover as we walk along it. And it will lead us somewhere, even though we can't yet say where.

2

A co-author's view: What did *The Limits to Growth* really say?*

Jorgen Randers

Professor emeritus, Climate strategy, BI Norwegian Business School BI and co-author of The Limits to Growth

Introduction

The book entitled *The Limits to Growth* (*LtG*)[1] is known to many. It has been printed in 3–4 million copies in at least 36 languages. It has been discussed aggressively for decades.[2] But there is still a lack of clarity about what this research report actually said in its 150 illustrated pages when it was first published in the US in March 1972.

Many believe that *LtG* used a big mathematical model of the world system to forecast the end of the world before the year 2000. Others believe *LtG* was a neo-Malthusian projection of population collapse in the 21st century that would be caused by global shortages of natural resources, including oil

* This paper is an updated version of a paper that was originally published as "The 40-year anniversary of The Limits to Growth" in the journal GAIA as Randers J. 2012. "The real message of The Limits to Growth. A Plea for Forward-Looking Global Policy". GAIA 21/2

and agricultural land. Yet more people think that *LtG* proved that economic growth cannot continue forever on a finite planet.

Apparently, few remember that *LtG* was a scenario analysis of 12 possible futures of the period 1972 to 2100. And that the main scientific conclusion of the study was that "delays in global decision making would cause the human economy to overshoot planetary limits before the growth in the human ecological footprint slowed". Once in unsustainable territory, human society would be forced to reduce its rate of resource use and its rate of emissions.

The contraction of human activity could – and can – only happen in two ways. Either through "managed decline" organized by global society. Or, through "collapse" induced by nature or the market. The only thing that could not happen, said *LtG*, was for world society to remain forever in unsustainable territory, using more of nature every year than nature produces during each year.

Irrespective of what *LtG* really said, "growth will come to an end" was the imprecise summary that stuck with the book. Unfortunately, the audience believed – and believe – that *LtG* spoke about "economic" growth, and hence that it argued for the halt in economic value added. In fact, the book spoke about "physical growth" – growth in the number of people, tons of resources used per year, and tons of emissions from human activity. *LtG* spoke about growth in what we now call "the human ecological footprint". This is important because this allowed for the possibility of continued growth (in economic value added) as long as that growth is not associated with growing physical impacts (e.g., in resource use or pollution output). Whether "economic growth without growing physical impact" is feasible for a century or more remains an open question. It is clearly possible in principle, but nations with a growing GDP and stable footprint are rare.

LtG did not seek to resolve the question of decoupling physical impact from economic growth, and the authors were split in their views on whether full decoupling is possible. But they did agree that global society ought to reduce its ecological footprint per unit of consumption, and much more important, start doing so in time to avoid global overshoot. They also agreed that the task would be greatly simplified if human society moved away from its fascination with growth, both in population and economic value. So that takes us back to the original question: what did the *LtG* actually say? And is this message of any relevance today – 50 years later?

The original messages of *LtG*

Let us first rephrase – in modern language – the formal conclusions of *LtG* as they appeared on page 23 of the first edition.[3] This rephrasing deliberately uses language that did not exist in 1972 – concepts and words which have evolved since, partly as a consequence of the lasting global debate around the validity of the *LtG* messages. The conclusions are extended to also include a modern rewording of the implicit recommendations of *LtG*.

LtG 1: The human ecological footprint grew rapidly from 1900 to 1972

LtG noted that the environmental impact of human society did increase from 1900 to 1972 because of growth in population size, growth in resource use, and growth in the environmental impact per person. In other words, the ecological footprint of humanity became bigger because of growth in the number of humans, and because of growth in the amount of resources consumed and pollution generated per person per year.

This growth has continued since 1972, despite the hope of many idealists that societal advance would stabilize the global population and/or reduce the footprint per person. But the footprint has continued to grow, and since the mid-1990s, the world has had the statistical apparatus to quantitatively follow the physical growth.[4] The good news is that the footprint *per person* has levelled off and even declined in some countries. But the total human footprint is still being pushed up by increases in population and physical (material) consumption.

LtG 2: The human ecological footprint cannot continue to grow – at the rate seen from 1900 to 1972 – for more than a hundred years from 1972

LtG said that the human ecological footprint cannot continue to grow indefinitely because planet Earth is physically limited and, in fact, rather small relative to human activity. Humanity cannot – in the long run – use more physical resources and generate more emissions every year than nature can supply and absorb sustainably.

The human footprint has continued to grow since 1972. It is worth repeating that *LtG* did use the words "growth" or "physical growth" instead of the modern, more precise words "growth in ecological footprint" or "growth in environmental impact". The latter wording did not enter the literature until

decades after the publication of *LtG*. The choice of words led to decades of unnecessary public debate because most readers interpreted the word "growth" as identical to "economic growth" or "growth in GDP (gross domestic product)" and argued against *LtG*'s message on this mistaken basis.

Furthermore, many critics of *LtG* thought that "technology" would be capable of solving any resource crisis by bringing forth substitutes for any scarce resource – in time and without a temporary decline in human wellbeing. In the widest perspective, they have been proven right so far; the world has not yet run out of the most critical resources – fossil fuels, crops, water, and fertilizer. But there are growing threats, primarily to world biodiversity, for example in coral reefs and old-growth forests. Currently, 50 years after the publication of the 12 *LtG* scenarios, it appears the "resource crisis" is less likely than the "pollution crisis". Currently, the global bottleneck appears to be on the emissions side. During the last 50 years, annual human-made emissions of greenhouse gases have grown to a level far above the sustainable level (that which can be absorbed by the oceans and land during that year). As a consequence, there is global warming and observable climate change. The planetary pollution limits appear tighter than the planetary resource limits.

LtG 3: It is possible, and even likely, that the human ecological footprint will overshoot the sustainable limits (the carrying capacity) of planet Earth

LtG said the human footprint is likely to overshoot the physical limits of the planet because there are significant delays in global decision making. When limits start approaching, society will initially spend time discussing their reality – and continue expanding while debating. Ultimately, debate will give way to decisions to slow down, but meanwhile, said *LtG*, growth will continue and bring the human footprint into unsustainable territory.

This is, of course, exactly what has happened in the global climate arena. Climate change has moved from being an unknown issue 50 years ago to a well-known, hotly debated issue today. And although it is clear to anyone who wants to see that we are in climate overshoot, annual emissions are still rising.

In more detail, *LtG* said it would take time (decades) to observe and agree that current global activity exceeds the long-term carrying capacity of the planet. It will take time (decades) for national and global institutions to pass the necessary legislation to stop overexploitation of the world's resources and ecosystems. And it will take time (decades) to repair the damage caused during overshoot and heal the damage caused to ecosystems. In sum, *LtG*

said that growth in the footprint will not be stopped until *after* the sustainable level has been exceeded. Overshoot will not occur for all resources at the same time, but through individual long-drawn-out stories (for example: the blue whale, Indian tigers, Canadian cod, Indonesian jungle, and Australian reefs).

The message of "overshoot caused by decision delays" was not picked up by the *LtG* readership. This is not surprising, because in 1972 (when the human ecological footprint was around one half of today's) it was seen as rather inconceivable that global society would allow itself to grow beyond the sustainable carrying capacity of the globe. Now we know better. In 2016, the human demand on the biosphere exceeded the global biocapacity by some 50%. Today's world is in deep overshoot. Luckily, the understanding of this sad fact has increased with the successful dissemination of Planetary Boundaries Framework of Johan Rockström et al.[5]

LtG 4: Once sustainable limits have been overshot, contraction is unavoidable

LtG said that the human ecological footprint cannot remain in unsustainable territory for very long. Humanity will have to move back into sustainable territory. Either through "managed decline" to sustainable levels of activity, or through "collapse" to the same levels, caused by the work of "nature" or "the market". An example of the former would be to limit the annual catch of fish to the sustainable catch through legislation and planned scrapping of fishing vessels and gear. An example of the latter would be the elimination of fishing communities because there are no more fish.

The world has not yet experienced large-scale environmental collapse since the publication of *LtG*. But there have been instances of local overshoot, followed by contraction.[6] The most famous case of "managed decline" was the effort to eliminate ozone-destroying chemicals through the Montreal protocol in 1987, upon discovery of the thinning ozone layer over Antarctica. Today, the situation is hopeful, although the ozone layer is still damaged. The most famous example of "collapse" was in the Canadian cod fisheries after 1992. Here the situation is less hopeful; after two decades without fishing, the fish stock has not yet recovered.

Some argue that contraction – forced or planned – is nothing but a normal element in the process of economic growth, and thus nothing to worry about. In this view, overshoot and contraction is simply a process of one resource being replaced by another. Or more generally, one technology simply giving way to another. This view can perhaps be defended if the transition is smooth – i.e., without temporary decline in human income or human wellbeing (like

in the ozone case?). Or if the overshoot and contraction only occur in one geography (like the Newfoundland cod).

But contraction will be less benign if a common problem emerges in many global localities at the same time. A current case is the excess of greenhouse gases in the atmosphere. In this case it is likely that the transition to a new "solution" (electrification based on renewable energy) will involve a temporary period of decline in human wellbeing – and feel like overshoot and collapse – before the new solution is in place.

LtG 5: Overshoot can be avoided through forward-looking global policy

In response to the challenge formed by its first four messages, *LtG* intoned an optimistic answer: "The challenge of overshoot from decision delay is real, but easily solvable if human society decides to act." *LtG* said that forward-looking policy can prevent humanity from overshooting planetary limits. Of the 12 scenarios in *LtG*, 11 explored various solutions to the challenge of overshoot. The final scenario – global equilibrium – showed how overshoot and collapse could be avoided, at least in principle. Translated into practical policies, this meant legislation to limit population size and to limit per capita material consumption. Or in more detail: to keep forest removals below sustainable cut; greenhouse gas emissions below the amount that can be absorbed by forests and oceans; desired family size low by improved education, health, and contraception; and social tensions under control through less inequality. Doable in a computer model, difficult in the real world of politics.

In essence, *LtG* said that if society can avoid overshoot, there will be no need for "managed decline" nor any threat of "collapse". The challenge of limits is solvable – at least in principle. But it will be hard in practice, because forward-looking policies requires action today to get a better tomorrow. Such policies must keep the human ecological footprint below the carrying capacity of planet Earth and ensure that the human footprint is not allowed to grow into unsustainable territory.

LtG concluded that forward-looking policy can solve the problem, but warned that technological measures will not suffice. A truly sustainable global solution will, according to *LtG*, require a combination of technological advance and behaviour change.

In the years since 1972, much discussion has taken place (inside and outside the UN), to solve the human problem through coordinated global action. The UN Sustainable Development Goals (SDGs) are the most concrete description of the challenge, and some progress can be measured[8] – especially

in the less detailed ambitions of the UN Millennium Development Goals. But the SDGs do not emphasize sufficiently the danger of environmental overshoot if all the social SDGs were to be satisfied.[9]

LtG 6: It is important to act as soon as possible

Finally, *LtG* also said that it was important to start early to achieve a smooth transition to a sustainable world – without passing through overshoot and contraction. This point was illustrated by scenario 12 in *LtG*, which showed that the same global policies that would solve the problem (in the model world) when implemented in 1975, would *not* suffice if implemented 25 years later, in 2000.[10]

Today we know that no real action to forestall overshoot was put in place (in the real world) in 1975. Nor was any genuine effort under way in 2000. The last 20 years have seen a steady rise in the number of statistical measures that indicate that humanity has overshot planetary boundaries and that number is still increasing. The ground is being prepared for collapse or contraction, or ideally, planned contraction. Climate change is emerging as the central challenge.

How was the message of *LtG* received?

The (relatively self-evident and optimistic) message of *LtG* was not generally well received and instead led to acrimonious public debate over the ensuing decades. A few enthusiasts viewed the book as the litany for a new ecological era, but mostly, people saw *LtG* as a threat to the cherished ways of the present.

The fundamental scientific message of *LtG* can be summarized as follows:

> Global society is likely to overshoot planetary boundaries before 2100 – and then be forced to decline or collapse – because of significant reaction delays in the global economy. These are the unavoidable lags in the localization and/or perception of global limits, the significant institutional delays involved in (democratic) decision making, and the biophysical lags between implementation of remedial action and the improvement of the ecosystem.

LtG did not succeed in conveying this message for many reasons:

- Many believe that continued economic growth is the only feasible solution to the three legitimate human needs of, a) a liveable income, b) full employment, and c) old age security for all.
- Many believe that technological advances will solve all resource and pollution problems (ahead of time).
- Many do not understand that economic growth (growth in value added, which equals growth in GDP) can occur without growth in the ecological footprint.
- Many view any interference with the engine of economic growth as an attempt by the rich to keep the rest down.

Has the message of *LtG* stood the test of time?

So, what has happened since the publication of *LtG* in 1972? How has the world evolved over the five decades since then?

In short, the *real world has evolved as foreseen* in *LtG*. But given that *LtG* did not include one "most likely" forecast, the answer to whether "*LtG* was right" is a little more difficult to answer. *LtG* included 12 different scenarios for 1972 to 2100, and none of these were presented as the "most likely". It helps that the 12 scenarios did not deviate much during the first 40–50 years (except the scenarios simulating the effect of extreme policy change – change that did not occur). And modern research[11,12] has shown the world has indeed followed the common trends of those "middle of the road" scenarios.

This means that the global population and physical economy have continued to grow, more or less, as foreseen in *LtG*. Importantly, it means that the *real world has moved into overshoot*, just like in *LtG* – at the aggregate level, probably in the mid-1980s. This is most commonly accepted when related to greenhouse gas emissions, but other dimensions of human activity have also moved into unsustainable territory.

But the same research demonstrates – as does common sense – that *the real world has not yet collapsed* – at least not in an aggregate global sense. But since collapse does not occur in any *LtG* scenario before 2020, historical comparisons using data up to 2020 do not say much about the quality of the *LtG* model. By 2030, or even more so in 2040, we will have a much clearer indication whether *LtG* was right.

On another score, the public debate since 1972, especially for and against growth, has *proven the utility of some concepts used* in *LtG*. For example, "limits",

"physical growth", "equilibrium" – although they have been renamed "planetary boundaries", "ecological footprint", and "sustainability". These are now common and helpful words in the academic and political debate.

Less prominence has been gained by other *LtG* concepts like "exponential growth" (growth at constant doubling time), "decision delays", "overshoot", and "collapse". This is unfortunate, given that these concepts are central to the main *scientific* message from the *LtG* study: "the likelihood that overshoot will result from decision delays, and that contraction is a necessary consequence once in overshoot".

Finally, we have not yet had a final resolution of one of the main challenges to the idea of "limits" – namely *the idea of the technological fix*. Many thoughtful observers oppose the idea that the world is finite – even in the physical interpretation. They believe instead that technology will be able to remove the planetary limits faster than the rate we approach them. In other words: technological advance will continue to push back limits or increase the carrying capacity of the planet, so to speak, expanding the size of the earth in the process. For this group, *LtG* will only be proven right once there is a significant collapse, caused by environmental limitations not being solved fast enough. For global society to continue to move the limits back faster than they appear, will require pre-emptive investment in new technology. Society must invest before the problem gets serious. It is going to be interesting to see whether such advance investment in electrification and renewable energy will indeed take place at sufficient pace to halt global warming and extreme weather. If the investment is delayed, the solution will appear too late, and society will be back in the overshoot and collapse mode.

Does the message of *LtG* have any relevance today?

Yes, in several ways.

First, *LtG* points to the urgent *need to develop "one planet living"*. If humanity wants to become sustainable, it is an unavoidable fact that humanity must organize its ways in a manner that fits within the physical limitations of planet Earth. *LtG* reminds us that "one planet living" is a condition for sustainable wellbeing, and thus the new ethic for the ecological civilization, as the Chinese put it.

LtG points to the *need for planned reduction in the human ecological footprint*. The most urgent need is for rapid decline in global climate gas emissions;

but decline in agricultural intensity and population size would also be of great help to keep the human footprint within planetary boundaries and ensure human wellbeing in the longer term. It should focus the mind that humanity is already in overshoot, and that the only way out is through contraction, ideally a well-managed decline. Given that the richest 15% of the world population represent 60% of the global footprint, the rich should start, allowing ecological space for the removal of poverty.

LtG points to the *need to avoid further decision delays* in the global effort to stop physical growth and reduce the footprint. The most obvious need is for the rich to start now, even if the benefits to them won't be reliably observable before a generation has passed. The rich must agree on investment in solutions long before they are commercially profitable. Sadly, this is unlikely to happen, as illustrated by the limited response since the Intergovernmental Panel on Climate Change (IPCC) started calling for climate action some 30 years ago.

LtG makes the point that *limits will appear surprisingly fast if growth is exponential*. Exponential growth is growth at a fixed percentage every year (for example, 3% per year). It is characterized by a constant doubling time (in our case doubling every 24 years). This means that if the world will be full by 2030, it was already half full (half empty) in 2006, one doubling time before overflowing.

At a deeper level, *LtG* points to the *need for a solution to the three fundamental and legitimate problems (poverty, unemployment, old age insecurity)* that underlie the Western fascination with economic growth. These three problems must be solved in a way that is compatible with a planned reduction of the human ecological footprint. Most likely, this will ultimately require equitable allocation of finite global commons on a per capita basis.

And at the deepest level, *LtG* reminds us that *the ultimate goal is wellbeing, not GDP growth*. Economic growth is a tool to reduce poverty through productivity growth. When properly distributed, the bigger pie leads to higher material standards for the majority. If the pursuit of economic growth no longer increases human wellbeing, the logical move is to drop physical growth and seek wellbeing.

It would be imprecise to give the impression that nothing positive happened in response to *LtG*'s call for action. The past 50 years have seen *an impressive, though painstakingly slow, rise in environmental concern*. National and global institutions have emerged with the objective of protecting the planet – institutions that were dreams in 1972. And, most important, it is

now well known (among those who care) what needs to be done to create a sustainable and equitable world.

It is true that what needs to be done is not profitable from the investor point of view and will require structural change that is resisted by those who will lose their job or profit stream (as fossil activity is replaced with green solutions). Thus, *rapid progress will require collective action* – regulation of markets, income guarantees, and subsidies – to get it to happen at scale. In other words, an active state working for the common good. This will not come easily to a world of short-term individualists.[13]

Final reflection

The Limits to Growth appeared when human belief in the power of technology was at an all-time high. There seemed to be no challenge that could not be overcome through the application of human ingenuity and effort in the form of productivity growth and equitable distribution – based on continuing technological advance.

In this context, the main message of *LtG* was perceived as out of tune, even outright wrong, when *LtG* implicitly warned that global politics in the first half of the 21st century would be dominated by global resource and pollution constraints.

That did not sound likely. But it appears to be coming true.[14]

3

Questions about *The Limits to Growth*

Dennis Meadows

Professor Emeritus of Systems Design
Co-author of The Limits to Growth

Since the first edition of *The Limits to Growth* in 1972, I have delivered over a thousand speeches that described the goals, methods, results, and implications of our research. The audiences were in over 50 countries. They ranged in age from 6 to over 70 years old and were in occupations from young students to senior government officials and royalty. Some lived in the remote mountain villages of Soviet Georgia or Japan; others were residents of big cities like New York, Vienna, Paris, Havana, Seoul, or Xi'an.

All these diverse peoples shared many common perceptions and concerns. Consequently, I dealt with many of the same questions, comments, and objections again and again.

In this paper, I will summarize 18 of the most common questions and provide abridged, non-technical summaries of my typical replies. Of course, any one of the questions listed below could be, and often has been, the subject of an entire book. Those interested in that level of detail will need to look elsewhere.

My goal with this essay is to give each reader an understanding of how I presently view the world's prospects. I derived my views from thoroughly reading thousands of reports, intensely discussing the issues with hundreds of professional colleagues, conducting professional research over five decades, and reflecting on the events and decisions of my personal life.

I could cite dozens of references to substantiate each of my replies, but I will not. I am not trying to prove that each answer is true. Indeed, my answers below are always incomplete, and some of them will certainly turn out to be at least partially mistaken. Most of the important questions do not have a single, simple answer. If any of them do, I do not yet know what it is.

The World3 model used in the three editions of *The Limits to Growth* was designed to give insights about the causes and consequences of growth in global population and material consumption on a finite planet. The model achieved that goal. It was not designed to give insights about the dynamics of decline in demographic and economic activity after the growth stops.

This era of rapid, planet-wide growth has been unique in the history of our species. The MIT team always recognized that the end of this global growth phase will bring enormous changes in the political and economic cultures of the world's many peoples. We did not attempt to include those changes in World3, and our reports never speculated about them.

Because even the general path of future physical growth could not be forecast with any confidence, we provided 12 different scenarios in the 1972 edition of our report – 12 different possible paths for the evolution of human population and the material economy. To generate those scenarios, we tested 12 different sets of assumptions about the accuracy of our estimates, the impacts of future technology, and the nature of social responses.

We did not consider any single computer projection to be the most likely future. But several recent, independent studies have found that one of our scenarios, Figure 35, in the 1972 book, tracks historical data reasonably well from 1970 through 2010. That scenario is reproduced opposite as Figure 1. It appears here unchanged from its 1972 original except for the addition of two vertical lines. The left line indicates the publication date for our book, and the right line shows approximately the present time.

That scenario has become an influential paradigm through which I interpret current events and anticipate the future. Its main features will be reflected in my answers below.

Before presenting the questions and answers, I offer four caveats.

My opinions about the globe's future were largely formed before I had my current understanding of the consequences of climate change for our species and before the Covid-19 virus had begun to alter social values, economic trajectories, and political priorities. In a decade, there will be a better understanding of the climate's and the pandemic's impacts on the globe's physical, biological, and social systems. They will not raise the limits to growth.

Since I will write as I spoke when responding to people's questions, you will see in the following many redundancies and omissions. The following compilation of questions and answers certainly does not exhaust the list of important concerns. Nor are the following responses listed in any particular order of importance.

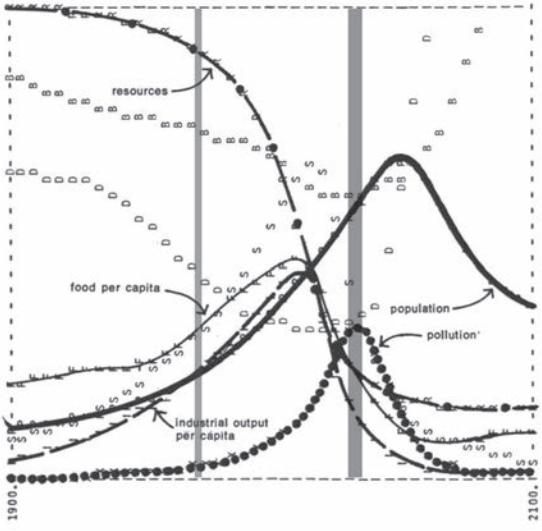


Figure 1. The World3 scenario that I consider the most useful – Figure 35 from the 1972 book.

1. Was *The Limits to Growth* right?

We presented 12 different scenarios of the way the main global factors might develop through the year 2100. Some of those scenarios showed a global society evolving sustainably towards a relatively high level of population and material consumption. Others showed population and economic growth overshooting the globe's carrying capacity before the middle of this century and then declining. The reality will lie somewhere within that range.

It is more appropriate to ask whether a model is useful than whether it is accurate. World3 remains a more useful basis for understanding global problems than the many models advanced by economists who refuted our work in the years since its first publication.

2. Why didn't you try to predict the future?

When the behavior of a system is affected only by physical forces, and the laws governing them are comprehensively and precisely understood, such as in many areas of astronomy, aspects of the future can be predicted very precisely. It is possible, for example, to predict when and where the next solar eclipse will occur to within a few seconds and meters, even centuries into the future.

However, when human free will influences the behavior of a system, influential factors are only incompletely and approximately known. Then it is not possible to predict accurately and with confidence.

This does not mean that any future is possible. Even when it is impossible to say with confidence what will occur, it is often easy to describe many futures that have no possibility whatsoever. Physical constants will not change. The laws of thermodynamics will not be repealed.

For example, if it were possible to raise the melting temperature of ice in the future, the declining extent of the glaciers could be reversed. I cannot predict precisely what policies humanity will adopt to fight climate change, nor can I predict with confidence how many glaciers will still exist in the year 2100. But I can absolutely rule out any future that assumes humanity will change the melting point of water.

3. Have advances in computers since 1972 made it possible to build better global models?

In some kinds of global analyses, for example, weather forecasting, more powerful computers have been an enormous boon. Computer simulations now permit meteorologists to make much more detailed, accurate, and extended weather forecasts than were possible 50 years ago. The advance in scientific understanding over that period was essential in making this progress, but it would not have been very useful if growing computer power had not made it possible to incorporate that new knowledge into weather-model simulations.

For other kinds of global analyses, for example, the kind presented in *The Limits to Growth*, the constraints are imposed mainly by gross deficiencies in the understanding of social behavior. Our global model was relatively simple in 1972 because scientific understanding of human behavior was relatively simple.

Because that understanding has not advanced significantly since then, hardware improvements – giving us greater memory and faster processing – have not enabled much improvement over World3. But software advances have been enormously helpful to the research process. Computer-modeling simulation languages have been made much easier to use over the past five decades. That is a benefit, but it only lets us construct and analyze models more easily and quickly. It does not alone let us make models more accurate.

4. Why did you leave the price system out of your model?

World3 did not exclude all elements of the price theory. We represented the long-term determinants of production and consumption in some detail.

When modeling the short-term dynamics of interaction between production and consumption, it is essential to include an explicit price. For example, my first book, *The Dynamics of Commodity Production Cycles*, was based on a model that incorporated precise assumptions about the causes and consequences of changes in price.

However, long-term dynamics can be understood without including price. In this century, depletion will be the dominant influence on consumption. You cannot consume something that you don't have, irrespective of its price. Depletion is a thermodynamic process. Raising the price of a depleted resource does not magically reduce its entropy or create more of it in the ground.

Price changes can often stimulate the production and use of alternatives to materials that are becoming scarce. However, World3 groups all nonrenewable resources together in a single stock. Thus, it implicitly assumes that there are infinite possibilities for substitution.

We therefore treated the energy fuels, coal, oil, and gas, as fungible with other nonrenewable resources, such as copper or phosphate. Obviously, they are not. Since infinite substitution among nonrenewable resources will not be possible in practice, the projections of our model are too optimistic.

Prices are important for understanding short-term issues, but they can be profoundly misleading in the analysis of longer-term problems. For example, the economic value of agricultural production may be increasing even while human hunger is growing. This paradox will occur when there is a shift from growing low-priced nutritional products for consumption locally to providing high-priced luxury goods for export – replacing cassava with

roses, for example. For that reason, World3 expresses food production in terms of calories, not dollars.

5. Will new technologies let us ignore the global limits?

It is misleading to speak of a single technology as a universal solution and to imagine that it arises quickly and spontaneously, has its own goals, and acts independently. On the contrary! Technology is highly specific. For example, technologies that combat a pandemic or facilitate telecommunication do not compensate for oil depletion. Technology is embedded in tools that typically are created slowly and at great cost to help their developers achieve personal, political, or corporate goals. Creating and implementing new technologies normally takes years and needs massive financial investments. Such investments will mostly be made only by those who expect to profit from them. And typically, the developers don't expect to profit by solving global problems because most people are unable, or unwilling, to pay for the solutions to global problems.

Consider a simple hammer. It is an elegant technology, but no one would suggest that it will independently solve problems. To gauge its potential, you need to know who is wielding it and for what purpose. In the hands of a fine carpenter, a hammer can facilitate the creation of beautiful, useful objects. But that same hammer in the hands of a psychopath can facilitate destruction and death. Most technologies have similar potential for good and bad. The difference lies not in the technology but in the goals of those who control it.

The motivations and the institutions that are creating new technologies generally are the same ones that have produced the existing global problems. It is naive to imagine that those institutions will suddenly start to use their new capabilities to solve the problems they have previously caused with their earlier technologies.

In fact, the technologies required to dramatically reduce global problems already exist, but the motivation to use them for that purpose does not. Without change in the institutions and motivations governing the development and use of new tools, the problems will persist, irrespective of the technologies we develop.

6. Does World3 take wars into account?

World3 incorporates no assumptions about the causes or consequences of violent conflict. We omitted war because there was no generally accepted theory about its causes. Without that consensus there was no scientific basis for incorporating warfare into the model.

Of course, there will be wars in the future, but they will not raise the limits to growth. Thus, omitting the consequences of war made our model results too optimistic.

7. How many people could the earth support?

The population that can be sustained on our planet will depend importantly on the productivity of the planet's resources and on the goals we have for the humans' condition – for their equity, liberty, health, levels of energy, and material consumption. If we are willing for a small fraction of the population to control most of the globe's wealth and to exert central control over the large fraction of humanity, who live in material poverty with poor health and little freedom, several billion people could probably survive on earth more or less indefinitely. If instead, we want the earth's peoples to live long and healthy lives with relative material affluence, good health, substantial liberty, and with equity in wellbeing and political power, the sustainable population level will certainly be far below current numbers. I intuitively believe that the planet Earth could sustainably support perhaps a billion people at living standards like those of Italy or South Korea today.

Whatever the best estimate for the sustainable population level today, it is declining rapidly as advances in technology fail to compensate for the consequences of humanity's accelerating consumption and deterioration of the earth's resources. World3 showed clearly that delaying the response to global problems leaves humanity with progressively poorer options.

8. How can the world's population be reduced?

The global population will decline whether or not we strive for that outcome. If it is not reduced through proactive social intervention, it will be reduced

through ecological forces. Deliberate action is required only if we want the decline to be peaceful, equitable, and gradual.

Any population will decline only when its death rate exceeds its birth rate. Migration may reduce population levels in some regions, but it is obviously not relevant to the entire globe.

Reducing the death rate is a universally espoused goal. Thus, the only politically realistic, proactive option for reducing the population is to reduce the birth rate by significantly lowering fertility.

Global fertility is slowly falling already. However, population is still rising and material consumption is already far above sustainable levels while the support capacity of the planet is plunging. Without an urgent effort to accelerate the decline of fertility combined with a redistribution of wealth to help the poorer populations weather the period when population overshoots and peaks, the death rate will increase in the coming decades to reestablish some sort of ecological balance.

Throughout history there have been three ways to increase the death rate – famine, pestilence, and war. Although most people do not consider any of those measures to be attractive, those are the implicit choices when vested political, economic, and religious interests successfully block any systematic effort to achieve major reductions in fertility globally.

9. Do you advocate imposing population control policies?

Some people have tried to use our report to justify such policies. We never did. Our report did not cause those efforts. Nor does it justify them.

In fact, overconsumption, not overpopulation, is the main problem. The consumption of an average person in a developed nation does much more damage to the global ecosystem than the consumption of a typical citizen in a poorer country.

Coercive policies seem to be relatively ineffective over the longer term. Our model included many influences on fertility, such as health, income level, and the availability of modern birth control measures. We found that the combination of giving women the right to control their own fertility so they can choose their desired family size with measures to raise equity, education, and material wellbeing would produce the most attractive global outcomes.

10. How can you advocate stopping growth while there is still a large gap between rich and poor?

Our analysis did not advocate that or any other policy. It merely used World3 to determine the possible long-term consequences of taking different actions.

Today's richer nations have used their political, economic, and military power to sustain their privileges. The judgment that this exploitation is unethical and unsustainable does not alter the laws that govern the globe's physical and biological processes. Like it or not, those laws suggest that the globe's population is entering a phase that will see falling population numbers and declining average material consumption. Of course, the rich and powerful will strive to maintain what they have. To the extent they succeed, the gap between rich and poor will grow even wider.

11. Why is it still possible to obtain resources that you predicted would be exhausted by the year 2000?

Our analyses of the 12 scenarios published in The Limits to Growth did not contain even one single reference to a specific mineral – much less predict its full depletion. We could not have projected anything about a specific material because World3 did not differentiate among minerals. The model's equations only defined the production and consumption of a single stock labeled Resources. And that stock does not go to zero in any of our simulations. For example, in Figure 1, the World3 model projected that the Resources stock in the year 2100 will still contain 15% of the materials that were initially available in the year 1900.

Then what is the source of the widely held assumption that we predicted the exhaustion of a specific material? It probably originated with a 1993 book, *Ecoscam*, by Ronald Bailey. In his chapter on geophysical limits, he misrepresented the data in Table 4 in our 1972 book. By ignoring 13 citations that we provided to indicate their sources, he implied the numbers were produced by World3.

They were not. The data in that table came principally from the US Geological Survey's summary of 19 important minerals and fuels. We used the data only to illustrate some important differences between the static

and the exponential reserve life indices, two different indicators of resource availability.

We explicitly stated that our illustrations did not foretell the actual exhaustion of any materials in our examples. On page 63 of our book we wrote, "Of course the actual nonrenewable resource availability in the next few decades will be determined by factors much more complicated…" On page 66 we wrote, "Given present resource consumption rates and the projected increase in those rates, the great majority of the currently important nonrenewable resources will be extremely costly 100 years from now." I still believe that will turn out to be true.

12. Will obtaining resources from the sea let us ignore depletion?

There are two relevant categories of marine-based minerals – those dissolved in sea water and those clustered in nodules on the floor of the deep sea. A few of the dissolved materials, such as salt, may be produced economically from the sea. But the vast majority of them are too dilute to serve as inputs to manufacturing. The capital and energy required to concentrate them would be more valuable than the materials they made available.

There are growing commercial efforts to obtain minerals from deep sea nodules – primarily manganese, but also nickel, cobalt, and copper. Perhaps those efforts will develop to provide significant sources of those few elements – and perhaps they will not.

Even if they are successful, no one claims that the few materials potentially available from deep-sea mining will ever be available in the quantity or the diversity required to sustain an industrial society. And the process will profoundly disturb delicate marine ecosystem environments in areas where regeneration is a very, very slow process – occurring only over centuries or millennia.

Why does the global cohort that happens to be alive today, merely one of the 15,000 generations our species has produced on this earth, implicitly believe it alone has the moral right to exhaust all the planet's high-grade energy and materials, and damage its environment, leaving less for future generations?

13. Will new energy sources let humanity cope with fossil fuel depletion?

Most of the potential new energy sources discussed today will provide only electricity. Electricity is essential, but it is a very small fraction of the total energy required to support a capital-intensive economy. An industrial society uses energy in four different forms – electricity, low-temperature heat, high-temperature heat, and transportation fuels. The latter three can be provided by electricity in limited applications. But the transition to the substitutes will be too slow, too costly, and too inefficient to sustain the present, global industrialized economy.

Plus, the so-called renewable energy sources have many serious side effects that will hinder their development. Although the "fuel" for many renewable technologies is "free," i.e., available without marginal cost, the capital required to capture, convert, and deliver the energy in those fuels is not free. Manufacturing that capital requires many scarce materials and much fossil energy. Most of the solar power sources provide only intermittent power. Thus, they must be augmented to substitute for traditional sources in an economy that requires consistency and reliability.

It is useful to search for, and implement, new sources of energy. But there is no possibility whatsoever that they will eliminate climate change or permit the globe's peoples to sustain current growth rates.

14. Why didn't you include nuclear energy as a solution?

Nuclear power offers neither a feasible nor an ethical solution to the problems we discussed in our book.

Nuclear reactors provide only 10% of electricity globally. Electricity is only a small fraction of the energy required to sustain the present civilization. After seven decades of unprecedented subsidies, political support, tolerance of their toxic wastes, and ignorance of their contribution to nuclear proliferation, nuclear reactors still provide only 4% of global energy. It is a fantasy to imagine they will ever raise the limits to growth.

The 2011 disaster at the nuclear power plant in Fukushima, Japan, was not a onetime anomaly. It was just another demonstration that complicated technologies cannot be made fail-safe. Systems created by humans cannot be

100% isolated from the consequences of human mistakes. Attractive global futures will only come with reliance on technologies that can fail safely.

In return for a minor benefit for a small population extending over a few decades, nuclear power forces humanity to deal with existential toxic waste problems that endure for centuries or millennia.

If human society would devote all the money, effort, technical expertise, and political support now sought by the nuclear power industry to develop other solutions instead, the results would be much more beneficial.

15. How do your 1972 scenarios relate to today's climate change?

Climate change was not a serious concern 50 years ago. World3 does not include any equations specifically related to that issue, and climate change was not discussed in our 1972 book. We did publish a graph showing the exponential rise of CO_2 in the atmosphere from 1860 through 1970. We wrote "this increase in atmospheric CO_2 will eventually cease, one hopes before it has had any measurable ecological or climatological effect." I believe that was the only reference to climate change in our first report.

Subsequent editions of our book did pay more attention to climate change as evidence for it mounted and scientific understanding of it grew. But we did not decide it was necessary to change any structural assumptions in the model for subsequent editions of our book, because we concluded that climate change would not raise the limits to growth. Instead, it will prevent the rapid recovery of population and economy after their peak in the coming decades.

Climate change is one of the main existential threats to industrial society on this planet. Magically eliminating it somehow would still leave other grave problems, such as how to arrest soil erosion and peacefully evolve away from the profound dependence on fossil fuels. But there is no miraculous way to avoid the profound disruptions in the coming decades and centuries as a consequence of climate change.

Climate disruption was triggered by exponential growth in society's combustion of fossil fuels. But even magically stopping all CO_2 emissions today would still leave humanity to cope with centuries or millennia of climate change, because past greenhouse gas emissions will affect the ecosystem for centuries, and climate change is being driven increasingly by its own internal dynamics.

The heat content of the planet's atmosphere has risen high enough to activate more and more of the climate system's positive feedback loops, such as melting of reflective ice cover and release of methane from the tundra. Climate change dynamics are thus driven less and less by human actions and increasingly by the reinforcing mechanisms within the biophysical environment of the planet.

Humanity suddenly cares about climate change, but climate change does not care about humanity. During its roughly 300,000 years on this planet, Homo sapiens has adapted numerous times to climates drastically different from the one society enjoys today. Therefore, I do not expect that climate change will eliminate our species from the planet. But climate change definitely will destroy the foundations for a high-population, fossil energy-intensive, high-material-standard society.

16. What is the most important problem we face today?

Many issues that are termed problems, such as climate change, extinction of species, and growing levels of plastic waste, are actually symptoms. Much as a headache can be a signal of cancer, many difficulties today are symptoms of material consumption levels that have grown beyond the planet's sustainable limits. A painkiller may make the patient feel better temporarily, but the underlying problem will not be solved without stopping the uncontrolled growth of cancer cells in the body. The amelioration of climate change, soil erosion, or pollution similarly may make people feel better temporarily, but humanity will face existential problems until the causes of uncontrolled growth in population and material consumption are eliminated.

17. Do you advocate a different form of government?

All contemporary political systems are failing to cope effectively with long-term global problems, such as rising persistent pollution, growing economic inequality, the spread of nuclear weapons, and climate change. This is not a failing unique to the democracies. Acknowledging this general failure simply recognizes reality; it does not imply a personal preference for one form of governance over another.

Human groups have employed many different forms of governance during the several hundred thousand years our species has lived on this planet – monarchy, democracy, oligarchy, theocracy, aristocracy, and numerous others.

Any of these different governance systems can potentially guide humanity to a more sustainable future if it reflects a concern for equity, environment, resilience, and welfare, and if it considers impacts that are distant in time and space to be as important as those that are proximate. No governance system will produce an attractive future if it reflects the opposites.

Sustainable governance requires institutions and a culture that have the ability to choose and sustain short-term sacrifices in order to secure long-term gains. So far, none of the present national governance systems have shown much proclivity for inducing their citizens to make short-term sacrifices for the long-term welfare of others.

Decline of our species is inevitable without an expansion of people's boundaries of concern – the span of time and space within which they compare the perceived costs and benefits of the alternatives they are considering.

Many problems have an inherent inertia that causes them to unfold over decades, centuries, or longer. And policies enacted in one place often have consequences far away. Measures that make those problems appear less serious in the short term and locally typically will make them more serious in the long term and far away.

Embedded in political, economic, and cultural systems are many mechanisms that favor the short term over the long term – frequent elections, daily stock market reports, investor preferences for short payback periods, and the brief attention spans of the media.

So long as such mechanisms prevail and policies are evaluated only by their immediate and local consequences, there will be no possibility of avoiding the negative consequences of limits to growth.

I am happy that I had the luck to grow up in a relatively liberal, equitable, and uncorrupt democracy. It offered me many advantages, but a sustainably healthy planet was not among them.

18. What is the biggest threat from declining growth?

The biggest threat from declining growth will be to our social fabric. Faith in the inevitability of growth – more for everyone – has been the single largest

contributor to the social cohesion necessary for effective governance. In a system where every participant expects eventually to have more, it is possible to reach a consensus even for actions that some expect will give them less in the short term. But when everyone understands that growth is no longer possible, when life becomes obviously a zero-sum game – if one gets more, another must get less – then consensus will disappear. No governance system will be able to make the necessary changes because those who expect to get less will block action.

19. What was the study's biggest success?

Clearly, our report did not make any discernible change in the policies of the world's leaders. Today, all national governments still instinctively seek to solve all their problems by promoting growth.

But our report did influence the thinking of many individuals. People have often told me that reading *The Limits to Growth* dramatically influenced their understanding of global issues and, in many cases, changed the course of their education and career.

The greatest accomplishment of our Club of Rome project is the thousands of people around the world who now deal with their day-to-day personal and professional challenges from the perspective that physical growth cannot, and will not, continue on a finite planet and that resilience, not growth, is the ultimate goal.

4

Crisis as a transition. What was, what will be.

Sviatoslav Zabelin

Coordinator, Socio-ecological union international

The Russian translation of *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*[1] wasn't published until 1991. It was only by the mid-1990s that I began to understand that the economic processes of reaching the limits of global economic growth with an inevitable collapse at the end, as described in the book, and the processes preceding the economic and political collapse of the Union of Soviet Socialist Republics (USSR), are extremely similar. This allowed me to formulate and publish[2] the hypothesis that the socio-economic system of the USSR collapsed because it reached the limits of growth in many key parameters at once, and not as a result of the political loss of competition with the capitalist countries, as was widely presented. Politicians and economists misunderstood the crisis of the USSR as the defeat of one management system (socialism) in competition with another management system (capitalism). In fact, it was a defeat of the method of managing nature (including the use of human resources) inherent in our entire civilization.

In a certain sense, the USSR's system has not lagged behind, but has overtaken the so-called civilized world, being the first industrially developed country to survive the crisis of the limits of growth predicted by the experts of the Club of Rome.

What happened to the USSR in the 1980s and 1990s, with its economy, population, and power system, is the result of the combination of several crises of growth limits in a system significantly isolated from the world economy, which was the USSR. And the relative softness of the crisis is explained by the fact that, due to the end of the Cold War, Russia and other post-Soviet countries become part of the global economic system, which, one way or another, took some of their problems on itself.

First, it was a crisis of the limits of the growth of the price that society can pay for the withdrawal of natural resources. The industry of the USSR "broke down" on oil production in the Siberian fields, the export of which let the country survive in the era of stagnation. In the 1980s, production volumes and proven oil reserves began to decline catastrophically and attempts to maintain the level achieved inevitably led to a flow of investments into raw-material industries, which led to the degradation of processing industries. To date, Russia remains a country with a predominantly raw-material economy.

Second, it was a crisis of the limits of the growth of the money supply, a crisis of the limits of the growth of hidden inflation in a closed financial system. In the USSR, the money-printing press worked nonstop to pay for a huge mass of deadened labor: to produce a giant number of weapons that were not sold to anyone, for digging canals that never paid off, for the construction of hydroelectric reservoirs on the site of fertile pastures and arable land, etc.

By the end of 1991, it turned out that they had printed several thousand times more than they "needed". And in 1992, when this money bubble burst, the country found itself without money, in debt, and every citizen of it without the savings they had accumulated over their lives.

Third, it was a crisis of the limits of the growth of environmental pollution in relation to the ability of the human population to tolerate it, expressed in a catastrophic decrease in the immune status of the population, a catastrophic increase in the morbidity of newborn children, a decrease in life expectancy, an increase in mortality, and a reduction in the number of Russians.

The crisis caused by the location of industrial enterprises in cities, deepened by the Chernobyl disaster, was intensified by the large-scale and stupid chemicalization of agriculture and many other decisions of the Soviet government.

Fourth, it was a crisis of the limits of the growth of the complexity of the managed system in relation to the control system. The Soviet system of governance was an extreme expression in the twentieth century of a strictly hierarchical system of governance of society as a whole, a system of

governance where, in the end, the final decision depends on the ability of one person – the General Secretary of the Communist Party – to choose the best option from the many offered.

The listed crises are real and, from my point of view, obvious and understandable. All the causes of these crises, which led to the catastrophe of the USSR's system, continue to operate in the global socio-economic system, causing its inevitable collapse.

According to the most likely scenario calculated using the World3 model based on statistical economic data for 2018,[3] a global collapse should occur in the decade of the 2020s. It is possible that events related to the Covid-19 pandemic will bring it closer. In recent years, the expert community has been actively discussing the likely beginning of the global economic crisis in 2020–21. Imbalances in the global economy increase the probability of a global crisis. In late 2019–early 2020, the concern of experts, and the world community as a whole, about climate change and environmental degradation has sharply increased. There was a strong belief that the failure to confront these problems would eventually trigger a global crisis. However, these factors did not trigger the global crisis. In the early spring of 2020, it became obvious that the cause or "black swan" of the new crisis is the Covid-19 pandemic.[4]

The hypothesis that the collapse of the USSR was caused by reaching growth limits, allowed us, based on observations of post-crisis events in the territory of the former USSR, to predict the main events that will be characteristic of the post-crisis period in the global space.[5]

The self-destruction of the USSR system was mainly expressed in the loss of the integrity and coherence of the system, in place of which the sum of economic, social, etc., subjects remained, having lost almost the entire complex of habitual connections.

Post-crisis events in the economy of the Newly Independent States allow us to predict a deep deglobalization of the economy – a significant weakening of the world market as a phenomenon, the rapid restoration and strengthening of all interstate borders and barriers, the restoration of full sovereignty of state structures over legally owned territories, that is, the reverse disintegration of the world into many closed state economic systems with varying degrees of self-sufficiency.

In 2021, the media is full of reports about the deepening confrontation between the leading powers (United States, China, and Russia), their accelerating militarization, and the exchange of trade and economic sanctions imposed for political and geopolitical reasons. The development of this scenario is also being discussed in the scientific community.[6] In this regard,

we observe a significant weakening of international law, and with it the authority of all international bodies, starting with the UN. This is perfectly illustrated by the policy of governments around the world in relation to the Paris Agreement on Climate Change: no one fulfills their own obligations.[7]

Justifying the crisis situation, the state authorities of most countries will be freed from all obligations for the social protection of citizens, environmental protection, education, science, and health, which were "attached" to it in the last 100 years, focusing on strengthening and improving law enforcement and police structures.

A good example is the draft budget of the Russian Federation for 2022 submitted to the State Duma in September 2021. Despite the ongoing pandemic, it was decided to cut the financing of the healthcare system by 117 billion rubles, about 9%. In total, the budget will "save" 640 billion rubles on medicine, the economy, and social support of citizens, and the government plans to allocate almost the entire amount to a record increase in funding for law enforcement agencies since 2012. Expenditures under the article "national security and law enforcement" in the 2022 budget are increasing from 2.384 to 2.799 trillion rubles, that is, by 17% at once, which the budget has not seen for almost ten years. Allocations for "national defense" are growing by 129 billion rubles, to 3.51 trillion.

A similar example is the decision of US President Joe Biden to reduce the costs of the "social" bill, which became the cornerstone of his first-term program. As a result, the $3.5 trillion that the Democrats were aiming for from the very beginning may turn into $1.9 trillion or even $1.75 trillion – not only ordinary Americans, but the environment will also be short of money. The bill will have everything: paid sick leave, payments for children, and subsidies to reduce rent payments for tenants. Only there will be less of everything – children's payments will be planned not for three years, but for one, sick leave can be taken only for four weeks a year, and not for 12, as planned at first, and subsidies will be significantly less than expected. Most likely, a program involving incentive payments to energy generating companies switching to environmentally friendly energy sources and fines for fans of "dirty" energy will go under the knife.[8,9,10]

Such a transformation, as a natural (and not a reasonable) rational response to the crisis, will be silently accepted by the population of many of the most "democratic" countries, in connection with which civil society and the rule of law will probably have to be forgotten.

The history of Soviet society, objectively the most educated society on earth in the twentieth century, demonstrates the lack of the ability to realize

the reality of what is happening, the ability to adequately, that is, scientifically, analyze the crisis that occurred and propose a meaningful program for overcoming the crisis. The rest of the world is also showing a little wisdom, not even trying to analyze the systemic crisis that began in 2008 as a crisis of the limits of growth. The result of attempts to "treat" this crisis with the old methods was that "for hundreds of millions of people in the world, the way out of the crisis of 2008 has been a tragedy, silent and bloodless but still a tragedy. It has completed a shift in their perspectives: the future of their children will be worse than their own, and now the children are aware of this reality as well. And we are still stuck in the same thinking which led us to the crash of 2008."[11]

In 2021, humanity found itself under the influence of the synergy of three crises. The environmental crisis has moved into an acute, i.e., palpable by most people, phase in the form of the Covid-19 pandemic. According to most environmental scientists, the main cause of the pandemic was "crossing the red line" of invasion and destruction of natural ecosystems. The climate crisis has also begun to be felt by the world community, and the destruction of natural ecosystems that regulated the composition of the atmosphere, enhanced by anthropogenic greenhouse gas emissions, is also its main cause. The economic crisis is a crisis of the limits of growth, predicted by the experts of the Club of Rome back in 1972.

Since no concerted actions are being taken to prevent or mitigate the consequences of these crises, it can be argued that the further development of the global system will take place according to the "business as usual" (BAU) scenario, and not "business as usual 2" (BAU2),[3] i.e., the worst possible.

There are no hopes for active government actions (I assume that the results of COP 26 in Glasgow will demonstrate this), so the inhabitants of the planet will have to cope with crises on their own. Right now there are three areas of real work, the implementation of which can mitigate the systemic crisis:

1. Explain that there is a global crisis ahead, and not a smooth movement by the governments of the whole earth towards the Sustainable Development Goals. This will reduce the level of stress, the level of morbidity and mortality provoked by it, and mitigate (prevent) many other negative phenomena experienced in practice by residents of the post-Soviet space.

2. To create economic systems of collective self-organization, one example of which may be the Mondragon cooperatives federation.[12]
3. To protect existing, and promote the restoration of, natural communities as the only guarantee of mitigation of the climate catastrophe, as formulated in the Kew declaration on restoration for biodiversity, carbon capture, and livelihoods.[13]

And to unite-unite-unite with everyone for this work, for the implementation of these activities.

In the long term, the crisis marks a change in the civilizational paradigm, to which the new report of the Club of Rome[11] is devoted. From my point of view, this will be a transition from a society based primarily on the handling of matter (consumption of matter and energy) with little attention to the production of information, to a society based primarily on the handling of information, with secondary attention to the material component.

In today's society, the goal of life and the measure of success is material wealth. The accumulation of things and money for an individual and his family is socially prestigious, and the results are inherited. It follows from this that:

- environment, nature, and people – consumable resources,
- production capacity and money, their quantity and growth – inherited accumulated capital,
- things (from shoes to yachts) are symbolic signs of success.

In the desired information society of the future, the goal and measure of success is the intellectual and personal level or quality of development, which are not inherited. It follows from this that:

- means of production and money – used (expended) resources,
- the surrounding nature and people are capital, objects of concern for their quality, and conditions for their own development: from the society of neighbors and the local forest to humanity and the biosphere,
- knowledge, skills, social relations are signs of success.

5

50 years after *The Limits to Growth*

Dr Ernst von Weizsäcker

Honorary President, the Club of Rome

Aurelio Peccei had the right instinct

In the late 1960s, I heard about the Italian industrialist Aurelio Peccei. Rumours went around that he was promoting thoughts about "the predicament of mankind". That sounded a little alarming. And it was.

Aurelio Peccei was deeply concerned about the sudden wave of protests worldwide, and he felt the protests were somehow justified because the future for the young generation could indeed be quite grim. In the year 1968, wild and partly revolutionary movements occurred in about two dozen countries around the world. Often it was students – at Berkeley, Paris, Warsaw, Prague, Belgrade, Stockholm, Mexico City, Rome, and Berlin, to name a few. But in many countries, the student uprisings were supported, in some cases overshadowed, by other movements, such as, in the USA, the civil rights movement, the Black Panthers, and the protest against the Vietnam War; in Poland, Czechoslovakia, and Yugoslavia the anti-Soviet movements; and worldwide various anti-capitalist movements. Also, air and water pollution became a public concern in the centres of heavy industry.

Several other thinkers and movers around the world joined with Peccei in such concerns. A common feeling emerged among the Rome group that

physical and economic limits could lie behind the widespread unrest. Another common view was seemingly shared, namely that rational research and analysis could help clarify what the predicament of mankind could be. Aurelio Peccei finally, in the spring of 1968, arranged a formal conference at a prestigious venue, the Accademia Nazionale dei Lincei in Rome, in the Palazzo Corsini.

The story goes that Peccei was not satisfied with the results of the conference. He was impatient and afterwards sat with five other group members: Alexander King (OECD Science director), Hugo Thiemann (head of Battelle, Switzerland), Max Kohnstamm (Dutch diplomat and historian), Jean Saint-Geours (Director General of Crédit Lyonnais), and Erich Jantsch (an inspiring systems thinker from Austria and California). During these informal chats, someone suggested they adopt the name of The Club of Rome for the group. The idea was applauded and accepted.

At a somewhat later meeting, two other group members were present discussing the "predicament of mankind": Professor Jay Forrester of the Massachusetts Institute of Technology (MIT), and Professor Eduard Pestel from Hannover, Germany. The two were pioneers of mathematical systems theory. They felt it was time to analyse the "predicament" challenge by using modern systems theory and modelling. Pestel, who was also associated with the Volkswagen foundation offered to help finance a project with this ambition, and Forrester said he would volunteer to get a team together to develop some kind of model of the world that would allow the Club of Rome to make solid predictions for the said predicament.

Jay Forrester got that team together, consisting of Dennis Meadows and his wife Donella Meadows, Jorgen Randers, a Norwegian graduate student, and William Behrens III.

As we all know, that team was fantastic, and the first models became the topic of the day in intellectual circles worldwide. The brilliant young Dutch journalist Wouter van Dieren made it an exciting "game" for his international readers to speculate and guess what that mysterious Club of Rome was cooking and what the results could be. This huge prepublication excitement greatly helped make *The Limits to Growth* an instant bestseller after publication. Translations were quickly made into all relevant languages. All in all, some three million copies were sold. Intellectuals worldwide would look foolish if they hadn't read the book.

The basic message of *The Limits to Growth* (*LtG*) was, and remains, absolutely important and trustworthy: A limited planet cannot support eternal growth. So, intellectuals, journalists, and finally some politicians

were grateful to the Club of Rome for having the courage to tell an unpleasant truth.

In short, Aurelio Peccei had the right instinct, and the group he attracted was just the right people to produce something that became the talk of the town.

Because the message was so important and convincing, hundreds of teams and institutions were established in almost all countries of the world, trying to build on the *LtG* message, to specify the challenge for their local audience, for appropriate technologies reducing the dangers, for reducing unnecessary consumption, for supporting birth rate reduction, etc. The Club of Rome, *because* of its success, swiftly lost its uniqueness as the prophet for the predicament of humankind.

Over-simplistic model for a great message

The powerful message of *LtG* was, in effect, based on a very simplistic model. The advantage was that the model was suitable for computers producing striking results in a very short time. Systems theory was tremendously fashionable at the time, engendering high credibility. The concrete model was proposed by Dennis Meadows, who called it the World3 model; public reference often called it the MIT model. It simply said:

- Take five parameters: human population, food per person, industrial output per person, exploitable natural resources, and pollution;
- Empirically establish the absolute numbers of the five parameters at time zero;
- Use empirical facts to establish the mutual relations between each of the five parameters; and
- Let the computer calculate the future.

Bang! It worked.

Funny effects occur, most of them plausible, however. Industrial output per person and food per person will shrink when population increases; fortunately, in the past, industrial output grew somewhat faster than population, so that the model allowed industrial output per person to increase despite some population growth. But according to World3, when natural resources begin to dwindle, industrial output is negatively affected. Pollution, as empirical evidence from the 1960s has shown, is increasingly in parallel

with industrial production. Also, population growth increases pollution. Pollution, on the other hand, damages food production. Moreover, as natural resources dwindle, food production will suffer. Small wonder that the model shows the food per person parameter as the first production factor getting weaker, shortly after the year 2000. Again, that's plausible.

Natural resources were assumed in the model never to be replenished, meaning they would shrink and shrink. In terms of geology, that assumption is correct. But in terms of practical availability of natural resources it was proven wrong a few years later. The oil crisis of 1973 quadrupled oil prices, and the oil cartel (OPEC) made it lucrative and necessary to explore and drill oil reserves unknown in 1972. In later decades, "fracking" came up, raising the known oil reserves further. Similar developments occurred with metals. Indium, for example, is a rare and silvery metal useful for many technological applications. It used to be produced only as a by-product from zinc mining, but with its elevated price, mining companies turned to indium mining in its own right.

The "shrink" message was actually the chief cause of widespread alarm in the early years of *LtG*. The authors, and the Club of Rome in general, responded correctly saying that the model allowed for quite different initial conditions and mathematical relations between the parameters. One of the most obvious options for a stable future world was reducing population growth and even stabilizing or shrinking population. Correct, but not plausible that it would happen.

"Correct but not plausible it would happen" must be said about nearly all other options proposed in the *LtG* for stabilizing the world system. Why that? Because growth was more or less the chief indicator of happiness and, indeed, for economic and political success.

Early Critique

Small wonder that commentators from the mainstream public began to criticise the Club of Rome, and the World3 model. The main critique was that the model aired "Malthusian" pessimism, and was mathematically too static. It did not include improvements resulting from the ingenuity of humans. Pollution control, for example, was the trend of the day anyway, beginning a few years before the publication of *LtG*. Pollution control legislation in Japan, the USA, and western European countries swiftly led to the situation where industrial output per person was accompanied by less, not more pollution.

Some academic critics immediately called *LtG* "doomsday literature". Remarkably fast, the Editor-in-Chief of Nature, John Maddox, a guru at the time for all matters of technological progress, published *The Doomsday Syndrome*,[1] castigating the Club of Rome and its flimsy model. H.S.D. Cole and Christopher Freeman went into more detail, exposing lots of exaggerations, simplifications, and guesswork in their book *Models of Doom*.[2]

From a different angle, the *LtG* book came under severe critique in Latin America. The prestigious Bariloche Foundation got a team together, headed by Amílcar Herrera and Hugo Scolnik, with a mandate to establish a Latin American World Model (LAWM). The basic message of LAWM was that to avoid the catastrophic trend, the world economic system had to be changed, allowing developing countries to prosper and induce the rich countries to reduce their over-consumption.[3]

Anyway, *LtG* was heavily criticised for its Northern bias, chiefly by politicians and writers from developing countries. But also in the North, the business world and neoliberal politicians heavily attacked the Club of Rome and its famous book. For US President Ronald Reagan, optimism was a prerequisite for being a good patriot. And with explicit reference to the Club of Rome, he declared that "There are no such things as limits to growth".[4] And for such statements, he became extremely popular in his country.

Long before Ronald Reagan's statement, what affected the sentiments of the public was the oil crisis's shock-like beginning in November 1973. The oil-exporting countries (OPEC) decided to elevate the price of crude oil fourfold in a unilateral move with no announcement. The decision was also meant as some kind of revenge against the countries supporting Israel during the short Yom Kippur war in 1973. As a result of the oil shock, unemployment soared, and the Keynesian recipe of deficit spending simply didn't work. "Stagflation" became the new dirty word: stagnant economies and endless inflation.

Well, the Club of Rome had absolutely no intention of engaging in the Near East conflicts, but it was tempting for some Western media to blame OPEC anyway and to suggest a connection between the *LtG* message and the OPEC action.

In any case, the early glory of the Club of Rome faded away during the late 1970s and the 1980s. Even the excellent updates of the *LtG* book, while overcoming earlier weaknesses, couldn't change the world trend of further growth, in the case of China even more accelerated growth. The world population grew ever further; in the year 2020 it was double that of 1972. Per capita consumption increased even faster, notably in China, and was celebrated everywhere as the great political success.

Factor Four

Fully acknowledging the growth desires of the global South, two Northern think tanks, the Wuppertal Institute and the Rocky Mountain Institute (RMI) of Snowmass, Colorado, joined in exploring the possibility of massively increasing wealth while simultaneously reducing the consumption of the planet's resources. In 1994, the Club of Rome arranged a conference in Bonn, Germany, in the presence of Ricardo Díez Hochleitner, then President of the Club of Rome. Amory Lovins and Hunter Lovins leaders of the RMI, and Ernst von Weizsäcker, head of the Wuppertal Institute, presented a draft of a new book proving that *a doubling of wealth could come together with a reduction in half of the resource consumption*, an extremely surprising proposal at the time.

After a stringent academic discussion during the conference and some written correspondence afterwards, the improved manuscript was accepted as a Report to the Club of Rome and was published – with some rather technical delays – under the title *Factor Four*.[5]

Clearly, that *factor four*, if achieved, also contradicted the World3 model because the model assumed that the growth of wealth was firmly coupled with resource shrinking. Alas, the World3 model stayed right and the decoupling of wealth from resource use never happened. The reason was essentially the Jevons paradox: improved efficiency was almost automatically "eaten up" by an additional increase of consumption. And countries North and South were only too happy getting more economic growth rather than reducing resource use. The logic of the Jevons paradox is that efficiency increases offer more financial room for added consumption elsewhere. Ordinary people and business and the state just love the increase of consumption. The World3 model correctly assumed that simply, people always consider increasing consumption to be better than saving natural resources.

Nevertheless, the promise of Factor Four technologies was also correct. They were available, but their commercial success was poor for the simple reason that energy prices remained low, while introducing new technologies remained a major cost factor. One exception was the success of LED lamps replacing conventional incandescent lightbulbs. They combined a tenfold increase of efficiency with longevity and reliable bright light. But the effect of the LED was essentially a lot more light, not less energy consumption.

Come on! We have to address the whole range of the limits challenge

All this unpleasant development does in no way diminish the importance of the *LtG* message. It is simply true that the conventional economic growth comes with high environmental cost. Climate change received little attention in 1972 but became the most prominent environmental challenge from the 1990s. Similarly, the loss of biological species, an old concern since the 19th century, became a major political issue during the "Earth Summit" of 1992 in Rio de Janeiro. Two international conventions were adopted at the Earth Summit, the Frame Convention on Climate Change (FCCC), and the Convention on Biological Diversity (CBD).

The new narrative of *LtG* invariably contains the assertion that the World3 model has got it right, notably with regard to pollution. That is mathematically nearly correct if you replace the local air pollution of 1972 by greenhouse gas emissions. The study by Graham Turner is often quoted for that purpose.[6] But replacing local pollution by greenhouse gas emissions is evidently wrong in terms of chemistry.

The relevance of the Club of Rome cannot be maintained by specific, and in some cases faulty assertions made in 1972. The relevance must be based on facts of today and by naming and discussing today's complex system of the most relevant challenges. However, for all such challenges, the world now has specific and well-financed organizations such as the Intergovernmental Panel on Climate Change (IPCC). As said before, the Club of Rome had a glorious start being the singular voice writing about the "predicament of mankind" and the limits to growth. But in its wake, hundreds of other organizations "stole" that singular advantage.

A fresh approach could be taken by a new report addressing the broad range of mutually related challenges of an overcrowded planet and by outlining strategies for restabilizing the planet. That was the intention started in 2015 by a broad discussion among all interested Club of Rome members. It eventually led to a rather comprehensive report co-authored by 40 contributors, 35 of them members of the Club of Rome. This report was meant to become a Report *by* the Club of Rome, and an 80% majority of voting members agreed on this unusual format. However, one member firmly insisted that the Club, as such, can never publish a report, unless there is a vote and a 100% agreement on the text.

To avoid a clash on that rather formalistic matter, we fell back on the

conventional format of Report *to* the Club of Rome, with the then acting co-presidents as co-authors. The report, called *Come On!* was published in 2018, also celebrating the 50th anniversary of the existence of the Club of Rome.[7]

The report had its "limits" discussion based less on the World3 model but more on the concept of planetary boundaries proposed by Johan Rockström and co-authors.[8] It needed a clear focus on the complex mutual relations of challenges, including world population, the assumed turmoil resulting from global warming, the dramatic loss of biodiversity, the dangers of extremely powerful financial markets preferring high returns on investments over stabilizing the planet, the need for fair distribution of wealth, geographically and socially, and technologies that could be helpful diminishing the threats.

In the end, authors agreed that the philosophical foundations of human thinking must be adapted to the enormous challenges. That means that the dominance of a rather short-sighted materialistic and utilitarian thinking must be overcome. The centrepiece of the book had the title "C'mon! Don't stick to outdated philosophies!"

But then comes the third chapter entitled "Come on! Join us on an exciting journey towards a sustainable world". It contains mutually compatible proposals on climate, energy, agriculture, regenerative urbanization, circular economy, reform of the financial markets, reform of economic theory, new measures of wellbeing – replacing the GDP dogma, global governance, and appropriate education.

After 2018, a new agenda of the Club of Rome was formulated consistent with the "Come On" philosophy but identifying five relevant "hubs" of new action for the Club of Rome, namely Climate-Planetary Emergency, Rethinking Finance, Reclaiming & Reframing Economics, Emerging New Civilisation(s), and Youth & Intergenerational Dialogues. This new programmatic agenda has been successful in enabling new perspectives, capacities and partnerships towards transformative thinking and action. The contributions of the co-presidents, Sandrine Dixson-Declève and Mamphela Ramphele, in this book show well the substance of what is now envisioned and catalysed by the Club of Rome. Beyond the description of the challenges in the wake of the work done in *The Limits to Growth*, the task now is different. The aim is to effectively contribute to the development of civilization in a direction where social and geographical justice make it politically feasible to concentrate on solutions overcoming the dangers we face.

6

From limits to growth to planetary boundaries

Gianfranco Bologna

Honorary President, Scientific Community WWF Italy[1]

In March 1972, the Club of Rome presented its first report, *The Limits to Growth*[2] (*LtG*), produced by the System Dynamics Group of MIT. In June of the same year, the first world conference dedicated to the environment took place in Stockholm – the United Nations Conference on the Human Environment,[3] which adopted a specific Action Plan, and decided to establish UNEP (the United Nations Environment Programme). NASA launched Landsat 1 in July that year.[4] It was the first satellite dedicated to monitoring our planet. Also in 1972, *The Ecologist* magazine published the report *Blueprint for Survival*. "Radical change is both necessary and inevitable because the present increases in human numbers and per capita consumption, by disrupting ecosystems and depleting resources, are undermining the very foundations of survival," wrote the founder and director of the magazine, Edward Goldsmith, along with Robert Allen and a team of colleagues.

Since its inception in 1968, the Club of Rome has decisively focused on a very clear message for the future of humanity, which has developed into a good definition of sustainability: it is not possible for humanity to pursue unlimited material and quantitative growth in a world with clear biophysical limits.

Only One Earth[5] – the aptly titled book by the economist Barbara Ward (Lady Jackson) and microbiologist René Dubos – was published on the

occasion of the UN conference in Stockholm. It is an eloquent summary of a report commissioned by the Secretary General of the Conference on the Human Environment, the Canadian, Maurice Strong. He asked a group of internationally recognized experts and strategic thinkers to analyze existing knowledge of, and provide their views on, the state of relations between humans and our natural environment in an era – the early 1970s – in which human activities had already caused profound and often very visible effects on the state of health of the planetary environment. Along with René Dubos, there were several members of the Club of Rome among these experts – Aurelio Peccei from Italy, Saburō Ōkita from Japan, Víctor Urquidi from Mexico, and Carroll Wilson from the USA. There were also other important international figures, who later became members of the Club of Rome, such as Jermen Gvishiani from Russia, Aklilu Lemma, the Ethiopian editor of a report for the Club of Rome in 1989, Thor Heyerdahl from Norway, Soedjatmoko from Indonesia, and Jan Tinbergen from the Netherlands, who won the Nobel Memorial Prize for Economic Sciences in 1969[6] and subsequently edited the report to the Club of Rome on *Reshaping the International Order*.[7]

When *The Limits to Growth* report was drawn up, scientific knowledge of the global environmental situation was certainly not comparable to what we have now. International scientific research bodies began to be formed in the 1970s to gain a deeper understanding of the state of the health of natural systems and the fundamental biogeochemical cycles of the earth (although even in the years before this, some initiatives and organizations had begun to investigate these issues in greater depth). The *LtG* authors could cite only a sparse bibliography, but this included two important volumes written by two renowned ecologists, Paul and Anne Ehrlich, and by the well-known energy expert John Holdren.[8] All three have produced crucial scientific research and books of considerable importance during their subsequent careers. In 1971, Paul Ehrlich and John Holdren had published an important paper that appeared in *Science*[9] in which they indicated the equation I=PAT. The equation reflects the truism that the impact (I) of a human society on its environment can be viewed as the product of its population size (P), its level of affluence (A) as measured by its per capita consumption, and "technology" (T), a factor considering not only the technologies used to service the consumption (e.g., bikes vs. automobiles), but also the political, social, and economic arrangements (such as environmentally perverse subsidies) involved.

Following the publication of *LtG*, scientific knowledge has been extraordinarily enriched, in general, and with the innovative perspective of Earth system science. Several scientists from various disciplines have understood

the need to analyze the physical, chemical, and geological dimensions of our earth, taking into account how much these have structured the biosphere, which, with its living organisms – from remarkable bacteria and archaea to plants and animals – has, in turn, influenced many of the geological, chemical, and physical characteristics of the planet itself. This is the perspective of Earth system science in its entirety and interconnection, where the atmosphere, oceans, hydrosphere, geosphere, and biosphere continuously interact and influence one another. A special report by the US National Research Council and NASA in 1986, coordinated by meteorologist Francis Bretherton, defines the objective of Earth system science as follows: "to obtain scientific understanding of the entire Earth system on a global scale by describing how its component parts and their interactions have evolved, how they function, and how they may expect to continue to evolve on all timescales."[10]

Thus, we have a vision of nature as made up of complex chains of cause and effect, feedback, and continuous interconnections that had extraordinary pioneers such as James Hutton (1726–1797), Alexander von Humboldt (1769–1859) and Vladimir Vernadsky (1863–1945). Today, this vision has been considerably refined, becoming an essential basis for implementing sustainability and in which key figures from the Club of Rome have also played an important role.

The mid-20th century was marked by an international cooperative scientific effort – the International Geophysical Year (IGY, 1957–1958). Commissioned by the International Council for Scientific Unions (ICSU), which became the International Science Council (ISC)[11] in 2018, the IGY saw scientists from 67 countries collaborate on research towards the greater integration of disciplines such as glaciology, oceanography, and meteorology. This research has contributed to a better understanding of how our planet works, linking interpretative and qualitative analyses based on observations collected in the field, supporting them with advanced instrumentation, continuous and quantitative monitoring of numerous variables, and the use of numerical models. These advances have led to the better structuring of modern climatology and research fields dedicated to various aspects of planetary geophysical dynamics, such as plate tectonics.

The success of the International Geophysical Year led to the launch of the International Biological Program (IBP) in 1964 (lasting until 1974), which coordinated large-scale ecological and environmental studies to better understand the effects of human pressure on the environment. Conrad Hal Waddington (1905–1975), a leading English scientist specializing in a wide

range of disciplines, was the leader of the program in the first years of its activity. He was also a member of the Club of Rome.

In 1969, SCOPE (the Scientific Committee on Problems of the Environment)[12] was founded, a non-governmental scientific organization aimed at identifying and analyzing the emerging causes of impacts on humans and the environment. SCOPE has produced authoritative, influential, and independent assessments on various issues, such as environmental risk, ecotoxicological problems, the biogeochemical cycles of the most important elements, global climate change, sustainable development indicators, the state of biodiversity, the role of invasive species, and the environmental impacts of the civilian and military use of nuclear energy.

Knowledge of the Global Environmental Change (GEC) caused by human intervention began to increase in the international scientific community between the 1950s and 60s, and to gain strength between the 1970s and 80s.

The work of two great scientists has come to exemplify this advance in our understanding of the extraordinary planetary dimension of the crisis of our relationship with natural systems. In 1957, the American Roger Revelle (1909–1991), oceanographer and precursor of Earth system science, and the Austrian Hans Suess (1909–1993), geologist and paleontologist, wrote about the increase in carbon dioxide in the chemical composition of the atmosphere.[13] The awareness of a pervasive and global effect of human pressure on the great cycles of nature became increasingly evident in the eyes of the two great scientists, whose statement has remained famous: "Human beings are now carrying out a large-scale geophysical experiment of a kind that could not have happened in the past…" Just two years earlier, in 1955, a major international conference in Princeton saw about 70 distinguished scientists and scholars of natural and social sciences investigating the role of the human species in the modification of our planet. The reports and discussions presented there were published – 1,200 pages[14] – documenting one of the first interdisciplinary panels of scientists questioning the environmental problems caused by human development.

In 1957–58, the scientist Charles Keeling (1928–2005) founded the first carbon dioxide detection station at Mauna Loa in Hawaii. In the decades since its foundation, the images of the iconic Keeling curve illustrating the increase in the concentration of carbon dioxide in the chemical composition of the atmosphere have become a clear symbol of the human impact on the earth's system and the role we have played in bringing about climate change.[15]

In the late 1950s, the significance of our negative impact on the environment became increasingly clear. It is no coincidence that the scientists of the

Earth System identify, based on their data,[16] 1950 as the starting point for the phenomenon called the Great Acceleration. Our world today is the result of this extraordinary and continuous escalation in the number of human beings, energy and water use, expansion of urban areas, level of carbon dioxide emissions, number of vehicles in circulation, use of artificial fertilizers, production of paper, acidification rate of the oceans, overall degradation of the biosphere, deforestation, soil loss, modification of large biogeochemical cycles (such as those of nitrogen and phosphorus), and so on.

Aurelio Peccei, in his first book, *The Chasm Ahead*,[17] published in 1969, and in his autobiography *The Human Quality*,[18] published in 1977, recalls that in the 1960s he had already begun to hold a series of conferences on the theme "The challenge of the 1970s for today's world," dealing with innovative topics for the time, such as global interdependence, the growing threat represented by the world's overarching problems, and the fatal error of addressing them in a fragmented and hesitant manner. He was already highlighting the need to involve all the countries of the world (be they Western, communist, or developing countries) in a collective effort to address these problems as a matter of common interest, and the urgency to act quickly to resolve them.

In the second half of the 1970s, I had the great good fortune to get to know Aurelio and to see him regularly until his death in 1984. The friendship that developed between us was, for me, truly unique, characterized by mutual esteem, attention, and deep listening. Aurelio Peccei's thought, vision and action were, and are, of great importance to me, of a value that is really difficult to put into words and that has accompanied me all these years, even after his death. I tried to make the most of his invaluable teachings. He always looked for the qualities present in every woman and in every man, beyond their role, their training, and the work they carried out; he tried to convince others to take care of our future and that of future generations, to develop perspectives beyond the limits of time, to nurture the world around us, and to know and understand it better. Aurelio always tried to "see" far beyond the more predictable connections, cultivating mental habits that tended towards the new, towards change, and towards the continuous evolution of things. He was always mindful of the fact that we build the future every day, by what we do or do not do, by our lifestyle choices, by even small gestures, striving to make links, and seeking out and understanding the complexity of the world around us. Aurelio stimulated the potential of networking, bringing together those who were interested, caring, and as open and innovative as possible. But he also sought those who were from profoundly different backgrounds and with different visions of the world. This meant they were not limited

and self-referential, but they could develop the ability to engage in dialogue and consider a variety of opinions.

Thanks to Aurelio, I also met Adriano Buzzati Traverso (1913–1983) with whom I established another excellent friendship. Adriano was a leading Italian scientist during those years, an internationally renowned geneticist, deputy director for sciences of UNESCO, and later senior advisor to UNEP.

Adriano kept me updated on the development of various innovative research projects he was working. One in particular, focused on a program to monitor the earth using the best detection techniques, for example, modern information from satellites (the first launched to monitor our planet was NASA's Landsat 1, while the first satellite for meteorological analysis was NASA's Tiros, launched on April 1, 1960) to observe the evolution of natural systems and record the effects of changes caused by human action. This project attracted the support of scientists and international research institutions. Adriano had defined it as "Scanning our Changing Planet" and his insights were taken up by the International Council for Science (ICSU, then called the International Council of Scientific Unions), the great institution that unites international scientific bodies across disciplines. A partner of the "Scanning our Changing Planet" was IFIAS (International Federation of Institutes for Advanced Studies), which was founded in 1972 with the support of prominent scientists and leading research institutions in developed and developing countries.

IFIAS was founded by Arne Tiselius (1902–1971), winner of the Nobel Prize in Chemistry, and Alexander King (1909–2007), a scientist and co-founder of the Club of Rome together with Aurelio Peccei.[19]

In 1986, three years after Adriano's death, the ICSU began planning for the first international program on the analysis of global change, called the International Geosphere–Biosphere Programme (IGBP). The aim of this program was to investigate the dynamics of natural systems in depth, to study change in progress but also to understand how humans are influencing global processes and how the effects of this influence can be distinguished from the modifications produced by the natural dynamics of the planet, to understand the dimensions of this influence, and what recommendations need to be made to decision-makers to change the direction of our models of development. The major concern behind this research initiative was the awareness that natural systems are dynamic, evolving, and changing, often abruptly; we have to understand what role we play in these changes and to what extent the modifications we induce pose a serious threat to our very survival.

Hans Joachim Schellnhuber (1950), theoretical physicist, founder, and director emeritus of the Potsdam Institute for Climate Impact Research (PIK), and full member of the Club of Rome, was another pioneer of the Earth system science.[20]

The considerable scientific knowledge gathered in the decades following the publication of *The Limits to Growth* report was, of course, not available in 1972. It developed thanks to extraordinary advances, particularly in the field of Earth system science research, using remote sensing satellite technologies. This began with the NASA Landsat series and supercomputers (the 2021 ranking of the world's top 500 supercomputers is led by the Fugaku supercomputer of Japan's RIKEN Center for Computational Science (R-CCS), which performs at 442 petaFLOPS, millions of billions of mathematical operations carried out in a second[21]).

Despite shortcomings in the knowledge of the dynamics of the earth's system at the time, the *LtG* report sparked international debate of enormous proportions. The report had – and will always have – the great merit of having seriously undermined the myth of unlimited and quantitative material growth that has always played a dominant role in the culture of our societies, particularly in the last century and with even greater insistence in recent decades.

The success of the report must be attributed to its excellent authors but also, and I would say above all, to Aurelio Peccei's great intuition, vision, and capacity to look to the future.

Aurelio Peccei, in his fascinating autobiography, recalls the details of the origin and impact of *The Limits to Growth* report. He writes (emphasis in original):

> The concept of the Earth's finiteness is by no means new. But its corollary, expounded in the report that *due to the planet's finite dimensions there are necessarily limits to human expansion*, was decidedly going against the grain of the growth culture prevailing in the world, and became emblematic of a new way of thinking, both highly praised and mercilessly condemned. The successes of the material revolutions had made this culture arrogant. It was and is the culture of a civilization of quantity which neglects quality, and which couples its ignorance of the real life-supporting capacity of the planet with the extravagant exploitation of its resources and the insufficient, erratic use of human capacity. Leaving aside the increase in population for a moment, let's look at that of production and consumption. When no remedies for the ills of society are in sight, faith in growth takes over. Growth is considered

a super medicine. By producing abundantly, it is possible to meet all needs and satisfy any demand; or, if demand is lacking, it can be boosted enough to establish a new equilibrium – always at higher quantitative levels, which is assumed to be good for the economy and, hence, for society. For a long time, nobody actually dared to question whether growth did indeed possess such wonder-working powers and whether economic expansion was in itself all that good. It has only recently become apparent that a policy of bounty can solve some problems and alleviate others, but that it is sometimes just a palliative; and that certain causes of human dissatisfaction cannot be eliminated by hiding them beneath a heap of goods. However, even admitting that growth could solve all problems, the report demonstrated that *material growth cannot go on forever*. From this core argument, the report went on to describe how some of the factors analyzed – exhaustible resources, persistent commitment to growth, long delays in decision making, short-term planning horizons – are causes of instability, overproduction and finally collapse. Partly as a result of the report's impact, the growth myth began to deflate like a punctured balloon. It is no wonder that the reaction to such an unorthodox stand was mixed. *The Limits to Growth* was written in simple and clear language, this being one of the main contributions of Donella Meadows, Dennis' charming and gifted wife.[22]

While Peccei's entire autobiography is extraordinary reading, these powerful words testify to the remarkable role he played in being one of the pioneers of what we now refer to as *sustainability* and *sustainable development*. In addition, the publication of *The Limits to Growth* coincided with the crucial scientific advances taking place in our analysis of the earth's system.

The authors of *The Limits to Growth* subsequently published two other important volumes that contributed to updating *LtG* along with a third volume, written only by Jorgen Randers and published in 2012.[23] These texts clearly document the deterioration of global planetary health in the light of new scientific knowledge, underlining the grave lack of precisely that political and economic activity necessary to reverse this trend.

The 1980s saw the emergence of highly authoritative international research programs dedicated to the analysis of Global Environmental Change, to the study of the natural variability that causes changes in natural systems and the analysis of the role that our intervention has on them: in 1980, the World Climate Research Programme (WCRP);[24] in 1987, the International Geosphere–Biosphere Programme (IGBP) mentioned above; and in 1996, the International Human Dimensions Programme on Global Environmental

Change (IHDP). In 2001, all these global programs came together in the Earth System Science Partnership (ESSP), which operated until 2012, when this great international effort of integrated research on Earth system sciences was merged into Future Earth,[25] a global network of scientists, researchers and innovators working together for a more sustainable planet, a crucial point of reference for anyone dealing with sustainability science.[26]

Today, the knowledge we have acquired on these fronts is truly interesting and stimulating,[27] although clearly with many gaps still to be filled. The great international research program Future Earth was promoted by two large international scientific organizations – the International Council for Science (ICSU) and the International Social Science Council (ISSC) – which merged in 2018 to become the International Science Council (ISC), demonstrating the increasingly transdisciplinary nature of their mission, with natural and social scientists working together to seek solutions for the future of humanity in harmony with the planet.

In 2000, Paul Crutzen (1933–2021), Nobel Prize for Chemistry, and the ecologist Eugene Stoermer (1934–2012)[28] popularized the term "Anthropocene," pointing out that the present geological time interval, in which many conditions and processes on Earth are profoundly altered by human impact, can be scientifically defined as a geological period dominated by the human species itself. The scientific debate on the Anthropocene is fascinating, rich, and vital.[29] The Anthropocene is recognized by the dedicated working group within the International Commission on Stratigraphy, which is studying the scientific elements of treating the Anthropocene as a formal chronostratigraphic unit. They are proceeding with their proposal for the recognition of the Anthropocene as a formally defined geological unit within the Geological Time Scale, which classifies the various stages of the life of our planet over 4.6 billion years.[30]

We have wasted decades vital to reversing the course of our models of continuous material and quantitative growth, models which have spread through almost all the cultures and societies of the planet, just as poverty, social unrest, and inequality have become equally widespread. It is not primarily the earth that is in danger, as we are increasingly aware, human civilization itself is in danger, civilization made possible by the very goods and services provided by nature and biodiversity, which now face this threat with us. The extraordinary wealth of the biosphere is in grave peril.

In the field of Earth system science and the research deriving from it, Johan Rockström (1965–), currently a director of the Potsdam Institute for Climate Impact Research (PIK) and former director of the Stockholm Resilience

Centre, is playing a particularly important role in that line of investigation called Global Sustainability. Rockström is the author of two reports to the Club of Rome,[31] with whom he works closely, and in 2009, he was among the promoters of the first paper on the concept of Planetary Boundaries and Safe Operating Space (SOS).

Rockström and other experts of the earth system and of Global Sustainability have pointed out that to be able to live in the Anthropocene we must learn to live in the Safe Operating Space (SOS), the space within which humanity can continue to develop and thrive without crossing certain planetary boundaries and increasing the risk of generating large-scale abrupt, or irreversible, environmental changes with cascading domino effects that are difficult for humanity to manage and are profoundly negative and dramatic for all life on the planet.[32] The authors of the original publication of the Planetary Boundaries concept published in *Nature* explicitly referred to *The Limits to Growth*. Planetary Boundaries are inevitably closely connected and interdependent: climate change, biodiversity loss, ocean acidification, reduction of the ozone layer in the stratosphere, modification of the biogeochemical cycle of nitrogen and phosphorus, the global use of water, changes in land use, the diffusion of atmospheric aerosols, and pollution due to anthropogenic chemicals.

For five of these, namely climate change, loss of biodiversity, modification of the nitrogen and phosphorus cycles, changes in land use, and novel entities, scholars point out that we are already beyond the boundary indicated by them based on the best scientific data available. Overall, the nine Planetary Boundaries identified can be conceived as an integral part of an area defined as a circle, and hence as a Safe Operating Space (SOS).[33]

The economist Kate Raworth, a member of the Club of Rome, added to the concept of SOS, linking the Planetary Boundaries to other boundaries deriving from the social sciences and defined as social foundations, based on internationally agreed minimum social standards, that is, those elements fundamental to the dignity of the existence of every human being. Raworth outlined an extremely fascinating and innovative approach, *Doughnut Economics*,[34] comprising the nine Planetary Boundaries beyond which lie unacceptable environmental degradation and potential tipping points in earth systems (a sort of "ceiling" – the outer rim of the doughnut) and twelve dimensions of the social foundation, internal boundaries (a sort of "floor" – the inner circle of the doughnut) below which people worldwide fall short on life's essentials. These are social priorities, such as food, water, healthcare, income, education, energy, employment, the right of expression, gender

equality, social equity, and resilience. The doughnut is the safe and just space for humanity between the ecological ceiling and the social (foundation) floor. Being able to live in this space is the environmental and social challenge that the whole of humanity faces. The Future Earth program in collaboration with the Global Commons Alliance[35] has launched the Earth Commission[36] (co-chaired by Rockström),[37] which will synthesize the latest science to underpin science-based targets that can help preserve the stability and resilience of earth's life support systems. The scientific guardrails defined by the Earth Commission will guide the Science Based Targets Network[38] in developing tangible science-based targets tailored to cities and companies.

I think we can safely say that all these developments and initiatives are part of the legacy and the intuitions of Peccei and of the succession of figures who have passed through the Club of Rome. Fifty years after *The Limits to Growth*, the Club of Rome is characterized by a strongly innovative spirit, firm reasoning, and a wealth of scientific documentation that will contribute to the construction of a path to carry us forward towards living within the limits of a single planet.[39]

Still the economy, but what kind?

7

How the Club of Rome influenced the world's agenda

Wouter van Dieren

Director of Inis Vitrin

This is the story of the creation of the Club of Rome myth in the years 1971 and on. It has never been told before in this format.

As a science journalist for Dutch television, I travelled to the USA in the fall of 1970, meeting the key players in the unfolding new green community: the World Resources Institute, World Watch, Environmental Defense Fund, Sierra Club, Environmental Protection Agency, and many others.

In Boston, I ran into a group of brilliant young scientists, Dennis and Donella Meadows, Bill Behrens, and Jorgen Randers, in a meeting about their research into the limiting factors of the earth system. I had never seen a computer and had no knowledge of the methodology, *systems dynamics*, or of the computer languages Dynamo and Fortran.

However, I instantly saw the scope of the study, the meaning, the drama, the power. And I grasped the idea of feedback loops and systems thinking. Several days later, I concluded to the scientists that they had "dynamite" in their hands, which they could not believe. Their plan was to complete the study the next year and to publish it as a report to the Club of Rome, which no one had heard of, including myself.

They handed me a draft, which I took back to the Netherlands. There, we produced a hundred copies, with the imprints marked *confidential* and *not for distribution*.

A long journey among major institutions began, starting off with the R&D directors of Unilever, Akzo, and Philips. At the Philips Physics Lab, the famous Hendrik Casimir was in charge, friend of Heisenberg, and Chair of the European Physics Society. He took immediate action – a call to his staff to review it. At Unilever, Wiero Beek held the R&D position, and at Akzo, Hans Kramers. All were professors, eminent scientists, and prominent opinion leaders. At the Free University of Amsterdam, Jan Willem Copius Peereboom was Chair of IVM, the Institute for Environment Research, and at Utrecht University, Jan Klabbers turned out to be one of the few who could handle the mathematical model called World3. There were just a few computers in the Netherlands to run the calculations, at Philips, Delft University, and Utrecht. Large, black boxes.

The draft report was distributed by visits and meetings, creating a buzz in the inner circles of science, and later with key stakeholders in politics and media.

In the meantime, the well-known Dutch society journalist Willem Oltmans met with the founder of the Club of Rome, Aurelio Peccei, who was close to FIAT, and fellow founders Carroll Wilson (American Academy of Sciences), Jermen Gvishiani (Soviet Academy of Sciences), Eduard Pestel (Volkswagen Foundation), Alexander King (OECD), and Hugo Thiemann. Intrigued by the unusual combination, Oltmans ignited a gossip campaign, which soon merged with the spreading of the story at large.

My contacts in the world of science, industry, media, politics, and NGOs were focusing on the variables and scenarios in the model. The Oltmans buzz kicked off the story about the "conspiracy". A close look at the various components of the societal environment, in which *Limits* was embedded, made it clear that something very unusual was happening.

Why Rome? Possibly, the Church was involved?

Why both the American and the Soviet academies? Did the CIA and the KGB have a stake in the conspiracy?

Why multinationals?

And what is a computer? An unknown black box, at the time. Could it indeed predict the future? And soon it also became clear that World3 had forerunners in the anti-missile programming of the Pentagon. A booming surprise was in the making.

Aurelio responded with doubt to our propositions about launching the story in full. Although he and Alexander King had deep worries about the predicament of humankind, and their choices were revolutionary, they also wanted to keep to the path of a proper scientific publication, which was due

in 1972. Their Dutch advisor, Frits Böttcher, professor in Chemistry at Leiden University, opposed any efforts of the Dutch *Limits* protagonists like myself, whom he considered too much anti-establishment and too political. Böttcher, prominent board member of Shell, Elsevier, and other institutions, fiercely opposed any connection of the Club of Rome with the *counterculture*, as well described by Theodore Roszak a few years later.

Yet, the drama began to create the planned noise, and we decided to set the trip to fame into motion. Some (science) journalists got informed, a television programme was planned, an imminent (October) conference with Dennis Meadows was scheduled, and in September 1971 the prominent media *NRC Handelsblad* and *Haagse Post* alarmed their readers with "Apocalypse on credit", headlines.

Oltmans interviewed Aurelio Peccei on the whereabouts of the Club of Rome, and my team filmed Jay Forrester at MIT. Both television programmes were aired in October 1971, and almost simultaneously went on screen in Germany, Japan, and Scandinavia.

Fierce opposition came from futurists such as Fred Polak and Herman Kahn (Hudson Institute), and, above all, prominent economists.

In the Dutch parliament, a famous speech was delivered by Hans van Mierlo, leader of the liberal democrats, quoting Peccei and Forrester about "growth which will and shall stop, either by mastering the challenge, or by conflict, war, hunger and misery".

Ever since, I have given innumerable speeches on *Limits*, relating it to the issues of climate change, energy, water, food, and so on. Dennis Meadows became world famous, a science prophet of an unusual stature. In 2009, with our institute, IMSA, we published a review, together with the Dutch EPA (Planning Bureau for the Living Environment).

Numerous articles have appeared, in my estimate some 800,000.

The catalyst as orchestrated in The Netherlands is unparalleled in the history of science publications. The Club of Rome is still puzzled by this extraordinary success today. It is still the key identity of the Club and the dream to be repeated. The paradox is that society is not attuned to a proposition which refers to a news story of decades ago. Society demands *news*, as if it is not news that *Limits* proves to be highly accurate when today's data are compared with the 1970 input. News hypes want *other* stories, and the fact that the 1971 alarm is the bell which rings today does not fit fast-moving media consumers' hunger for other, even more exciting stories. Okay yes, there will be overshoot and collapse in 2030–2050, but do you have something better than that?

Casimir, Beek, and Kramers donated a then high sum of 250,000 Dutch guilders (120,000 euros) to our initiative to create a systems dynamics group in the Netherlands. Colleagues Eric-Jan Tuininga, Roel Beijdorff, and Maarten Koeman joined the systems dynamics courses in the USA and Denmark, and Eric-Jan Tuininga took on the job to translate *Limits* into Dutch with a motivated team of young scientists. In the spring of 1972, the Dutch translation came to market, soon peaking at sales of 250,000 copies. Countless debates, articles and conferences followed, the echo of which can still be heard today.

When alarmed now, the audience remembers, even if they were not even born then. I myself became Mr Club of Rome in The Netherlands, often dismissed, yet rewarded, and always controversial.

The story is volatile, and the establishment has its mechanisms to shoot the messenger. Every eight years, they ride out for this shoot, especially the left, who could never really combine their promise of smoking chimneys and affluence for the working class with the reality of nearing limitations.

Without a doubt, *Limits* became the most powerful scientific paper of the last 50 years. Ever since, uncountable references can be found, numerous actions have been undertaken, technologies have developed, faculties have started, regulation has got off the ground. Resource policies can be traced back to *Limits*, and so can climate and energy innovations. In his last year as president (1972) of the European Commission, Sicco Mansholt declared to his colleagues that the Club of Rome message had to become the basis of the European Union. In many countries, the Club of Rome is still a myth and a hero, a messenger like Cassandra, honoured and despised. In 1990, at the first Perestroika conference hosted by Michael Gorbachev in Moscow, the Club of Rome announced its comeback, under a new president, Ricardo Díez Hochleitner. In 1991, I was nominated as a member, having been too young before. In 1995, I published the Club of Rome report on the corrected GDP, and in 2009 we hosted the Club's Global Summit in Amsterdam, in the presence of Her Majesty Queen Beatrix (who is an honorary member), President Gorbachev, ex-Prime Minister Ruud Lubbers, and 800 prominent guests from all over the world. The Club now has 150 members and 22 Country Chapters, organising scores of meetings every year. New reports are published regularly, most of them related to *Limits* subjects, such as *2052: A Global Forecast for the Next Forty Years* by Jorgen Randers (2012) and *The Limits to Growth Revisited* by Ugo Bardi (2013). The members belong to the elite of science, diplomacy, politics, industry, and NGOs worldwide. And royalty.

No question that decades of necessary action got lost because of the framing by vested interests to shuffle the work into the outskirts of scientific

debate. PhD studies of the early days about the intentions, research, launching and effects are manifold. Though often requested, I have never written it down. Until now.

Although thousands of scientists have devoted their efforts to the question of how reliable World3, the computer model used, was and whether it is even at all possible to forecast the future in this manner, *Limits* has, in our view, come through all the criticism untarnished. First, because the primary aim was not to make a prediction but "to improve the insight", in the words of Jay Forrester, and second, because nobody has yet really succeeded in finding fault with the main calculations and the underlying hypotheses.

Since 1972, countless studies and books have been published that confirm the message of *Limits*, but even more extensive than this scientific work has been the worldwide denial of the limits to growth and the impassioned attempts to remain one step ahead of the imminent shortages through policies of continued economic expansion. Meanwhile, additional new insights have arisen, which not only confirm the impending disasters but also indicate that the limits to growth may well have been exceeded and that the world has been in a state of decline for some years already. The most important study in this context is *For the Common Good* (1989), in which Daly and Cobb develop an information theory to replace or supplement the incomplete data function of what is known as the Gross National Product. By processing US statistical data on some twelve so-called welfare indicators, they drew the conclusion that for the previous twenty years the link between production growth and the creation of welfare has become progressively weaker. Prior to that date, production growth had achieved exactly what Adam Smith foresaw in 1752: the addition of value to indeed create *The Wealth of Nations*. In the 1970s, this link began to be lost, however, and this process is proceeding at such an accelerating pace that we are now confronted with the curious phenomenon of production growth leading to a decline in welfare; stated differently, the limits to growth have been reached without us even noticing it because we have been interpreting the figures wrongly.

The main thrust of the opposition to *Limits* lies in the belief that economic growth is a kind of law of nature that humanity must obey. Since Adam Smith invented the "invisible hand", this power has been a guiding principle for all those who believe that free trade, or the market, will ultimately lead to a natural order of things. They think a moment will come when everything will fall neatly into place: free trade will provide income and employment, welfare for all, equality, peace, and a future. In this way of thinking, the problems outlined by *Limits* result from obstacles to free trade – and if things

are not well with the world, that is a logical consequence of these obstacles. Obstacles such as too much government intervention, too high social benefits, too much environmental and labour legislation, an overly expensive quaternary sector, and so on. Allow the free market to do its curative work, in other words, and the Divine ordination of the invisible hand will balance out the world economy.

It is no coincidence that this kind of metaphysical notion was a nursemaid to the industrial revolution, nor that it is part and parcel of modern economics. Adam Smith certainly intended the invisible hand to serve as a metaphysical, divine principle, which effortlessly took over the role of Divine Providence, on which Western humanity had focused its aspirations until the Enlightenment. The Enlightenment blocked this Providence, because it called for science, technology, and mechanization, and thus distracted attention from God's will. By introducing the invisible hand, Smith took up the deistic thread once more; now the economy too, or precisely the economy, was to be driven by supernatural laws, and in the industrial age, too, the role of God would remain of decisive importance.

It is our conviction that this metaphysic is still as topical as ever. The opposition to *Limits* is so strenuous that clearly forces other than science are at work. One would expect humanity to take up the challenges of *Limits* and set up an international organization to halt the decline. The opposite has been the case. A veritable crusade of economic expansionism has been unleashed, as if to prove that *Limits* was pessimistic and in error, and everywhere the conquests of this crusade are praised as providing the desired proof, such as the economic miracles embodied in the Chinese growth figures. And for the sake of convenience, we then ignore the enormous price of these miracles, the ecological destruction, the plundering of the surrounding oceans, the consumption of natural capital, the underpaid workers, and the absence of social security. And while these miracles are seen as proof of the power of the invisible hand, nobody is prepared to answer the question of why the same metaphysic has caused war and famine. Does the invisible hand pick its favourites? Or are the poor paying the penalty of disobeying the laws of natural economic ordination? Or is it the case that here – and in the former Soviet Union – the law of Keynes holds: that suffering is a precondition, albeit temporary, for later success?

It is of crucial importance to state that the invisible hand does not exist, that there are no laws of economic ordination, that although the notion of economic growth can be defined, its political usage is, above all, rhetorical, that economics is not really a science but a set of theories, and that every

attitude towards the limits to growth is a question of culture, choices, free will, and – possibly – rationality. There is no inevitable fate compelling humanity towards unlimited free trade, over-exploitation of nature and labour, exhaustion of resources, and finally towards a war of all against all (Hobbes) to gain control of the last remaining resources and food. Economic thought differs from culture to culture, and within each culture, even from school to school and from university to university. There are myriad options to choose from, and none of them needs to satisfy a single requirement of a metaphysical nature. What is of key importance is that we rid our economies of hypocrisy, and this is what we have tried since the beginning.

A key hypocrisy lies in the system of the Gross Domestic Product (GDP), which has been employed in the Western economy for half a century, with partial implementation in most other countries. Our aim is to set out why we consider this topic to be so vitally important in the debate on growth and the limits to which it is subjected.

Until 1945, the notion of economic growth was used differently from today. It was not until about 1932 that several economists came up with the idea of measuring a country's economic performance and not until 1950 that the ensuing system was introduced in most industrialised countries. It was thus inevitable that the costs of production growth would be encountered, costs that for decades had been termed negative external effects. In former times, these effects had been happily accepted, but when production as a whole is encapsulated in a profit and loss account, the costs, or negative expenditure, automatically appear on the balance sheet. And that is where we stand today.

Surprisingly enough, users of National Accounts have long remained deaf to recommendations to subtract these costs from the profits, despite an information load that has become so heavy in recent years that for some economies the point appears to have been reached whereby the costs are perhaps even greater than the profits – without this being reflected in the GDP or the National Accounts. This is of vital importance for the debate on the limits to growth because these economies continue to literally count themselves rich while poverty is on the rise, or, in other words, because the subtracted value is higher than the added value. Phrased differently: the economy is being kept afloat on paradoxical information, not even on incompleteness, and the abuse of the National Accounts is at the core of the matter.

GDP has gained metaphysical significance: it stands for the mark given to the country by the invisible hand and thus even acts as a symbol of the degree to which that nation has been elected in the Divine ordination that

steers the invisible hand. In this vision of things, one has subjected oneself to the natural laws of the economy, and the nation is seen to have passed the examination if the number attached to GDP is positive: one, two, or three per cent growth per annum, whatever that may mean. Orio Giarini has made a comparison between the effect of GDP in heaven, in hell, and on earth. He describes the complication of Industrial Revolution accounting by the paradox of hell and heaven when applied to the notion of scarcity. Heaven, being probably blessed by an infinite stock of goods and services of all sorts (material and spiritual), knows nothing of scarcity. Economics and the economy, therefore, do not exist. There are no prices and there is no money because everything is readily available without any restriction or work. Heaven, then, must be something very different from earth, but it is also a place of zero GDP. Hell, as the opposite of heaven, is a place which consumes a lot of energy in maintaining its celebrated image and presumed activities. It therefore probably needs to develop a huge value added that nobody has ever tried to measure: GDP must be very high indeed! On our earth, the maximum possible achievement in the fight against scarcity is to create an abundance in as many sectors as possible. But human and economic development also entails identifying and coping with new scarcities. Scarcity is ultimately the hallmark of the system of disequilibrium within which human endeavour is destined to operate; it is the *sine qua non* of man's quest for fulfilment.

It is important to define a level for the wealth of nations in terms of stock, its increase, depletion, use, conservation, and its diversification. Measurements of value added are important for the organization of an industrially productive system, which is an important subsystem of the economy as a whole. But is only partially relevant to the business of measuring, targeting, and organizing the wealth of nations.

If the growth of GDP is three per cent, but the uncalculated costs of output are some four per cent of GDP, then at least we know that the quality of life in that country is declining. To argue that these costs be discounted is to argue for introduction of a system we term SNI, Sustainable National Income, a national income in which interest and yields are indeed added up, but in which depletion of resources and nature are subtracted from the income, as it were. Even then, the problem remains that even a corrected GDP still says nothing about the real value and dignity of a society. However (so say the politicians) without a growing GDP, the country will become a second-rate nation, and so we must subject ourselves to interventions that are

progressively demolishing the whole post-war social fabric. We are being colonized by the economy, as it were, and that was certainly not the original aim.

Classical economists, and in particular Ricardo, were well aware that the methods for the accounting of economic wealth that they were devising were not really reflecting of the real level of wealth of an individual or a country. A clear distinction was made between the notion of riches on the one hand and of wealth on the other. There was even an implicit acceptance that there could be situations where an increase in wealth would not correspond to an increase in riches.

However, these considerations remained secondary because the main problem during the Industrial Revolution was to identify the most dynamic system for increasing the wealth of nations, i.e., the industrialisation process, and to concentrate on its development. Inconvenient discrepancies between wealth and riches were considered of minor importance. The writings of classical economists and their later commentators were very much influenced by the fact that the first formulation of economic theory was a description of the industrialisation process; the priority, which was quite adequate for this purpose, was to measure a flow of goods and the value added, whether supply or demand based.

The divergence of the notion of riches from the notion of wealth corresponds to what can be called the development of deducted values in the modern economy. Increases in these deducted values stems from the increasingly higher allocation of economic resources to activities that do not add to the real level of wealth (or of riches), but that are, in fact, absorbed by the rising costs of the functioning of the economic system.

Examples of this trend, which began in the 1960s, abound. Air and water pollution are obvious cases of diminishing real wealth (or of diminishing riches). If money is invested to depollute water or to develop alternative solutions, such as bottled water, special reservoirs for drinking water, or swimming pools next to a polluted seashore, we are once again confronted by catch-22 situations where investments are necessary to compensate for riches lost through, for example, pollution. These investments are not net added value to our wealth!

The growing discrepancies between levels of wealth and riches (or the contradiction between economically accounted wealth and real wealth) clearly indicate the need to refer increasingly to stock, i.e., variations in real wealth, as a substitute for the measurement of production flows. Furthermore, there is also a problem of matching real added values to deducted values. A new

conceptual approach to systems for measuring the real results will have to replace the simple analysis of the costs of an isolated activity.

Economics is not a law of nature, and when it comes to output, income growth and distribution, and resource use and welfare development any system can be chosen and moulded because primarily questions of culture are involved along with choices that are made and implemented by human beings, with the economy merely a tool to help us, nothing more. Economics should then be – and can be – an instrument to define the truth.

What happens if we fail in this quest?

We would reiterate our original message; in the words of Jay Forrester:

> Over the last hundred years, life on earth was dominated by growth. Growth of population, of production, of income and capital formation, of exhaustion and pollution. This growth is going to stop and must stop, and the only question is by what means? Voluntarily, by government and free will, or through natural processes, which means collapse and disaster?

Ultimately, this is the vision of the future, and many elements of it have already become reality in the world around us: collapse of life-support systems, communities, regions and nations; lack of food; scarcity of water; climate change; and, ultimately, war. Of the wars now being fought in the world, most of them originate in part because of exhausted resources and collapsing life-support systems. This is the ultimate consequence, clearly confirmed by such authors as Meadows, Kennedy, Kaplan, and others.

The second consequence occurs in the mild precursors of this collapse: the process of individual enrichment of the few at the cost of growing public poverty; the decline in wealth and welfare to be observed everywhere today, now methodologically confirmed by the studies of Daly and Cobb; and all their successors.

It is important to hold modern Western political practice up to this light, a practice consisting of ever more austerity programmes to secure the integrity of purchasing power or of individual consumption, to which political affairs are being sacrificed.

Because the dominant focus of technology is to substitute for labour (a process known as productivity growth), an imbalance in income growth sets in between those sectors where productivity rises – in other words, industry – and those where it cannot, for example, in health care, education, justice, and public administration. Wage demands in these sectors cannot be absorbed by rising output, although attempts are made by amalgamating

schools, closing senior citizens' homes and hospitals, abolishing police forces, and overloading the courts. The ultimate outcome is that the modern welfare society is disappearing to the benefit of growing private consumption and the enrichment of a small elite. The neoliberal model thus becomes the future: miserable public services; bad public transport; decrepit and unsafe inner cities; overcrowded and ever-more unhygienic hospitals; impoverished senior citizens; unmotivated, poor education; neglected culture; minimisation of scientific research; and environmental neglect. Today, every government holds up this agenda, and it is no wonder that each one is concerned, above all, with cranking up production growth in the hope that this will generate funds to compensate for the new poverty. That may have worked with growth in the past, but it does so no longer, because an ever-greater proportion of each new round of production growth consists of negative economy: compensation and repairs, processing of waste, and controlling of complexity. In other words, expenditure that is taken to be income. The contemporary example par excellence is in those countries which today suffer from war, guerrillas, and dictatorship where the arms industry is earning masses of money and, when one day there is peace, so will the demolition companies, the clear-up gangs, the contractors, the international consultancy agencies, and the whole redevelopment business. When, 25 or 50 years from now, the country has been redeveloped to its condition prior to 2000, no net achievement will have been made, but the growth figures will be high.

This is the fate of every economy that has exceeded the limits. This means that in those countries, monetary policies are leading to accelerated demolition of both the welfare state and the cornerstones on which production growth rests.

Both forms of collapse are the result of the hypocrisy and the metaphysic bound up in economic information. We have risen to the task to unmask that hypocrisy and this is thus a plea for a form of rationalization that in the world of economic metaphysics has until now proved extremely difficult. Economics can be a beautiful instrument when applied with its original meaning: to put the house (*oikos*) of humankind in order.

8

Growth of what?

L. Hunter Lovins

President, Natural Capitalism Solutions

The crises facing us, predicted in the 1972 book *The Limits to Growth,* are the result of exponential growth in population, industrial activity, pollution, and destruction of ecosystems.

Updates of the old *The Limits to Growth* collapse graph, plotting on top of it the actual data from 1972 to 2000,[1] show we're still on track for collapse.

In 2021, Gaya Herrington brought the numbers up to date, with the same conclusion.[2]

The economist and aphorist Ken Boulding testifying on the seriousness of these projections remarked that, "Anyone who believes that exponential growth can go on forever in a finite world is either a madman or an economist."[3]

Much of today's economic "growth" is speculation in the capital markets, financial transactions delivering no real economic benefit, or the conversions of one form of capital (natural capital in the form of minerals in the ground or timber on the hills) to money and stuff. World Bank Chief Economist Herman Daly warned that this is just bad accounting. It also risks life on earth.[4]

Undifferentiated growth is the ideology of cancer cells and neoliberal economists. The rest of us ask, growth of what? To solve the existential climate crisis[5] we need more solar panels, powering more electric vehicles. We need a lot more regenerative agriculture sequestering carbon in the ground far faster and more cheaply than any mechanical form of carbon capture could ever

achieve. People living on the margin need more stuff and material comfort. At the same time, those in the "overdeveloped world" might be happier with less junk. Both want clean water, healthy air and beauty in their lives, fewer oil wells, but far more wind turbines, more gardens and less industrial agriculture, more education, and health. Regenerative growth, if intelligently provided, does not cost the earth.

Dana Meadows, lead author of *The Limits to Growth*, believed that to avoid collapse we need to distinguish more and better. She observed,[6]

> People don't need enormous cars; they need respect. They don't need closetsful of clothes; they need to feel attractive and they need excitement, variety, and beauty. People need identity, community, challenge, acknowledgement, love, joy. To try to fill these needs with material things is to set up an unquenchable appetite for false solutions to real and never-satisfied problems. The resulting psychological emptiness is one of the major forces behind the desire for material growth. A society that can admit and articulate its nonmaterial needs and find nonmaterial ways to satisfy them would require much lower material and energy throughputs and would provide much higher levels of human fulfillment.

"Cheater capitalism" or "crapitalism" ignores such distinctions. It also has three fatal flaws:

- It's bad history,
- It's bad science,
- It doesn't work.

To frame a new approach to economics, it's important to understand where the system we seek to replace came from, what's wrong with it, what's worth preserving, and most of all, the future we want.

It's Bad History

Early economic theorists never envisioned a global, unregulated market. They understood that economies were nationally bounded; nations trade with each other. They might charter a corporation to do the haggling, but these entities (now endowed with "personhood") were understood to be agents of nations, nothing more.

The real Adam Smith, not the caricature of Economics 101, never saw himself as an economist. His Chair at the University of Glasgow was in moral philosophy, and from it he denounced the gluttony of the rich as "unproductive labour."

Mishko Hansen, former investment manager, now researching ethical issues at the University of Cambridge, points out:[7]

> Smith was writing not about how economic growth was going to lead to happiness or wellbeing, but rather how a country became economically prosperous, and hence militarily powerful. He believed that people living in conditions of relative freedom and equality could be very happy with almost nothing in the way of material goods (i.e. his example of North American Indians), but that this could lead them to being subjugated and made miserable by more militarily powerful forces.
>
> Smith was then, contrary to how he is usually (mis)interpreted, writing about how people can live in conditions of peace, freedom, and justice—which he believed were the prerequisites to happiness—and about the economy as a means to this, rather than an end in itself.

Smith rejected the notion that greed was good, stating:[8]

> Hence it is, that to feel much for others, and little for ourselves, that to restrain our selfish, and to indulge our benevolent affections constitutes the perfection of human nature; and can alone produce among mankind that harmony of sentiments and passions in which consists their whole grace and propriety.

How did Smith come to be so misread?

To serve ideology. In 1947, 36 men met for ten days in Switzerland to frame the economic system they believed would deliver prosperity. Ludwig von Mises was appalled at what National Socialism had done to trash Europe in World War II. Friedrich Hayek feared the rise of Soviet collectivism in the east. Milton Friedman championed the freedom of the individual as the only legitimate actor to make economic decisions.

They called their ideology neoliberalism, restoring the irrefutable truths of the "liberal economics" set forth by Adam Smith.

The narrative is appealingly simple: You, as an individual, are the only legitimate economic actor. You're greedy, but that's okay because the market is perfect,[9] and in a market, you against me will aggregate to the greater good for all. Those who deliver value *should* win. It's just how the world works.

Neoliberals believe that maximizing individual desires is the force that drives maximization of what economists call "utility." They tell us:

- The sole goal of the economy and business is to generate financial wealth,
- The freedom of the individual (person or corporation) is the primary societal value,
- Government should be small, protecting individuals and their private property.

The fact that eight men now have as much wealth as the bottom half of humanity[10] neoliberals say is not only inevitable but entirely acceptable.[11,12] Are people poor or hungry? The market will fix it. Is the economy suffering? Implement greater austerity.

They drew from the Calvinist belief that being rich was a sign of being blessed.[13] This framing guides politicians to cut taxes, especially on corporations and the wealthy.[14] If wealth is the sign of success, shouldn't we promote and increase it? Milton Friedman argued that the only legitimate goal of business is to maximize shareholder (owner) value in the short term.[15] Any other action by a company is philanthropy at the expense of the corporate owners.[16]

How, then, did this wonkish ideology, flying in the face of New Deal success, conquer the world? The answer is story and strategy. Neoliberalism's storyteller, novelist Ayn Rand, wrote: "Capitalism was the only system in history where wealth was not acquired by looting, but by production, not by force but by trade, the only system that stood for man's right to his own mind, to his work, to his life, to his happiness, to himself."[17]

Her books were credited by Alan Greenspan, the Tea Party, a Secretary of State and a US President as foundational. Her dismissal of the poor as parasites and celebration of naked greed, described as the philosophy of a psychopath, have been read by one third of Americans.[18]

The neoliberals helped create the Nobel Prize for Economics and got eight of its members as winners. They advised essentially every head of state on the planet. Three of them became heads of state, others central bankers.[19]

The strategy solidified in 1971. Lewis Powell, a corporate lawyer, was asked by the head of the US Chamber of Commerce to detail how business could relegitimize itself after the sex, drugs, and rock and roll of 1960s. Powell penned "Attack on the American Free Enterprise System"[20] as the strategy corporate America should use to enshrine neoliberalism. It targeted

30 needed transformations, from local school districts to local judges and local and national media.

Powell stated,[21]

> Business must learn…that political power is necessary; that such power must be assiduously cultivated; and… used aggressively…without embarrassment… Strength lies in organization, in careful long-range planning and implementation, in consistency of action over an indefinite period of years, in the scale of financing available only through joint effort, and in the political power available only through united action and national organizations.

Powell got that funding, aggressive use, and consistency of action. Foundations and donors assembled many millions to implement Powell's strategy.[22] The Koch brothers founded and endowed the Heritage Foundation, Cato Institute, American Enterprise, Hudson, Hoover, and others. They created and endowed such organizations as the Pacific Legal Foundation to embed the concept of tax cutting and protection of property rights into California law. They groomed a young actor named Ronald Reagan for the governorship of the state.[23] The American Legislative Exchange Council (ALEC) wrote model legislation for newly elected republicans. The Federalist Society and the Judicial Crisis Network identified lower-court judges to climb the ladder to the Supreme Court.[24] The best marketing firms massaged the neoliberal principles, sold them and created the intellectual architecture that propelled market fundamentalism as commonplace and neoliberal ideology to dominance. And over the last 50 years, they influenced the systematic dismantling of American democracy[25] and government policies around the world that were designed to protect the wellbeing of people.[26]

In 1980, with the election of Ronald Reagan in the US and Margaret Thatcher in the UK in 1979, neoliberalism won. It became the economic ideology. In the Reagan Era of the 1980s, deregulation spread to many countries. Corporations assumed greater control and gobbled up smaller companies. With the fall of the Berlin Wall and the collapse of the Soviet Union, neoliberalism became global.

Accounting scandals were predictable results.[27,28,29] Financialization swept the economy.[30] The orgy of outsourcing and offshoring jobs, costs, and profits cost millions of American jobs.[31] Because neoliberals reject higher wages, taxes to support government programs and regulations of any sort,[32] their systematic dismantling of government protections[33] enabled the "Great Recession"

of 2008 to evaporate $50 trillion and 80 million jobs.[34] It sowed the seeds of the 2016 Electoral College victory in the US of a reality TV star, Brexit in the UK, and nationalist populism across Europe.

Neoliberalism now underpins most economic policies, even in countries nominally labeled communist. It forms the basis for economics courses the world around, and if you've had one, this stuff is in your head.

It's Bad Science

Smith and his compatriots never believed themselves to be scientists. But their successors did. Professor Robert Nadeau has described the physics envy of later economists:[35]

> Neoclassical economic theory was created by substituting economic constructs derived from classical economics for physical variables in the equations of a soon-to-be outmoded mid-nineteenth century theory in physics. The mathematical formalism that resulted from these substitutions was predicated on unscientific axiomatic assumptions that remained essential unchanged in subsequent extensions and refinements of neoclassical economic theory…
>
> The strategy used by the creators of neoclassical economics was as simple as it was absurd—they wrote down the equations … and substituted economic variables for the physical variables. Utility was substituted for energy, the sum of utility for potential energy, and expenditure for kinetic energy. The forces associated with utility-energy were represented as prices and spatial coordinates described quantities of goods. In the mathematical formalism that resulted from these substitutions, the economic actor is presumed to operate within a field of force identified, in both figurative and literal terms, with energy.

Neoliberalism's belief that markets are superior to any alternative is based on a neo-Darwinist theory that selfish individuals acting in their own selfish interests, fighting it out, will always deliver superior outcomes.

David Sloan Wilson observes:[36]

> Evolutionary theory's individualistic turn coincided with individualistic turns in other areas of thought. Economics in the postwar decades was dominated by rational choice theory, which used individual self-interest as a grand explanatory principle. The social sciences were dominated by a position

known as methodological individualism, which treated all social phenomena as reducible to individual-level phenomena, as if groups were not legitimate units of analysis in their own right (Campbell 1990). And UK Prime Minister Margaret Thatcher became notorious for saying during a speech in 1987 that "there is no such thing as society; only individuals and families." It was as if the entire culture had become individualistic and the formal scientific theories were obediently following suit.

People who believe the world is a nasty, brutish, competitive place are quick to cite Darwin's misquoted "survival of the fittest." By which they mean that the strongest, toughest, meanest individuals will triumph, because this is the way of nature.

What Darwin actually wrote about was the "survival of the best adaptive." In 1909, he stated:[37]

> The small strength and speed of man, his want of natural weapons, etc., are more than counterbalanced by his *intellectual powers*, through which he has formed himself weapons, tools, etc., and secondly by his *social qualities* which lead him to give and receive aid from his fellow-men.

Darwin also observed:[38]

> …that any animal whatever, endowed with well-marked social instincts, the parental and filial affections being here included, would inevitably acquire a moral sense or conscience, as soon as its intellectual powers had become as well, or nearly as well developed, as in man. For, firstly, the social instincts lead an animal to take pleasure in the society of its fellows, to feel a certain amount of sympathy with them, and to perform various services for them.

Biologists now know that nature is based more on cooperation than competition.[39]

The best of modern science tells us that the neoliberal narrative is just bad science. In his 2010 book, *Driven to Lead: Good, Bad, and Misguided Leadership*,[40] Dr Paul Lawrence sets forth what he calls Renewed Darwinism, a correction to neoliberal dogma. Yes, Lawrence says, there is a human drive to acquire and defend, but, he adds, as Darwin noted, humans have an equally powerful drive to bond. They also have a drive to comprehend, to create, to innovate. To be happy, says Lawrence, to be truly fulfilled, humans need to meet each and all these drives.

The evolutionary biologists, the archeologists, the anthropologists, and the geneticists agree that caring is baked into what it means to be human; it was that which enabled prehumans to survive. Fossil records show that early hominids were not fearsome warriors, they were prey animals, dependent for their survival on working together. They were naked, their claws not worth much, their teeth puny. "Lacking size or weapons, this early human species most likely used brains, agility, and social skills to escape from predators," says Dr Robert Susman, author of *Man, the Hunted*.[41]

Prehumans faced species extinction on several occasions, their numbers reduced to a breeding population fewer than the now endangered gorillas.[42] Yet we survived lions, bear-sized hyenas, volcanic eruptions, and ice ages because we formed tribes, and were creative, entrepreneurial creatures.[43] We're storytellers, meaning-makers. We're puzzle-solvers and communitarians.

Dr E.O. Wilson, one of the planet's most famous biologists, states that we are the dominant species on earth now only because we are inherently social beings: "super-cooperators, groupies of the group, willing to set aside our small, selfish desires and I-minded drive to join forces and seize opportunity as a self-sacrificing, hive-minded tribe."[44] To Ed Wilson, group and tribe formation is a fundamental human trait.[45]

These early people were kind and moral, prone to empathy and collaboration, quite the opposite of the neoliberal narrative. We know this from the fossil records that show that the tribe of prehumans that survived cared for old, toothless men, and those who had disabilities.[46] If you're in it only for yourself, you abandon those who slow you down, who take food that could sustain the more able. Why should old fossils influence our understanding of economics? The DNA found in those bones is in you. These were our ancestors.[47]

Traits like caring and empathy, says Wilson, are hardwired into us. These decision-making tools guide us towards the sorts of cooperative outcomes we call "morality." We behave in ways that are genuinely altruistic because it is in our genes to benefit the group, not the individual. We aren't all kind and loving, Wilson argues, because these behaviors are "prepared" and ready to be developed as part of our genetic makeup, but the implementation of them is learned.[48]

How then do we train our young businesspeople? Economists are fond of saying that emotions cloud the mind of rational, utility maximizing Homo economicus. Business schools, economics classes, and corporate management drive caring out of us, tell us that rational people only maximize and defend

their possessions, that wealth is the measure of worth. But this denies half of what makes us human. Education and socialization can make us more like the economic model of perfection but only by making us miserable. What has for millennia been critical for human survival is also essential to making us happy.

Dr Michael Pirson, founder of the Humanistic Management Network,[49] is countering the neoliberal pathology with a global network of scientists and academics using the best of modern science[50] to emphasize respect for human dignity. This approach is spreading, helping organizations become caring communities to produce wider benefits.[51] Positive Psychology practitioners[52] study what makes people happy, fully functioning humans, not what makes them neurotic and self-destructive. Biologists explore the "wood wide web,"[53] the notion that in nature organisms communicate and cooperate more than they engage in cutthroat competition. Policy officials at OECD and in various national governments develop Better Life Initiatives,[54] move beyond GDP,[55] and create happiness indexes.[56]

The best businesses operate on this basis. When Paul Polman, CEO of Unilever, rejected a lucrative offer from corporate raiders to take over his company, he replied that his obligation was not to owners, but to the world as a whole.[57] "Do you run this for society or not?" Polman queried,[58] answering, "The real purpose of business has always been to come up with solutions." Unilever stock soared 300% under his leadership, the raiders' stock suffered a 124% decline.

It Doesn't Work

Neoliberal, business-as-usual capitalism has created a planetary emergency.[59] The triple threats of the climate crisis,[60] inequality,[61] and biodiversity loss,[62] if not reversed, will drive civilizational collapse.[63] The inequality created by industrial capitalism already causes appalling death rates among the millions of slum dwellers in the megacities of Asia, Africa, and Latin America.[64] Inequality now concerns even the apologists of capitalism.[65] The loss of the planet's wild spaces and intact ecosystems is spreading pandemics.[66]

Neoliberal mythology aside, there are no free markets. Classical economists identified 18 aspects that must characterize free markets. None are present in what we call markets today.[67] Market theory assumes that all actors have perfect information. Was this ever true? There are assumed to be no barriers to entry, or to exit. There must be equitable access to capital.

Few assumptions could be further from the truth today. Adam Smith was clear that markets only serve the common good when no buyers or sellers have enough power to affect market outcomes, and when all players are moral actors. Seriously?! In most markets, neither of these conditions exists. Antitrust policies, however poorly implemented by nations, are nonexistent at the international level. Digital platforms like Google and Facebook (which along with Netflix and Amazon are called FANG) are creating powerful new international monopolies that drive "winner takes all" outcomes, economically, and increasingly, politically.[68]

Market ideologues even reject policies to address monopolies as interference with the free operation of the market. But without them, markets cease to be anything but a cruel fraud. When companies become more powerful than most nations, change is needed. Unless we reduce national and international inequality, control monopolies, and oligopolies and ensure that we live within the earth's means, capitalism itself is at risk. As businessman Ray Anderson asked, "What's the business case for ending life on earth?"

Market forces are powerful, but they must be managed. Industry apologists suggest that all the economy needs is government to get off the back of business. That's like a bad light bulb joke: How many economists does it take to screw in a more efficient light bulb? None, the free market will do it.

Except it won't.

Regulations that ensure the fair operation of markets safeguard public services. Ball bearing factories and local restaurants need little management outside of rules to ensure fair employment and health and safety. But zealotry about evil regulations serves us badly. What one set of players label "burdensome" are precisely what another, typically less powerful set, calls "protection."

Well-managed markets can empower the new narrative of an economy in service to life. Markets make good servants, but bad masters. They're a terrible religion.

Bernard Lietaer points out that Homo sapiens has:[69]

> …this odd tendency to create a world, forget that we have created it, and then throw up our hands and proclaim our inability to change the system. Capitalism (and socialism for that matter, which is equally unsustainable) is not a set of natural laws that Adam Smith discovered. It is our creation, constantly evolving and changing.

People hunger for a sense of who they are, where they belong and what they believe in. Think about it. You are here because your distant ancestors cared more for the good of the whole than any one of them cared for themsleves. It's literally in your DNA to care, and to act to create a greater good.

Capitalism, as currently practiced, has brought our world to the verge of collapse, made us all poorer and less equal, and failed to make us happy. It's time to ask what will. And the answer is not undifferentiated growth.

9

Moving beyond limits to growth: Solidarity capitalism

Dr Ndidi Nnoli-Edozien

Chair/Founder, Growing Businesses Foundation
& Circular Economy Innovation Partnership
Member of the Club of Rome Executive Committee

Introduction

In 1972, the Club of Rome globally published *The Limits to Growth* report, which accurately posited that a planetary emergency would arise if "growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged." Sadly, the Club of Rome's report and warnings went largely unheeded. The flawed, exploitative, profit-oriented practices that allowed for many of these trends continued unabated, even as the predicted consequences permeated the world.

If the prediction seemed dire 50 years ago, it is worse now that the future scenarios, discussed in the report, are becoming a reality. "Emerging from Emergency" is a term we often refer to at the Club of Rome. We find ourselves needing larger quantities of the earth's resources as they grow more limited (pun intended) at an exponential rate. Surely, we now see that the unrepentant pursuit of self-interest and business-as-usual, profit-centric capitalism is a recipe for human extinction. Our world urgently needs a

framework in which financial and economic structures are more inclusive and sustainable, and where balancing the needs of both humanity and nature takes precedence over the limitless growth pursued in the name of profit and progress. The question is: how do we ensure that capitalist agents engage with this awareness differently now?

Given the planetary emergency we find ourselves in, the rationale behind the law of demand and supply, for example, should no longer hold true without healthy debate. Rather, we must strike a new balance, considering not just those who demand and can afford access to resources, but also those who have needs and good cause to make demands but are denied their seat at the table. "Solidarity Capitalism", in this context, speaks to a new understanding and approach to managing our economic and financial systems that becomes essential if humanity is to collectively address the challenge of climate change and the Sustainable Development Goals (SDGs), among other things. We will explore what is required to enable the implementation of such a model by shifting from an individualistic capitalist ideology to one of solidarity, wherein the common good is safeguarded in tandem with the pursuit of self-interest. This shift, when consciously applied to global best practice, could enable agents of capitalism to serve stakeholders and not just be held to ransom by a privileged few.

Shifting from mainstream capitalism to Solidarity Capitalism

The capitalist ideology has influenced predominant consumption and production patterns. It underlies the governing principles of the prevailing economic systems that accelerated depletion of the earth's resources and exacerbated global inequity and attendant conflicts. There is, however, a diverse range of perspectives that could, and should, shape our emerging global socio-economic systems if we choose to prioritize the earth – perspectives that underscore our duty as human beings to support the regenerative systems of natural ecosystems. In essence, we need to find ways to fast-track humanity's learning curve and seek inspiration to act in unison with nature. In alignment with Solidarity Capitalism, one must recognize that, in your own space, you are acting alone but in collaboration with a range of actors as interdependent on you as you are on them.

Promoting Solidarity Capitalism is not about introducing the world to an alternative terminology for capitalism, but more about embedding the

ideas of solidarity and social responsibility into the ideals and culture of how businesses and economic systems are managed. The Club of Rome founder, Aurelio Peccei, came to the realization that unless there is a human re-evaluation of our cultural framing, we will not make much progress. Our challenge is that after a while, we no longer see the system – we become blind to it – just as we become oblivious to the cultural frameworks in which we operate. We build on flawed values and belief systems, which we no longer think to question. In this way, Solidarity Capitalism is not just about saying or even doing things in a socially responsive fashion but rather also about changing mindsets, re-engineering the system, building an internal framework that draws from a multiverse of perspectives and sets the minimum benchmark for innovation to be in service of Life at large.

This means that we must choose to build regenerative, not exploitative, systems such that natural-resource management strategies become circular, emphasizing reuse, sharing, repairing, refurbishing, remanufacturing, and recycling. This requires going beyond minimizing the use of natural capital to ensure outright elimination – not just mitigation – of waste, pollution, carbon emissions, etc. The Igbo people, who originate in Nigeria, have this circularity thinking embedded in their approach to life and death, which was considered a continuum that enabled the transfer of knowledge across generations. In traditional society, the unborn and the young – the future – have a special bond with the elders and the ancestors – the past. It is believed that the unborn and the ancestors have the strongest connection to the spiritual realm, which also creates their unique bond. This lends credence and substance, supported by underlying belief systems, to the very important intergenerational dialogue that is needed to address our global state of emergency. As part of this transgenerational dialogue, we need to consciously cultivate a mindset that embraces diversity, consciously opting for a pluriverse in which the voice of youth and indigenous wisdom has a place.

We should intentionally opt for collective accountability and responsibility in creating the new future. This creates new possibilities of economic access, equity, social justice, facilitating connection, and a sense of belonging for all – solidarity. If humanity collaborates across race, gender, age, culture, polity, geographic location, and inherent belief systems we can protect and co-inhabit this planet. In this regard, traditional jurisprudence systems, as practised by the Igbo, where human life and a healthy ecosystem co-existed in harmony, as well as kinship systems like "Umunne" (children of the same mother) and "Ummuna" (children of the same father), can be reapplied to

modern thinking, reasoning, and solution-building. With this understanding, private corporations would no longer consider corporate social responsibility or philanthropy as optional, but rather be required to ensure that their accountability includes creating enduring value for all.

All these suggestions that encourage the fulfilment of equitable human aspirations in alignment with sustainability principles that protect the earth, humanity – both as the individual and community of persons – and the economy as a regressive living system can be collectively called Solidarity Capitalism. I believe it is possible to model a new kind of capitalism by rethinking, designing, and co-creating a system that serves the community as opposed to only prioritizing the interests of a select number of individuals who work within the community. This is the challenge Solidarity Capitalism embraces.

For answers, Solidarity Capitalism as an idea, or academic concept, would encourage autonomous thinking by aligning the sense of community and social responsibility with the capitalist model. The capitalist model, of course, speaks to the pursuit of self-interest and profits and the allocation of scarce resources in accordance with the laws of demand and supply. However, this capitalist model is currently so embedded in the prevailing education system that we have become less open to new thinking and innovation. Introducing new perspectives to tested and tried models, such as the term Solidarity Capitalism implies, could impact the education system by encouraging an idea of capitalism that allows people to think for themselves and also think about others. This solves the issue of being blinded by the system rather than redesigning the system for the benefit of the common good.

Solidarity Capitalism as an ethical concept, as well as an economic model, ensures that we accompany the switch from a shareholder-centric to a stakeholder-focused model with ethical principles that include fairness and equity. The opportunity to consider indigenous cultures' community and solidarity principles, and how these feed into modern capitalism, also offers new perspectives on reframing economics, and rethinking finance and capitalism. So, looking at Solidarity Capitalism from a range of indigenous perspectives could offer new solutions on how to organize our economic systems and create impacts similar to the shift from the linear to the circular economy. The Frankfurt-Hohenheimer Leitfaden, which are guidelines for the ethical assessment of companies, called this important principle out as *kulturverträglichkeit*, or cultural compatibility, which also laid the foundations for the world's first ethical-ecological rating, and also became the foundation for the Seven Pillars approach to sustainability, which was applied to embed sustainability thinking, action, and reporting in Africa's largest business.

Pragmatically speaking, by our embracing the term Solidarity Capitalism we can serve as an influencer for the way economic systems are managed. For instance, in developing new frameworks for sustainable finance and how the capitalist model addresses market failures, such as unemployment and inflation, which in turn create all manner of secondary impacts. The opportunity here is for Solidarity Capitalism, as an alternative lens, to ensure our mindless approach of business-as-usual is curbed and we emerge from this planetary emergency in a stronger position to address societal and environmental challenges as well as explore new business and life opportunities.

One practical manifestation of such a shift would be the move from a linear economic model of "take – make – waste" to nurture a more circular model that ensures the sustainable management of natural resources for the good of all at the level of the individual (and community), the corporation, and government.

Conceptually, therefore, bringing solidarity and capitalism together as a theoretical idea and applying this to the sustainable finance track, for instance, gives us an opportunity to practically address longstanding market failures from a different perspective. When we consider the fact that the world is racing away from credit and risk ratings that have a purely financial focus towards those that incorporate environmental, social, and governance (ESG) factors, we have cause to hope that this transition we are in goes more than skin deep.

Shifting from "no limits to growth" and embracing "no limits to learning"

What should be understood is that Solidarity Capitalism is not just about the terminology, but rather about seizing the opportunity to merge the old with the new by allowing a multiverse of viewpoints to truly cross-pollinate. It is about achieving the interests of the business while keeping the interests of the community and society in mind. To achieve the change we seek, we need to start somewhere. Beyond reflecting upon how to act on insights gained from *The Limits to Growth* report, we must declare there to be "No Limits to Learning", and we must show the way! This is in order to initiate a mindset shift to more solidarity-based outcomes and firmly set us on our path to regenerative growth and a state of sustainable wellbeing for all. Part of this lifelong learning journey requires each of us to seize the opportunity of merging the old with the new, allowing a multiverse of viewpoints to

truly cross-pollinate. This involves being open to learning from collaborative approaches, such as have been practised by resilient, indigenous cultural worldviews, and embodied in indigenous African philosophies, such as Ubuntu and Umunne/a, curated over centuries to promote communalism.

By going back to being indigenous again, we are not going backwards, but rather innovating on millions of years of nature's intelligence, our common heritage. Whether we call it Ubuntu or Umunne, which in this context are used interchangeably, it is time to draw on traditional knowledge systems to build a capitalism that is geared towards a decided solidarity consciousness. Such cultural beliefs, applied to modern systems thinking, can serve as a basis for rethinking and restructuring the global economy. We need a world where a pluriverse of cultures may feed each other in a continuous learning process. We need a world system founded on new thinking which merges the old and the new, with the term Solidarity Capitalism being a case in point. This is why we need to go back to our roots, back to what we used to do in order to ask: What do we really need, why, and what for?

Repositioning indigenous cultural frameworks

Currently, very few individuals have negotiated their way to the modern perspective and way of life without losing their indigenous and traditional knowledge systems that are anchored in communities where knowledge systems operate across cultures. There is a diverse range of perspectives that could, and should, shape our emerging global socio-economic systems if we choose to remove the blindfolds shielding us from seeing the ancient paths and what they offer. The model of Solidarity Capitalism put forward here is modelled after the African concepts of Ubuntu and, closer to my own cultural heritage, Umunne/a, in order to underscore the fact that solidarity principles already existed at the core of some indigenous cultures.

Solidarity Capitalism seeks to bring new perspectives and mindsets to the table, such that capitalism is opened up to new concepts from other cultures. For instance, Igbo models of land ownership where the absolute right to use (and even destroy) property did not exist but rather ownership was conferred as a form of trusteeship and owners were seen as custodians of resources with a duty to safeguard them for future generations. Even more important was that the self-worth of an individual was intricately linked by their existence as a member of the community. In bringing together solidarity and capitalism, we can rethink existing economic and financial frameworks while

prioritizing our common interest to rebuild a society that does not exist at the expense of retaining a healthy, regenerative ecosystem. By allowing more interdependencies to arise from an openness to the pluriverse of views that is our common heritage, we may find better ways to work across cultures and find a common denominator that goes beyond profits to aspire to prosperity for all. We need to go beyond standardizing financial and economic systems to incorporate more holistic thinking.

In traditional Igbo society, for instance, the economy is considered as a living system that brings together people as economic actors, but also as community members co-existing in harmony (and solidarity) with each other and nature. Nature itself was considered to be the custodian of culture, which may be why culture "Omenani" or "Omenala" in Igbo had as core to her meaning the word earth, "Ala" or "Ani". As such, any crime against humanity was also a crime against the earth. Mother Earth was trusted to safeguard balance and ensure equity was served among humans, even as she was offered thanks for nurturing the flora and fauna that grew and nourished our human bodies. In traditional Igbo culture, individual and communal welfare co-existed in harmony with nature, which was accorded legal personhood, at the very least in the spiritual realm. This belief system of the Igbo has persisted until today and shows up in the Igbo attachment to their ancestral lands. Such cultural beliefs, applied to modern systems thinking, can serve as a basis for rethinking and restructuring the global economy.

We need to allow for cultural adaptability. This is because the commonality, interconnectedness, and interdependence of the human person and nature has many dimensions; human consciousness can manifest communally, economically, financially, socially, culturally, and environmentally. Sadly, the individualistic perspective of Western societies has tended to clash with the more communalistic cultures and undermines such holistic thinking. As such, rather than being enriched by a pluriverse of views, modern capitalism has crowded others out. Notwithstanding, the importance of culture as a perspective and influence cannot be underestimated.

Beyond learning from Igbo traditional jurisprudence, it is important to acknowledge that, at the most subsidiary level (community) and the highest degree of solidarity (globally), our multiverse of cultures share more in common than what sets them apart. In fact, the values promoted by Igbo culture alone, though hardly recognized in the global community, share key principles with contemporary global aspirations, as pronounced by the United Nations Charter:

- to maintain (international) peace and security
- to develop friendly relations (among nations) based on respect for the principle of equal rights and self-determination of peoples
- to cooperate in solving (international) economic, social, cultural, and humanitarian problems and in promoting respect for human rights and fundamental freedoms

Relating Solidarity Capitalism to the Digital for Life movement

Now, more than ever, is the time to work together on communal harmony and cross-cultural learning. The state of emergency we all face today presents us with an opportunity to value collaborative approaches over and above competitiveness, thus offering a new ray of hope. People are not just part of the problem, we are also key to finding solutions. The time is right to look to natural and indigenous knowledge systems to redesign a new way forward, learning from the past and acting in the present with the future in mind. If we can reconnect with life at large, then humanity becomes the solution, and not the problem, in redefining economic models to build and support a more regenerative way that humans interact with the earth. This is also a unique age for collaboration because we have technologies emerging that humankind never had access to before and which are changing the way that we live, engage, and contract. Digital technology can connect communities, people, and systems together. It transcends the artificial barriers that arose by virtue of geography, language, gender, etc. However, technology must be about enhancing life – human and natural – and we must contemplate ethics in this regard.

New ideas are emerging, and digitalization is progressing much faster than many of us can keep up with. It is clear that unless we design systems that tap into the right core values, we are not going to bring nature systems into our economic models. Yet, with solid motives, the ongoing digital transformation can be a powerful force for good when it comes to the achievement of human potential. In terms of applying new technologies, we could design a new financial architecture to address the needs of people at the base of the pyramid. So, let's focus on the universal language of the Sustainable Development Goals. For instance, how to finance the SDGs, e.g., Goal 1, 2, 3, etc. What kind of creative innovation and market design could be initiated to make the money flow to enable the society? Often the problem is not lack

of money, but rather that the flow of resources and their access is skewed. So how do we make money flow into things that relate to the goals?

We could rebuild trust through smart contracts and decentralized finance – peer-to-peer lending. This is what blockchain offers. Blockchain technology has the potential to transcend the reach of the international development and finance community, if we deploy it properly. With all its flaws, this technology offers a case study for disrupting the centralized, top-down finance model that is currently mainstream in building a peer-to-peer financing model. How we use blockchain to enhance and achieve the goals we set ourselves for sustainability in the achievement of globally equitable aspirations, while curbing unbridled consumption, will only be achieved when we have a mindset that aligns private interest with the common good.

Aligning with, and co-creating, the Digital for Life movement is an aspirational goal for the concept of Solidarity Capitalism. One way that it will be achieved is by connecting the potential of blockchain to address the day-to-day needs of those facing adversity across the world. While there are questions raised about blockchain and its negative externalities, with the right thinking, e.g., prioritizing building prosperity over making profits, there is an opportunity to create major mindset shifts and systems change. Can blockchain create a new age of service companies and technologies that serve, not exploit, people and nature? Can we dare to imagine a living system where Solidarity Capitalism, not individualism, survival of the fittest, self-interest, or competitiveness comes first, but rather solidarity principles whereby we value ourselves in relation to the wider ecosystem?

Conclusion

In the *No Limits to Learning* report, the Club of Rome founder, Aurelio Peccei, talked about a human re-evaluation of our cultural framing. My mentor's favourite line was, "It's not what you don't know that's the problem, it's what you know for sure that just ain't so." So it is that we become oblivious to the cultural frameworks in which we operate, and then build on flawed values and belief systems. Unfortunately, our education systems are themselves steeped in values and belief systems that blind us further. As such, modern capitalism and its flaws have come to negate our intuitive ability to think independently and challenge the system and direct the manner in which many national economies are governed. All of this we must address by engendering a mindset shift.

To remodel modern capitalism as a system that serves humanity and the planet, we are well served to view the economy as a living system that exists to protect the wellbeing of all. This process must commence with us questioning the thinking that underlies our thinking. It means taking a holistic point of view, incorporating alternate cultural ways of living in harmony with nature, and each other, as essential elements to achieve our transformational aspirations. Mindset shifts will need to be actively supported by raising awareness, reappraising our education systems in theory and practice, empowering communities and their cultural best practices, challenging leadership, and integrating the oft unheard voices of the youth, nature, and other marginalized perspectives all too often ignored or suppressed. This integration of diverse cultural perspectives not only enriches discussion but also offers hope that we can collaboratively arrive at new ways to address this issue of the planetary emergency, ecologically, socially and economically, locally and globally, together.

As such, we would have new goals for humanity. We would embed solidarity in modern capitalism, both as a social principle – to ensure we serve the common good – and as an ethical principle – to ensure fairness and equity – with considerations at the personal, corporate, and governmental levels. We would enable individuals to move from a self-interest-driven to a shared-value-creation mindset. We would facilitate corporations to shift from a profit-centred business paradigm to one built around holistic value creation (socially, economically, environmentally, etc.). Finally, we would require governments to step away from old-school policies to instead nurture a new way of thinking and doing business that ensures that the capitalist system earns its social licence to operate.

10

Bhutan and beyond: The emergence of wellbeing economies

Dr Julia C. Kim*

Program Director, GNH Centre Bhutan

A powerful shift in perspective

On 24 Dec 1968, the Apollo 8 mission, the first crewed voyage to orbit the moon, gave us a breathtaking glimpse of planet Earth rising like a glistening jewel above the dusky surface of the moon. In that instant, the now iconic Earthrise image held up a remarkable, consciousness-shifting mirror to our beautiful and fragile planetary home. The image has since been credited with propelling the environmental movement that would lead to the first Earth Day in 1970.[1] What is remarkable is that during this same period, three separate events raised powerful and equally paradigm-shifting questions about the deeper meaning, and continued viability, of our human presence on planet Earth. All three centred around the concept and consequences of what we call "growth".

* Aspects of this paper were originally published in "Weaving Wellbeing into the Fabric of the Economy: Bhutan's Journey Towards Gross National Happiness" by Kim JC, Richardson JA, and Tenzin T, in: *Toward an Integrated Science of Wellbeing* ed. Rieger E, Costanza R, Kubiszewski I, and Dugdale P, Oxford University Press (in press) and have been reproduced by permission of Oxford University.

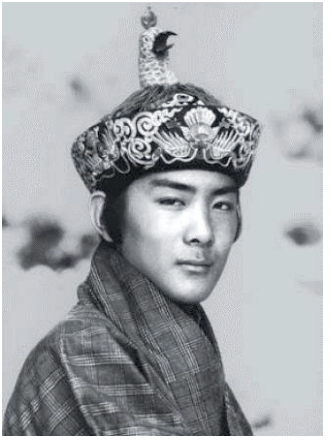
The first took place at the University of Kansas on 18 March 1968, when a young US Senator and presidential hopeful named Robert Kennedy delivered a now historic speech in which he criticized the prevailing measure of economic growth, Gross National Product (GNP). Since World War II, most countries around the world had come to use GNP (now GDP or Gross Domestic Product) as their core metric for prosperity. But as Kennedy rightly pointed out, it is a deeply flawed measure because it counts all marketed economic activity as *positive*, even when it leads to air pollution, the destruction of redwood forests, the production of nuclear warheads, or "armored cars for the police to fight the riots in our cities." Moreover, as he noted, it *fails* to measure, and therefore to value, those qualities and activities that fall outside the market, yet undeniably shape our wellbeing – such as good health, creativity, caring communities, and the integrity of our political systems. As Kennedy concluded: "it measures everything in short, except that which makes life worthwhile".[2] This prescient critique of chasing GDP growth did not gather further momentum at the time. Three months later, while on a successful campaign tour in California, Robert Kennedy's life was tragically cut short by an assassin's bullet. Yet today, these words are regarded as having planted the seeds for a global "Beyond GDP" movement – one that is now gathering momentum – to challenge and redefine the meaning and metrics of our growth paradigm.[3,4]

Earthrise: Photo by Apollo 8 astronaut William Anders (1968)

Senator Robert Kennedy (1968)

The second event unfolded shortly after Kennedy's speech, when in 1972 the Club of Rome published *The Limits to Growth*. A team of researchers at MIT wanted to understand the potential consequences of exponential economic and population growth on a planet with finite resources. Using computer simulations to generate future scenarios, their report concluded that without substantial changes in resource

consumption, the most probable result would be a sudden and uncontrollable decline in both population and industrial capacity.[5] The report sent a shock wave through media, scientific, and policy circles, and although some of its methods and premises were vigorously challenged upon its publication, recent work to validate its forecasts continues to confirm that since then we have not made sufficient changes to significantly alter their warning message.[6] If Kennedy's speech highlighted the folly of our single-minded pursuit of GDP growth, *The Limits to Growth* analysed and further clarified the potentially catastrophic consequences of the resulting resource consumption on a planetary scale.



HM Jigme Singye Wangchuck, 4th King of Bhutan

At the same time, halfway around the world, amidst the majestic Himalayan mountains, another event was quietly setting in motion the possibility of an alternative vision. Bhutan's Fourth King, Jigme Singye Wangchuck, having ascended to the throne in 1972, was asked by a reporter about his country's GNP. Instead of responding with a numerical figure, His Majesty replied that in Bhutan, Gross National Happiness is more important than Gross National Product.[7,8] In so doing, the young king expressed his vision that as the country began to expand its engagement with the modern world, the happiness and wellbeing of its people – rather than the nation's economic output – would be the focus of development. In that moment, the king's articulation of Gross National Happiness (GNH) planted the seed of a response to Kennedy's critique of GNP, raising the possibility of radically shifting our perspective on measuring what matters.

Fifty years on, much has changed. Amidst unprecedented heat waves and extreme climate events, the impact of our continued growth and consumption on a planet with finite resources is now foremost in our collective awareness. And since the time of the Apollo mission, the driving force behind space travel has now shifted from governments to the pocketbooks of a handful of billionaires. Rather than inspiring a sense of hope in our collective human potential, this privatized "billionaire space race" has been greeted as a spectacle of ego-driven self-interest – a test run for the privileged few, eager to escape the planetary crisis unleashed by the very economic system

that enabled the accumulation of such extreme personal wealth in the first place.[9] And yet, there is also cause for hope. As we will see, Bhutan's bold, national-level experiment of GNH has now been joined by a growing range of "wellbeing economy" initiatives that are beginning to show what is possible when wellbeing of people and planet, rather than GDP growth, is prioritized as the purpose of the economy. Moreover, important new findings from diverse disciplines including modern neuroscience, are highlighting the power of cultivating "inner leadership" capacities, and transforming mind-sets and behaviour – as part of the wider systems change needed to amplify these emerging economies of wellbeing.

Re-imagining the purpose of the economy: Bhutan and Gross National Happiness

Bhutan's development approach of GNH is unique in several ways. First, it articulates happiness and wellbeing (rather than economic growth) as the purpose of the economy. It is important to note that the term "happiness" here does not refer to the transient "feel-good" emotion or state often associated with the word in Western cultures.[8] Rather, happiness in GNH is viewed as being deeply relational – emphasizing responsibility, harmony with nature, and concern for the wellbeing of others. In the words of Bhutan's first Prime Minister Jigme Thinley:

> True abiding happiness cannot exist while others suffer, and comes only from serving others, living in harmony with nature, and realising our innate wisdom and the true and brilliant nature of our own minds.[10]

Consequently, principles of interconnectedness, sufficiency, service, and self-cultivation, are regarded as part of the integration of "material and spiritual development" that is intrinsic to GNH.[8] This relates to the second unique aspect of GNH – that it places an equal emphasis on cultivating both the *outer* factors (an enabling environment) and *inner* conditions (values and mindsets) to support a society oriented towards wellbeing. A third, and related, aspect of GNH is its reference to cultivating a form of leadership that could be described as "leadership of the self". The importance of leading from the inside out is captured in an address by His Majesty the 5th King of Bhutan who urges citizens to live their lives guided by values of kindness, integrity, and justice. As he notes, in order to bring positive change in the

world – to eradicate poverty, reduce inequalities, reverse environmental degradation, and improve healthcare – we need to actively seek out "leadership of the self", rather than leaders to lead the masses.[11] In Bhutan, this cultivation of self-leadership has historically been supported by a living tradition of Buddhist ethics, philosophy, meditation, and related spiritual practices. These are seen as vital for cultivating awareness and insight into the interconnectedness of all life, and for nourishing compassionate behaviours rooted in appreciation, empathy, and generosity.[12]

Measuring what matters: Moving from vision to action

Gross National Happiness aims to measure national progress in a more holistic way – as the sum total not only of economic output, but also of environmental impacts, the spiritual and cultural growth of citizens, their mental and physical health, and the strength of corporate and political systems. The GNH survey tool collects national data across nine GNH "domains" that collectively create the enabling conditions for happiness and wellbeing.[8] While many national surveys also routinely collect data on health, living standards, education, and the environment, Bhutan's survey goes further to include more intangible, but no less important domains, including time use, psychological wellbeing, community vitality, good governance, and cultural diversity and resilience. To align government decision-making with these priorities, the GNH Commission applies a GNH policy-screening tool to assess the impacts of proposed projects and policies on wellbeing. The Commission also applies the nine domains to guide resource allocation and to set targets in the country's Five-Year Plans.[13]

To date, Bhutan has conducted three rounds of GNH surveys, and introduced a range of policies to promote sustainable and equitable development, while preserving its unique cultural heritage. The country has seen impressive gains in key social indicators, including a reduction in poverty and infant mortality rates, rising life expectancy, and substantial increases in primary school enrolment.[14] Between 2005 and 2018, Bhutan's Human Development Index increased by 20.5%, positioning the country in the Middle Human Development Category.[15] All of this has been accomplished while making a peaceful transition to a democratic constitutional monarchy, and earning the distinction of becoming the world's first carbon *negative* country.[16] In many ways, GNH is a bold and vitally important work-in-progress, and its leaders

remain aware of both the opportunities and challenges that lie ahead.[17] In the words of former Prime Minister Thinley: "Bhutan is not a country that has attained GNH… Like most developing nations, we are struggling with the challenge of fulfilling the basic needs of our people. What separates us, however, from most others is that we have made happiness, the most fundamental of human needs, as the goal of societal change."[18] Moreover, given the interdependence between Bhutan and the global community, it is clear that a movement towards Wellbeing Economies cannot be pursued in isolation. As one Bhutanese minister succinctly put it: "we cannot be a GNH bubble in a GDP world".[19]

Beyond Bhutan: A growing movement towards Wellbeing Economies

In the wake of the overlapping global impacts of the Covid-19 pandemic, accelerated climate emergencies, and intensifying social crises, we are now witnessing heightened interest in a range of Wellbeing Economy models that replace the goals and metrics of economic growth with the flourishing of people and planet.[20,3,21] For example, economist Kate Raworth has introduced a range of indicators to measure planetary and social boundaries[22]; The Happy Planet index[23] tracks progress in life expectancy, inequality, ecological footprint, and qualitative indicators of wellbeing; and the OECD has launched its Better Life Index.[24] In order to support these important efforts, initiatives such as the Wellbeing Economy Governments (WEGo) partnership are bringing together national and regional governments (including Scotland, New Zealand, Iceland, Wales, and Finland) to share experiences and broaden commitment to wellbeing economies more broadly.[25]

Moreover, where a national or government-led effort may not initially be feasible, it is possible to introduce wellbeing metrics and approaches at smaller scales. Indeed, this combination of "top-down" and "bottom-up" approaches may be a vital strategy for shifting from the current GDP growth paradigm towards an economy centred on wellbeing. To this end, the GNH Centre Bhutan has been collaborating with international partners including Schumacher College (UK), the Global Leadership Academy (Germany), the Presencing Institute (USA), and the Robert Wood Johnson Foundation (USA) to develop a range of transformative action learning programs geared towards wellbeing economy innovation and leadership at individual, institutional, and local governance levels.[17] In this sense, GNH is not so much a

static model to be standardized and replicated out, but rather points to a profound shift in how the purpose of the economy is viewed, accompanied by a dynamic process that can be applied in response to a specific, evolving context.[12] In this way, a *culture of equity and wellbeing* can be grown from the grassroots level, cultivating fertile soil for the seeds of new national-level wellbeing measures and policies to take root.[26]

The Global Wellbeing Lab (Bhutan, 2013)

The importance of shifting mindsets and paradigms

> People don't need enormous cars; they need admiration and respect. They don't need a constant stream of new clothes; they need to feel that others consider them to be attractive, and they need excitement and variety and beauty. People don't need electronic entertainment; they need something interesting to occupy their minds and emotions… Trying to fill real but nonmaterial needs – for identity, community, self-esteem, challenge, love, joy – with material things, is to set up an unquenchable appetite for false solutions to never-satisfied longings.
>
> — Donella Meadows[27]

One of the enduring contributions of GNH has been the clear articulation by Bhutan's leaders of the importance of balancing both material and spiritual development or, expressed differently, the tangible and intangible

aspects of happiness. In contrast to a GDP-based paradigm, this concept of happiness suggests a higher purpose for development – one that encompasses the realisation of our individual and collective human potential, in balance with the natural world. While this approach has been historically supported by the cultural heritage and leadership of Bhutan, it would be a mistake to dismiss it as the product of a primarily Buddhist or Eastern world view. As economist Jeffrey Sachs has pointed out, Aristotle considered happiness and a meaningful life – "eudaemonia" – to be the highest human good, and one which was accompanied by virtues including moderation, justice, courage, and wisdom.[28] Similarly, when Robert Kennedy cautioned against the dangers of pursuing GDP growth, he spoke of an inner "poverty of satisfaction, purpose, and dignity" that was the price of surrendering our highest aspirations and community values "in the mere accumulation of material things".[2]

One of the tragedies of the modern neoliberal economic system, is how it has reduced this vision of human possibility to the caricature of "Homo economicus" – solitary, calculating, competing, and insatiable – promoting this pattern of behaviour, to the extent that it is now widening inequities, eroding communities and endangering our planet.[22] As Tim Kasser notes, in the United States, shopping has been marketed as a civic responsibility for more than a century to the extent that the word *citizen* has slowly come to be replaced by the word *consumer* in popular media.[29] At the same time, structural factors, including the decline of community and social connection, the intensification of inequality, the rise of mass media, and changes in the labour market have contributed to a growing aspirational gap.[30,31] As a result, for many, shopping is no longer about gathering the resources necessary for a safe and happy life. Over time, it has become an expression of personal identity and social status, as well as a form of entertainment or distraction.[32] As Adam Lerner notes, "in a society where consumption has become one of the only ways for the individual to exercise power, we consume as an aspirational response… No wonder breaking our consumptive habits proves so difficult and that increases in income and consumption have little to no benefit on our overall wellbeing while simultaneously harming the planet."[30]

Inner transformation and systems change: Leadership for Wellbeing Economies

> Because mindsets and paradigms guide behaviours, changing them can have a profound impact… People who manage to intervene in systems at the level of paradigm hit a leverage point that totally transforms systems.
>
> — Donella Meadows[33]

To date, efforts to promote sustainable development have been guided and driven largely by technical, economic, and policy interventions and expertise.[34] Important as these may be, without *simultaneously* shifting values and mindsets, they will not be enough to inspire the deeply transformative societal changes required for a paradigm shift towards wellbeing economies.[35,36] Indeed, one of the critical challenges of the 21st century will be to recognize the interdependence between the economic systems we ultimately create and the awareness, or consciousness, of those participating in their creation. In other words, self-leadership matters:

> The success of our actions as change-makers does not depend on what we do or how we do it, but on the inner place from which we operate… We cannot transform the behavior of systems unless we transform the quality of attention that people apply to their actions within those systems, both individually and collectively.
>
> — Otto Scharmer[37]

In this respect, the notion of "leadership of the self" has implications for wellbeing economies beyond the borders of Bhutan. A growing body of research and practice indicates that leading from the inside out requires a new set of skills and capacities that can be cultivated at both individual and collective levels.[34,38] Bringing together ancient wisdom traditions and modern neuroscience, new initiatives are beginning to strengthen inner leadership capacities, including *awareness*, *connection*, *insight*, and *purpose*, and integrating them within key areas including education, healthcare, and business, as well as climate and social justice activism.[39,40]

My own approach to the fields of global health, sustainable development, and wellbeing economics has gradually shifted over the past decade to deliberately incorporate such inner, transformative leadership dimensions.

Through action learning platforms, such as the Right Livelihood and GNH programme, the GNH Centre Bhutan and partners have brought together participants from business, banking, healthcare, education, social justice, and philanthropy to explore wellbeing economy innovation and leadership at individual and collective levels. In addition to encouraging wellbeing projects and prototypes, the programmes have drawn on a range of skills and resources to cultivate leadership of the self. Starting with a personal inquiry or challenge related to cultivating wellbeing in their own life, workplace, or local economy, participants are invited to observe their current situation and the wider systems of which they are a part. Going beyond the usual modes of intellectual analysis and evaluation, they explore more nuanced ways of perceiving, interacting, and knowing. These include developing greater awareness of one's own mind, mindsets, and values; practising progressive levels of listening; perceiving the wider system through engagement with diverse stakeholders and environments; and attuning to one's own embodied experience through a range of methodologies.[41,42,43,44,45,46] Reflecting the relationship between inner and outer transformation, some programme participants have described experiences of personal wellbeing arising from shifts in perception that clarified a sense of purpose and meaning in their own life. This inner alignment in turn equipped them with the motivation, courage, and skills to enact new behaviours and life choices, and to apply wellbeing economy values, metrics and principles in their own sectors and spheres of influence.[12]

In applying wellbeing metrics such as GNH to a range of contexts, there is an opportunity to expand our understanding of how such data can be used to shape systems change in ways that acknowledge and engage with the fluid and complex dynamics of living systems. Nora Bateson[47] has made an important distinction between cold and warm data. "Cold data" refers to the conventional *quantitative data* that is used, for example, to capture wellbeing indicators, such as income per capita or environmental impact. "Warm data" on the other hand, refers to the fluid, *qualitative dynamics* of systems, and calls attention to the interrelationships that underpin cold data, including important information about systems change leverage points. Building on collaborative work with the GNH Centre, Richardson extends this framework to incorporate "hot data" which refers to *qualities of awareness* that are brought to engagement with inter-relational processes.[48] Drawing on the inner leadership skills described earlier, hot data refers to a more conscious engagement with stakeholders and evolving circumstances, to notice and

shape emergent change processes. Table 1 summaries these different forms of data and their ontological roots.

Table 1: Cold, warm, and hot data as applied to GNH[48]

	Cold data	**Warm data**	**Hot data**
Description	**Objective** (separation of subject & object), measurement of visible forms, de-contextualized	Immersing in **relational** processes, dynamic networks & complex systems, contextualized	Cultivating capacity for **awareness** of relational processes; more conscious interaction to notice & shape emergent processes
Ontological roots	Newtonian science	Complexity science	Contemplative sciences & traditions
Example	GNH index & surveys	Adapting GNH metrics & approaches in relationship to new actors or contexts	While adapting, cultivating awareness – to shift mindsets, and ultimately, behaviors & actions

Each form of data has its respective utility and applications, and taken together, can shed light on GNH and wellbeing economies in different ways. For example, cold data refers to the GNH measurement index which provides a useful snapshot of wellbeing measures at a particular temporal point and country context. "Warm data", on the other hand, is activated when the GNH metrics and approach are adapted to a different community or context, in relationship with new actors. Finally, "hot data" (illustrated by the above GNH action-learning platforms) points to cultivating qualities of awareness within relational processes to co-create and influence an emergent future.[47,48,37] These and emerging innovations in leadership practice[49,50,51] can be thought of as part of the "inner technology" that is now urgently needed to tackle the complex systems challenges of our times.

Looking outwards, looking inwards

There are encouraging signs that global efforts to cultivate self-leadership, and to integrate both inner and outer technologies, are gaining momentum through initiatives such as the UN Sustainable Development Goals

Leadership Lab,[52] the Inner Development Goals,[53] the Wellbeing Project, and others.[54] We need to advance such integrated approaches within key sectors including business, banking, and finance,[55,56] while also shifting societal values and behaviours around consumption – in ways that promote a "fair consumption space" for all and the "richness of human life",[57,58] rather than the pursuit of GDP growth. This is a potent and multidisciplinary field where further research and application could make a significant contribution to our collective efforts to cultivate and amplify economies of wellbeing.

A half century has passed since a constellation of historic events directed our collective gaze simultaneously outwards, towards the vastness of space – as well as inwards, to ask important questions about the purpose and trajectory of human life on Earth. We are now at a critical juncture. Although there is much to provoke a sense of anxiety, loss, and deep concern for our future, we are also living at an extraordinary time – when the potential to develop and integrate "outer and inner technologies" has never been more available or more vital.

As Bhutan's journey towards Gross National Happiness illustrates, the goal of human flourishing is profoundly connected to our ability to tackle the urgent existential crisis we now face. Far from being a "luxury" or "trade-off" in the face of sustainable development, prioritizing wellbeing and reconnecting our inner experience with the external world are *vital* to making the leap from our current economy of consumption, towards one of planetary wellbeing. In the words of Andreas Weber, as we contemplate our uncertain future in the age of the Anthropocene:

> The goal of leading a fuller life, is the most important steppingstone toward changing our relationships with the animate earth and among ourselves. If we adopt this perspective, we will begin to see that something is sustainable if it enables more life – for myself, for other human individuals involved, for the ecosystem, on a broader cultural level. It is crucial to rediscover the linkage between our inner experience and the external natural order.[59]

New lenses for a different future

11

The Limits to Growth paves the way from futures shock to futures resilience

Sirkka Heinonen

Professor emerita, Finland Futures Research Centre, University of Turku
Full Member of the Club of Rome

Humanity's clock is ticking painfully loud. As never before in the history of human beings, we today face existential risks with the potential of human extinction. Two risks stand higher than the others: climate change with its impacts of rising temperature, extreme weather conditions, loss of biodiversity; and artificial intelligence (AI) with its promise of improved wealth and wellbeing and its perils of abuse and loss of control. Can we learn before the tipping point surprises us?

It is 50 years since *The Limits to Growth* report to the Club of Rome sent us a clear message of the futures to be if we follow certain pathways and do not change our systems and behaviour. The early warning of *The Limits to Growth* is only now getting the full momentum it deserves. Yet, it has to be reformulated and crystallized to get the message through this time, both to the youth and the leaders. The relevance is now more valid than ever – if we want to survive, we have to live within the limits of the spaceship Earth. The key is to communicate the core message and shed light on the relevance of the report. This requires clear recommendations for how to use the report's message to generate concrete actions. Shocks, risks, and crises are all part of the rapid change. We have to embrace them with systematic, proactive, forward-looking orientation and concrete pioneering acts to make the change

turn towards futures resilience. It all starts by realizing that humans are part of nature, not above, and technology should serve the purpose of maintaining nature's health alongside human wellbeing. We need pioneers and visionary leaders to get concrete action harvested from the seeds that *The Limits to Growth* sowed.

Growth thinking and exceeding the limits create self-induced existential risks

The original message of *The Limits to Growth* addressed two clear concepts – growth and limits. What part did we not understand? Growth cannot continue *ad infinitum* because there are limits to what the planet Earth can endure. Repurposing the original message means appealing to the paradox that the concept of growth has a Janus face. In other words, immaterial and inner growth in fact can continue, even though the physical growth consuming fossil energy and natural resources should be restricted. Cognitive, mental, and spiritual growth knows how to differentiate limits to physical growth from *neo-growth* – a new kind of growth that is based on renewables, does not abuse natural resources, and nurtures biodiversity. There are no limits in our efforts to achieve this.

The climate change and artificial intelligence risks differ in nature but conspicuously share one characteristic. If the risk of one of these two is realized and turns into an existential catastrophe, then the other one no longer needs to be solved. We are prisoners of the past and present. But we must become pioneers of the future! Breaking out of this prison and tackling both these risks requires nothing less than transformation – thorough change in our relation to nature and to technology. The first is the renewable energy transition.[1] The fossil industry has locked us to a pathway to peril from which we should immediately detach ourselves. The answer is de-learning from generating emissions, continued fossil fuels use, and the abuse of natural resources. Besides this de-learning, we need re-learning to understand how to live in partnership with nature while not exceeding its limits.

Doomsday rhetoric leads to a cul-de-sac. We have to honestly identify and face emerging threats, even existential risks. At the same time, however, there should always be thoughtful pathways, strategies, and solutions for how to avoid, alleviate, or overcome such risks. Every invention or breakthrough in society will have both advantages and disadvantages, opportunities, and threats. We are at a watershed – we can make all efforts to use AI to combat

climate change. Profound analyses should, however, be made concerning the three different types of AI: artificial narrow intelligence (ANI), artificial general intelligence (AGI), and artificial superintelligence (ASI). It is essential to recognize the distinction between these three forms of AI and anticipate their corresponding implications. Only in this holistic context, discussing the role of AI vis-à-vis humans and all living beings makes sense. ANI is often better and faster than humans, for example, in face recognition, mathematics, medical diagnosis, and game playing. AGI is the next and critical level of AI sophistication – if we do not get the initial conditions "right" for AGI it could evolve quickly beyond our understanding. The ASI sets its own goals independent of human awareness and understanding.[2,3] Both climate change and the uncontrolled development of AI are already rightly included in the current debates on existential risks. We have, however, the choice of harnessing the positive potential of AI to combat climate change,[4] thus turning both these existential risks into existential harbingers of hope. It has to start now with the AGI.

The development of AI is now the key area of technological development on which also other technological advances will depend. Besides continuous monitoring of the technical development of AI, it is highly important to understand its impacts on other technologies and on social and economic developments, even on cultural evolution. Besides affecting the future of work, AI also raises various kinds of other ethical problems and risks discussed, for example, in the Work/Technology 2050 study by the Millennium Project.[5] Interestingly, Farrow suggests exploring the potential of AI by asking people to develop "user stories" of what they "do not want" AI to do.[6] A key issue seems to be the role of AI as a co-worker or co-learner beside human beings, instead of as an AI technology that will replace human beings in various activities. A realistic utopia is having AI as a trustworthy personal digital twin following high ethical and social standards. This kind of personal assistant would be important in the time of AGI or even ASI, promoting both the wellbeing of individual human beings as well as the handling of global challenges. Combatting climate change would be number one in priority.[4]

Rebuilding on the heritage of *The Limits to Growth*, the Club of Rome could become a forerunner of responsible introduction of AGI. In Europe, the development of responsible personal assistants or avatars is a promising target. At the global level, foresight should be focusing on tapping into all the various manifestations of ANI evolving into AGI. Climate change, the ageing of the population, and the growing population in developing countries, means for subsistence, elimination of war, and the search for a meaningful

life are global challenges where the progress of AI could be harnessed for concrete solutions – with a futures vigilance to avoid unwanted impacts. In a research project by the Academy of Finland called RESCUE (Real Estate and Sustainable Crisis Management in Urban Environments), the development of AI is proposed to be used for anticipating, identifying, and analysing possible crises and their impacts on sustainable land use and urban space. Thus, new policies and recommendations will be sought to develop futures resilience for cities, while preserving the natural environment and combatting climate change. Concrete policies and recommendations for action are now needed for all levels of society and for all stakeholders to cooperate.

The complex nature of urgently exploring AI and its stages evolving into more developed ones is now acknowledged, and tentatively its relations to combating climate change are being sketched out. AI now poses a grand challenge, as climate change has been doing for decades. As a token of evidence, the UN report "Our Common Agenda"[7] recognizes the need for action regarding AI by claiming:

> ... an effort is warranted to better define and identify the extreme, catastrophic and existential risks that we face. We cannot, however, wait for an agreement on definitions before we act. Indeed, there is an ethical imperative to act in a manner compatible with the dignity of human life, which our global governance systems must follow, echoing the precautionary principle in international environmental law and other areas. The cost of being prepared for serious risks pales in comparison with the human and financial costs if we fail.

Indeed, global cooperation and governance is needed, on one hand, to combat climate change and, on the other hand, to address the multifaceted evolution of AI. Both are critical challenges alone, not to mention combined, for the future of humanity.

Learning from crises and shocks while living in the VUCA world

When will we ever learn before the tipping point surprises us? It is 50 years since the publishing of *The Limits to Growth* report to the Club of Rome sent us a clear message of the futures to be if we follow certain pathways, not changing our systems and behaviour. The message was not heard clearly enough nor taken seriously. However, it was a pioneering early warning

which triggered a positive future shock to some – heavy food for thinking about the futures to come and about the way of the world at its present dynamics in politics, economy, society, technology, environment, and culture. Change is evident, giving us future shocks and crises built on unexpected events, but its directions can be affected if there is a vision and a shared strategy to proceed and act upon. Both these are missing since there is not yet global governance nor global futures consciousness.

As stated earlier, we humans have to learn to *de-learn* and *re-learn* things. Above all, we could now take the opportunity of really learning from crises. There is resistance to change in society in general – it is a human characteristic. The thought of change may take us out of our comfort zone – change means uncertainty, extra effort, even fear. However, (the need for) change is evident. The ancient philosopher Heraclitus declared "Everything is in change". Alvin Toffler's book *Future Shock* (1970) revealed how the pace of change is the very future shock we experience. Today we are living increasingly in a VUCA world (volatility, uncertainty, complexity, and ambiguity), with its fertile soil for risks and crises. The VUCA approach originates from strategy thinking at the end of the Cold War era and was taken up in businesses and strategy planning.[8,9]

Ulrich Beck emphasised that risks are socially constructed and affect population groups differently, implying that risks and crises are contextual.[10] Often, the meaning of crises is determined by their time and place. A crisis can be seen to emerge and have a series of different specific impacts, requiring differentiated approaches. Increasingly common extreme weather events are attributed to human influence.[11] Various environmental crises becoming more prevalent reveal the deeply interconnected aspects of our planet through travel and digitalisation. Environmental degradation already affects biodiversity and planetary systems. Climate change, combined with the Covid-19 pandemic and with politically motivated violence is an example of an ongoing, hybrid three-fold crisis.[12] In the future, situations where multiple crises coincide will become more common. If risks turn into crises, mega-risks may become mega-crises with wide ramifications in diverse cultural contexts. Mega-crises can slowly creep or emerge as shocks from unexpected events, as the Covid-19 pandemic has shown. Bearing in mind existential risks,[13] we only need one of them to be realised to find ourselves as a humanity in a mega-crisis. Are we already in a "crisis society"?

Change is inevitable and crises are accumulating. The way to go is not "ostrich politics", trying to hide and look the other way, but to embrace this uncertain world of crises with determination to alleviate risks and overcome

crises, i.e., to become resilient and survive. This is not happening automatically – we need to *learn to learn* in diverse new ways,[14] using creativity and convoluted consciousness. Creativity plays a key role in dealing with crises, especially in postnormal times.[15] The crisis of the imagination is connected to the "crises of the future", where the ways to deal with uncertainty have not yet been imagined.[16] Blinded by mega-challenges and mega-crises, a new mindset equipped with a new modus operandi, which recognises crises, and their far-reaching ramifications, is called for and proposed in the following.

Futures resilience through new consciousness in digital and meaningful bio-society

The early warning of *The Limits to Growth* is only now getting the full momentum it deserves. Yet, it has to be crystallised to get the message through this time, both to the youth and the leaders. The relevance is today more valid than ever – if we want to survive we have to live within the limits of our planet.

The key is recommunicate the core message and shed light on the relevance of the report. This requires clear recommendations for how to use the report's message to concrete action. Shocks, risks, and crises are all part of the rapid change. We have to confront them with systematic proactive orientation and concrete pioneering acts to push the change towards futures resilience. Creativity-driven new consciousness, crisis awareness, and learning from crisis are all needed in order to build up such futures resilience – capacity to survive in the face of multiple crises. It all starts by realizing that humans are part of nature, not above, and technology should support nature's health alongside with human wellbeing. These two are categorical imperatives. New consciousness will give hope to the planet. The next paradigm in societal development could be digital and meaningful Bio-society.

We as human beings have to renew ourselves. According to Jeremy Rifkin we are living a historic transition into the age of biotechnology.[17] He calls the process where information and life sciences are fusing into a single powerful technological and economic force the foundation for "biotech century". He sees it as a promise of a cornucopia of genetically engineered plants and animals to feed a hungry world, genetically derived sources of energy and fibre to propel commerce to build a renewable world. Bio-society would go beyond ecological transition, it would require restructuring all core systems of our societies – food, energy, cities, economy, and infrastructures. Production

and consumption patterns should become sustainable, adopting the potential of a circular economy.

In bio-society the energy can be generated with renewables, and for citizens it will become meaningful to be able to self-produce renewable energy on their rooftops. The energy system will become not only based on renewables but also more efficient when AI and digital data from multiple sources are optimized. The whole system of agriculture is transformed to follow the principles of regeneration to qualify for real bio-society. Food production will also cover new modes – such as that of producing food without soil. With the help of electricity produced using renewable energy, carbon dioxide extracted from the air and microorganisms, we can produce protein-rich food even without the need for land or raising of cattle.[1] This environmentally friendly method may, in the future, parallel traditional agricultural food production methods. The agricultural sector is globally the second-largest producer of greenhouse gas emissions, after the energy sector. Bio-society will expand the conventional notion of agriculture, farming, and forestry. Forests may also emerge as commodities and services for tourism and health sector,[18] rather than raw material for paper and pulp.

Bio-society is regenerative and dynamic. In cybernetics a living organism is no longer seen as a permanent form but rather a network of activity. With this new definition of life, the philosophy of "becoming" supersedes that of "being". Rifkin conceives thus life and mind becoming intricately bound to the notion of "processing" change.[16] Bio-society itself is in the continuous process of change. There are seven core characteristics (all starting with the letter R) that can be considered as prerequisites for meaningful bio-society and nurturing the message of *The Limits to Growth*:[19]

1. Recognition – of humans' role as part of nature
2. Respect – life as intrinsic value
3. Rethinking – conventional concepts and relations critically revisited
4. Remixing – using the potential of technology convergence
5. Regeneration – changing systems as regenerative, especially agriculture, forestry, and communities
6. Responsibility – built on technology foresight, technology assessment, and long termism
7. Resilience – futures resilience as a result from systematic foresight and responsible action toward renewable energy transformation and peer-to-peer activities[1]

Concluding remarks of nature as our ultimate teacher

A new treaty with nature could be signed, based on a new kind of economic, technological, and ethical union where Nature is a stakeholder. "Nature always wins – either with or without humans," Pentti Malaska, the first Finnish member of the Club of Rome, emphatically stated on many occasions.[20] Such a new nature partnership could be taken to environmental education in schools to strengthen environmental awareness and future thinking. Often children and young people – our hope and actors for the future – educate their parents about recycling practices, for example, thus forming a forefront to bio-society. More researched information on the state of the environment and how everyone can influence their own activities and choices could be produced as teaching materials of schools, drawing from *The Limits to Growth*. Bio-society in a meaningful context goes beyond economy and technology and requires an educational reform. Warning of the future is not a doomsday forecast, but a recommendation to follow another path if the current highway leads to a very dark place. Climate change is the last straw on humankind's back unless appropriate action is taken. Bardi reminds us how growth is slow, but collapse is rapid, as Seneca said.[21] Linear growth thinking, relying on depleting natural resources should be urgently replaced by neo-growth thinking where economic growth minimizes the waste of natural resources, building on immaterial growth.[22,23] Incremental or sectoral transformation is not enough, we need new vital blueprints for ensuring our future on earth (Botkin 1990; Martin 2007).[24,25] James Martin calls this century consequently a "make-or-break century".[24]

It is a learning process where human beings' relation to nature and technology are reassessed. The information society should produce not only technology but, above all, knowledge that will direct us to a postmodern society based on sustainable development. The role of technology should be seen as that of a mediator between human beings and nature, not as an instrument for exploiting or devastating nature.[26]

Nature has been able to create a conscious being with knowledge – a human being. Now it is the turn of humans to regenerate themselves as wise beings. This requires a map of knowledge for navigating in the landscape of eco-consciousness. All the necessary knowledge for adopting a wise attitude to nature and technology is already at hand. What is needed is the will to change. Bio-society based on sustainable development, utilizing digitalization

and AI, could also be an example of the wisdom society. Relevant wisdom here would be formed of knowledge provided by the information society and digitalization (concerning us humans, nature, and technology) and of moral values and responsibility (concerning human relation with fellow beings, nature, and technology). The information society based on sustainable development would reach to grow into bio-society, built on life-sustaining knowledge with a moral dimension.

This provides us with a preferred vision of bio-society. It does not materialise automatically, though. Urgent action and new kinds of thinking are needed, alongside with leadership and pioneers – both companies and individuals. Pioneers can show us a way forward to bio-society.[1,27] new notion of the relationship between human beings, nature, and technology could provide fertile soil for building the modern bio-society based on the principles of sustainable society and utilizing digitalisation and AI. The ancient Stoic approach can be used to break up the myth of separation between humans and nature. Such breaking-up would help us see that human society is a subsystem of the ecosphere, and further of the biosphere. We have to learn to live as part of nature. Humanity is dependent on nature, but not vice versa. Instead of managing natural resources, we have to manage knowledge, technology, and ourselves. To conclude, human beings have not yet truly turned out to be rational animals. The metaphor of nature as a teacher would better lead us towards rationalism in the Stoic sense where "following nature" means "following reason". Thus, there are both rational and existential reasons for aiming at digital and a meaningful bio-society as a preferred future. The signature line from *The Limits to Growth* is transformed into no limits to learning to change and reinvent us as human beings, learning from crises to achieve new consciousness to act before the crises overwhelm us. This we owe to future generations.

12

The historic *The Limits to Growth* report – 1972 and the present world

Dr Yury Sayamov

Head of UNESCO Chair on Global Problems, Moscow State University

When *The Limits to Growth* report appeared in 1972, I was young and among those striving for a better future. During that time with the International Union of Students (IUS) – the world umbrella organization of national unions of students from over 100 countries – I was at its headquarters in Prague and was responsible for information activities. I edited, among other things, the *World Student News* magazine published in seven languages. It is no wonder that I learned about the report practically as soon as it became known. First, it was analyzed in an article published by the West German magazine *Der Spiegel*, which I regularly received on subscription and had a habit to read attentively. Soon after, one of my colleagues bought *The Limits to Growth* book and brought it to the IUS Secretariat for common reading and knowledge. The impact it made was remarkable. The most important result of the report was that it made people think in a new way, discovering the fragility and the limitedness of the world we live in.

Of course, not everyone arrived at such a vision, and those who did, not immediately. Many did not, and some of them most probably will never be able or willing to see the world in its immense complexity, full of interdependences and growing existential risks. As the first president and co-founder of the Club of Rome, Dr Aurelio Peccei, witnessed later, his words sometimes

found no more response than the sermons of the Pope, the exhortations of the UN Secretary-General, or the warnings of concerned scientists and thinkers.

The report alarmingly extracted global problems from the everyday usual context and made clear that they must become the main concern of peoples, their representatives, and governments to jointly pave the way to human survival. But it did not happen. Today, half a century after the report, we find ourselves much closer to the precipice than ever before, but people are too often inclined to drive away unpleasant thoughts about the impending catastrophe, cherishing illusions that it is still far away and everything will somehow work out. Too many politicians prefer immediate personal gains, ignoring inevitable common losses and following Napoleon in his approach "after me – the deluge". However, today the result might be not the flood, but a lifeless desert. Public consciousness obviously lags reality, recognizing the new only after time has passed and demonstrating the human gap phenomenon, described in the report to the Club of Rome in 1979[1] as the inability of people to keep pace with understanding the growing complexity of the world.

Coming back to the origins of the report, it could be mentioned as a little-known fact that its idea grew up, to some extent, from the friendship between and the joint research by the American and Russian professors and systems scientists Jay Forrester and Nikita Moiseyev. They presented its first outlines at the UNESCO International scientific conference in Venice in 1971.

Professor Moiseyev, who later, together with his American research partner Professor Carl Sagan, developed the concept of the "nuclear winter", proving that there will be no victory and no survival in a nuclear war, emphasized the relationship between humans and the biosphere as the main problem of the present. Another great Russian scientist Vladimir Vernadsky also had an influence. He had introduced the notion of the future noospheric civilization, described by him as the planetary "sphere of reason" and the way out for the common survival. Vernadsky's scientific heritage affected the increasing understanding of the key role of the educational intellectual process for the future destiny and the existence of humanity. It was becoming ever-more evident that the contradiction between global interdependent problems of the planetary scale and the existing rather fragmentary and desultory way of acquiring knowledge is a principal challenge to the present and future quality of human potential.

Another important outcome of the report arose from it being based on system analysis, affirming the system approach as a new and valid scientific direction, which helped in the understanding of the entity of processes by bringing into a system initially scattered and redundant information. The

report opened eyes to complex systems in their integrity, which should not be treated as a simple sum of their components, showing that the analysis must necessarily be supplemented by a deep system synthesis based on an interdisciplinary approach and interdisciplinary research with the application of completely new scientific instruments and technologies.

Within the Soviet Union at that time, the reaction to *The Limits to Growth* was publicly quite limited and basically didn't reject the report because its conclusions were attributed mainly to the shortcomings of the capitalist system, while the socialist one enjoyed the advantages of the planned economy and respective crisis prevention abilities. But in professional circles of science and policy makers the report was met with all the attention it deserved. The national mental soil was already prepared and fermented by the advanced philosophical studies of Moiseyev, Frolov, Zagladin, Kapitsa, and other globally thinking Soviet scientists, among whom a special place was occupied by the figure of Dzhermen Gvishiani. For several reasons he could be considered as one of the fathers of the Club of Rome. Gvishiani was the son of a Georgian KGB general and an Armenian mother. He was married to the daughter of Soviet Premier Alexei Kosygin. Kosygin wielded great power, had a computer brain, and, together with Aurelio Peccei, made a breakthrough in the East–West relations by signing a "contract of the century" with Fiat for a joint project of a huge automobile plant construction in the USSR.

In October 1972, the USSR established, together with the USA, the International Institute for Applied Systems Analysis (IIASA) in Vienna, which was a significant result of scientific diplomacy and a remarkable project that aimed to build bridges across the Cold War divide and to search for system solutions to multiplying global problems. In 1976, with Gvishiani at its head, the All-Union Scientific Research Institute for Systems Analysis was founded in Moscow under the Academy of Sciences and the State Committee for Science and Technologies of the USSR. It was considered by many as a Soviet branch of IIASA. It is hard to deny the influence of the *The Limits to Growth*, especially taking into account that the global problems analyzed in it became the object of studies of the newly born scientific structure.

Working at UNESCO, and later in my capacity of the first deputy chairman of the Committee of Soviet Scientists from 1989 to 1991, I had a chance to meet Dr Gvishiani. I talked to him about global problems, visited IIASA, and participated in joint research projects. I remember him saying that the application of the system model is more important for the study of the logic of reasoning and of solving problems than for the examination of the logic of processes taking place.

The present Russian school of systems analysis and modeling of global processes continues its tradition in developing not just one model, but a modeling system in the form of an open and replenished library of blocks or elements from which it is possible to model individual processes reflected in their global composition. For this, powerful processing is needed that allows researchers to quickly and efficiently construct a model corresponding to the tasks, ideas, and settings of the given case.

Half a century after the famous *The Limits to Growth* report to the Club of Rome, the scientists of the Lomonosov Moscow State University (MSU) decided to attempt to examine the new limits to growth in an almost unrecognizably changed world. The team was composed of mathematicians with global vision and systems analysts from the Faculty of Global Processes (FGP), and headed by the university rector Professor Victor Sadovnichy, who hosted the only meeting of the Club of Rome in Moscow, in 2000. They took the approach that provided a high level of flexibility of global modeling combined with the inclusion of new elements reflecting contemporary changes, multiplying risks, and challenges.

When searching for the new limits to growth, it is hard to disagree with the UN Secretary-General António Guterres, who named the current "four horsemen of the Apocalypse" that currently most threaten humanity, saying that the world is approaching the point of no return.

The first horseman appears in the guise of very high and continually increasing geopolitical tension. The nuclear, biological, and other existential threats for humanity are growing. As a result of military conflicts and various oppressions, ever more people are forced to leave their homes and join the mass migration. In the course of increasing global competition, fierce trade, economic and technological battles are unfolding in the struggle for markets and resources.

The second horseman is the existential climate planetary crisis threatening millions of species with extinction.

The third horseman is a catastrophic decline in the level of trust in a society suffering from social inequality, discrimination, double standards, and disillusionment in political institutions and the values they proclaim.

The fourth horseman, and global threat, is the reverse side of the new digital world, in which technological progress is faster than the ability of a human being to meet it or even to realize it.[2]

Permanently developing and improving technologies change the quality of human life, bringing huge benefits, but with them huge harm and danger. Civilization's processes are being reprogrammed and reshaped on digital platforms in the interests of the few against the interests of the majority.

Human consciousness is subjected to manipulative influences and is gradually transformed under the impact of purposefully constructed information flows with a wide use of fictions and historical falsifications.

There is a growing alienation, frustration, dehumanization, and desocialization of people. The moral and ethical principles on which the construction of human society was based are being progressively destroyed, and instead alternatives are offered that contradict to the very nature of a human being and to their life destination.

Previously unknown digital crimes and opportunities are emerging and being used to incite discord and hatred, "new slavery", discrimination, and exploitation of people for mass and permanent invasion in their privacy.

A little later, adding to the biblical image, the UN Secretary-General called the worldwide Covid-19 pandemic the "fifth horseman of the Apocalypse", which joined the other four and increased their destructive power. Humanity is facing an epochal health crisis and the largest economic setback since the Great Depression. Countries are experiencing upheaval, and the already fragile foundation the world stands on is being shaken and is in the need of global leadership.[3]

The ring of global risks in the contemporary world, which includes geopolitical, economic, social, technological, and environmental threats, is increasingly compressed around every human being. We need a comprehensive approach that refocuses efforts, energy, and resources on the natural and social environment in which humans exist.

Human security should be considered as an integral part of the global agenda for sustainable development adopted by the world community.[4] To achieve its goals, cooperation is needed based on mutual respect of interests and on the rule of law, now increasingly marginalized and replaced by a "position of strength" approach. The world situation is gravely complicated by the global problem of inequality, which takes on catastrophic dimensions, threatening a social explosion at points of extreme tension. As the UN Secretary-General stated, in 2018, 26 people own as much wealth as the poorest half of the earth's population,[5] while more than 70% of its population is experiencing insufficiency or lack of necessary income.[6] Social instability is growing dangerously because of increasing income and opportunity inequality and the widening gap between the poor and the rich. Social inequality generates, and will continue to generate, new conflicts and threats to human security until a mitigation and subsequent comprehensive solution to this problem is achieved in the context of the Global Development Agenda, which, however, seems to be a very distant prospect.

Global threats to the physical destruction of people and the entire civilization are nowhere near eliminated. On the contrary, they are becoming ever more dangerous against the background of irresponsible reflections of individual politicians and the military about the possibility of a "limited nuclear war". It is necessary to reduce and then eliminate the threat of a global catastrophe, which would most likely end the history of humankind. It could be done by joint efforts at the global level, but newer generations who were born and grew up after World War II and have had years without a global slaughter, got accustomed to taking world peace for granted. They perceive it as a kind of inalienable given, paying less attention to the prevention of accidentally unleashing of the final holocaust than to global warming or forest fires.

The emergence of a polycentric world from the obvious world emergency, which was rightly made the focus of attention by the Club of Rome, is taking place under conditions that have become seriously and dangerously complicated over the past year. Against this background, a new concept of "asfatronics" was born to denote the emerging theory of a comprehensive vision of global security problems.[7] Scientists and "thought laboratories", such as the World Academy of Arts and Science and the Club of Rome, are working on a comprehensive vision of the changing world.

Global social transformations and civilization prospects were discussed at the first (May 2020), second (December 2020), third (June 2021), and fourth (Dec 2021) forums on the scientific platform of the Moscow State University Faculty of Global Processes raising the issues of new threats and showing that the Covid-19 pandemic outbreak presents a real global transformation that made the world different from before. It provoked a deep global economic and social crisis, which, unusually, was caused not so much by economic factors but primarily by medical factors and social circumstances. It rapidly acquired a clear civilizational character and has led to radical changes in the genotype of civilization and to the transitions to a new historical era in the world's civilizational dynamics. It has caused changes in social and economic relations and in geopolitical configurations.

The question could be posed: Was this crisis unavoidable and what humanity must expect? There is a point of view that the present crisis should not be considered just as a negative event. It appears that the crisis, along with all its negative implications, might also have positive features that play a progressive role in, according to Joseph Schumpeter, the "creative destruction" of old, outdated elements of social and economic systems and mechanisms, opening space for innovative development.

As with every crisis, the present one has its specific features. It is a kind of a hybrid disaster combining a crisis of demography, a crisis of economy, as well as a social and political crisis. They mutually deepen and affect each other. Another specific feature is the human factor. Without indulging in the discussion of whether Covid-19 is a human-made virus or not, it could be stated that in the origin of the pandemic crisis there was a human failure to master the threat. That teaches important lessons about the inadmissibility of approaches that say there can be a "little" or limited use of nuclear, bacteriological, chemical, or any other means of mass annihilation. The world has proved to be too fragile for it.

The crisis was caused by a pandemic factor for the first time since the 13th century, when about half of the population of Europe was killed by plague.

The Covid-19 crisis will inevitably lead to changes in the character and correlation of global social transformations. It will obviously raise the social role of the state and increase the public attention to medical care. It will decrease the mobility of the population and slow down internal and external migration processes. It will digitalize the society and change the way of life.

Every global crisis represents a serious challenge and problem for humanity, generating transformations and posing new tasks for scientists who need to describe approaches and solutions for how to master it. Today, humanity is performing a deadly, dangerous dance on a wire over a crevasse, at the bottom of which coals are burning, representing an unprecedented set of threats and challenges to human existence. In the current deregulated, divided and unjust world, the "zero growth" solutions in economics, population, use of resources, consumption, armaments, amusements, and whatever other voluntary limitations, obviously have no chance of being achieved and so will not radically improve the global situation. New limits to growth could be developed as a combination of limits for excess and growth where there is insufficiency applied not only to economic, environmental, or resource matters. But they could also embrace spheres of education, culture, and science, which are to prepare humans for the adequate assessment of the world together with the facts of life and prospects thus rejecting the selfishness and thirst for global power of those who are used to, and want to continue, living at the expense of others.

13

Today's human predicament: The convergence of tipping points

Sandrine Dixson-Declève

Co-president of the Club of Rome
Chair, European Commission Expert Group on the Economic and Societal Impact of Research and Innovation (ESIR)

The intent of the *Limits to Growth Project on the Predicament of Mankind* in 1972 and 50 years of multi-disciplinary and systems thought leadership spearheaded by the Club of Rome and its members was to:

> examine the complexity 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.

These seemingly divergent parts of the "predicament of mankind (humankind)" as examined by the Club of Rome in 1972 have three characteristics in common, which continue to resonate in the 21st century: "they occur to some degree in all societies; they contain technical, social, economic, and political elements and most important of all, they interact."

Today, humanity faces a deep trilemma. The Covid-19 pandemic has shown us the convergence of the public health, climate, and biodiversity crises and the impact of an overpopulated world living well beyond its means and

the planetary boundaries. This is affecting all societies and is the greatest predicament of humankind and humanity's greatest existential risk.

The pandemic has demonstrated the high degree of interdependence between people around the world. In the words of the International Committee of the Red Cross: "No one is safe until everyone is safe."[1] We face the same kind of interdependence with regards to climate change, ecosystem decline and biodiversity loss. Every citizen around the world will be negatively affected by climate change as well as by environmental degradation and resource depletion. In the recovery phase ahead, we need to "build back better", while recognizing that we will never be able to build back or recuperate our glaciers, permafrost, old-growth forests, or extinct species. But we must bounce forward.[2]

This requires governments and citizens to recognize that we are in a planetary emergency created by humanity's thirst for economic growth at all costs and a disrespect for our planetary boundaries and that indeed the interaction between these crises and their catalysts must be addressed to "emerge from emergency".

Using Covid-19 lessons: Transformational economics is possible

Twenty-first century economics applied today is about the understanding of humanity's interdependency to get through future shocks and stresses. The Covid-19 pandemic has been the perfect parable for this, where we experienced how humanity's encroachment on nature and human-made climate change must be stopped as both catalyze the expansion of zoonotic diseases, where developments in one part of the world affect us all, where we redefined what we truly value, and where we found leadership in unusual places.

The paradigm advanced by transformative economic models and thinking focuses on development within the earth's limits and revolves around reconciling economics, the environment, and the social dimensions of life systems. This paradigm shift is anchored in a body of economic science which seeks to open up pathways for economic policies to enable inclusive and sustainable wellbeing of people and the planet.

In April 2021, 126 Nobel laureates said we are taking "colossal" risks with our collective future. On top of that, we know inequality is causing deep instabilities in societies. There seems to be no way out.

Is collapse our destiny?

A team of today's leading scientists and economic thought leaders from the Club of Rome, Potsdam Institute, the Norwegian Business School, and the Stockholm Resilience Centre decided to find out. Working with an upgraded, state-of-the-art adaptation of the original World3 model, they ran new scenarios through the Earth4 model for food, equality, poverty, population growth, and climate change and stress tested these results against new thought leadership and regional knowledge. They calculated the risk of crossing irreversible tipping points this century and analysed the outcomes of various solutions to stabilize societies and the planet by addressing optimized systems relationships and policy options.

Building on the legacy of *The Limits to Growth*, which warned that the old economic rules are rigged, EarthforAll brings together the ideas of the world's leading economists and scientists to show how collectively we can change the rules of the economic game and ensure greater wellbeing for all species on a finite planet. These ideas will be turned into policy recommendations for decision makers to adequately respond to today's multiple crises and build a more equitable future for all species within planetary boundaries.

Across the globe, governments are struggling to understand how to rebuild their economies, protect employment and restore prosperity. Nations will exit the pandemic with significantly higher levels of unemployment and with levels of public debt not witnessed since World War II. Many governments recognize the urgent need to address the underlying economic and social inequalities that have made this pandemic so devastating, but few seem equipped with the political will or the right policies to do so. Nor do many nations seem ready to either address the fundamental systemic weaknesses exposed by Covid-19, nor link the immediate recovery with the converging tipping points that are quickly accelerating climate change and ecosystem loss even if the pandemic is a manifestation of this fact, showing that the wellbeing of societies and the stability of economies are deeply connected to the health of our ecosystem.

That said, in some regions, such as in Europe, extraordinary financial and human resources have been mobilized for an ambitious recovery plan including the allocation of funds to climate abatement, a just transition and, to a lesser degree, nature protection. The impressive action taken by the EU stimulus package and 30% allocation of funds to climate should stand as an example for future courses of action in the face of economic, environmental, and social transformation.

The European Commission's high-level expert group on the economic and societal impact of research and innovation (ESIR) articulates the following key

lessons from the EU response to the Covid-19 experience and the growing openness to adopting new economic models:

> First, there is no use in trying to restore the status quo ante. Since its inception at the end of 2019, the von der Leyen Commission had already expressed its willingness to move away from a purely growth-oriented paradigm, which was showing critical flaws in terms of economic, social and environmental sustainability. The EU has since then launched the Green Deal (with a just transition) as its strategy for prosperity, and deeply embedded the Sustainable Development Goals in the European Semester, as well as in its external action. Moreover, the pandemic added two important imperatives to the EU agenda: the need to protect the overall wellbeing of individuals (not just their income), at a time in which the pandemic is leaving a deep trace by taking away lives and placing the mental health and perceived security of individuals under strain; and the need to prepare for future pandemics and crises and transform the European economy and society into a resilient holistic system for people, planet and prosperity at the same time.[3]

The necessary transformation of the prevailing economic model and lessons from the pandemic is also increasingly recognized by leading economists. One reflection on the possibility of economic transformation within a European context is that of Dennis Snower, until recently the President of the Kiel Institute for the World Economy, in a recent article in *Evonomics*:

> How the EU region responds to the pandemic as a bloc will determine its credibility in the eyes of citizens and the rest of the world. Failure to act in the long-term interests of citizens, to protect their health and wellbeing and ensure an equitable and inclusive recovery, could create an existential crisis for the bloc. Most importantly it will not lay the foundation for the transformational resilience needed to both ensure a more positive future across the region and an exciting new sustainable pathway for human progress across the globe led by the EU.[4]

If efforts are to be made in enhancing EU leadership globally, then further attention must be given to the fact that the current global economic system is not equal, fair, or just and must be transformed to address net zero carbon emissions alongside zero biodiversity loss, zero inequality, and zero poverty in particular in high-income countries. We know that the footprint of high-income countries is three (land-use-related biodiversity-loss footprint)

to seven (climate change footprint) times greater than those of low-impact countries.[5] Although the EU's share of global greenhouse-gas emissions may be falling, this is largely due to the EU's "outsourcing" of production to low-income countries. The EU's share in global trade flows is not decreasing.

In order to apply sustainable pathways and introduce new economic models we must therefore ask ourselves whether the European institutions and EU governments, alongside non-EU countries, are able to anchor transformational economics in existing value systems, economic foundations, and in international alliances and completely shift current trade flows and growth indicators away from short-term growth and age-old relationships based on resource dependencies and colonialism? Thus, dramatically reducing their ecological and carbon footprint.

Anchoring economic transformation through a Systems Change Compass approach

The mainstay of Club of Rome thinking has been new economic theory and practice since 1972. The Club of Rome's members, such as Robert Costanza, Ida Kubiszewski, Stewart Wallis, and Kristín Vala Ragnarsdóttir, are directly advocating for a wellbeing economy and have influenced decision makers across the globe to adopt their models. Similar approaches have been applied in different models by Club of Rome economists Tim Jackson and Kate Raworth. The contributions of Julia Kim and Hunter Lovins in this book also build on the concept of wellbeing as central to economic transformation.

As a result of this economic and multidisciplinary thought leadership alongside other new economic crusaders, today there are a wide variety of alternative economic models, including the wellbeing economy currently adopted by the five wellbeing economy governments (WEGo)[6] (Finland, Iceland, New Zealand, Scotland, Wales), Doughnut Economic models adopted by cities across the globe, and beyond-growth indicators. Importantly, this wider range of economic insights all point towards designing policy beyond a rigid focus on GDP growth, towards a focus on the wellbeing of people and the planet.

At the EU level, social and environmental dimensions feature jointly and centrally within the new economic paradigm that will turn around policies in the Covid-19 recovery phase and to achieve the Sustainable Development Goals within planetary boundaries. Luckily, from a policy perspective this transition could be quite easy because the policies needed to put Europe

further on the path towards a more sustainable and inclusive society and economy have their anchors in the EU's own history, traditions, initiatives, and legislation. Notably, these anchors are found in the Treaty on European Union, the European Commission's Strategic Foresight Dashboards, and the European Green Deal (EGD). However, bringing EU member states and citizens on the journey of transformation will be fundamental. The proof of its effectiveness will be in implementation as well as the immediate choices taken by EU member states regarding a green and social recovery rather than business as usual policies and bail out schemes. This will also require developing new policy tools that better reflect sustainable wellbeing and value driven prosperity for Europe's citizens and integrating these more effectively into the body of European law and standards.

Success will also depend on how the EU includes the rest of the world in this economic shift, in particular ensuring that the circle of care alongside environmental and social indicators are applied when addressing trade and foreign relations. Creating "net zero apartheid" is not an option if an inclusive and equitable future is to be realized.

For this purpose, the Club of Rome together with SYSTEMIQ designed a System Change Compass[7] to guide the implementation of the European Green Deal through a series of necessary transformations for a new socio-economic system. The Compass sets out ten principles which provide intellectual guidance on how to transition towards a more sustainable, resilient, and equitable model fostering a greater balance between people–planet–prosperity, while underpinning a new type of value-driven growth and understanding the need to apply similar principles beyond the EU27.

Figure 1. Principles of the System Change Compass.

The System Change Compass entails a three-step process: mapping and envisioning the system; designing and implementing interventions; and mobilizing and enabling actors. Its focus is also to connect the dots between insights from the Covid-19 experience and the orientation of transformative economic thinking, and domestic and international policy recommendations.

Ultimately, implementing the above ten principles will enable the transformational policy needed for a European Social and Green Deal to become a reality and thus a North Star for other countries across the globe. The System Change Compass and its principles can also be used as a tool to set the tone for deep economic systems change and the adoption of more value based economic indicators globally.

Enhancing the resilience of our economic model and increasing the health, wellbeing and resilience of our citizens and communities are of top priority so that all Europeans are better protected and prepared now and in the future for further crises and future pandemics. Going back to business as usual will only create more crises while building in resilience and solutions for a more positive future will guarantee both a possible "emergence from emergency" and a more equitable and holistic economy that will stand the test of time and futures crises.

Concluding reflections: Emergence from emergency is possible

As 2022 is the 50th anniversary of *The Limits to Growth* it is our responsibility as the Club of Rome to remind global decision-makers that we have collectively wasted 50 years of valuable time. Over the course of 2022 and beyond, we will continue to translate our thought leadership on economic transformation into action by working directly with governments and citizens on the minimum economic and systems turnarounds needed to ensure humanity survives within planetary boundaries.

The Covid-19 pandemic has exposed the vulnerabilities of health, social, economic, financial, and political systems across the world and propelled us to a critical juncture that provides the opportunity and necessity to reshape our future and adopt transformational economic models that embrace systems logic as solutions to the convergence of today's and future tipping points, placing a value on what truly matters.

History shows that it is unrealistic to expect the market or regulatory structures, with outdated measures of success, to change by themselves.

Equally, it is unrealistic to think that the public or youth will, in the short run, be able to force economic actors to change, because this is even proving a struggle for governments. This is therefore the moment to influence the public and policy debate, seize the growing shift in consciousness that Covid-19 has brought to the fore, address past failings, and create future-proof systems in order to "emerge from emergency" into a healthier, sustainable future for all. Decisions made in the next year as we emerge from this health crisis will set the contours of systemic resilience to future shocks and stresses, survival, and wellbeing for many years to come. This is the greatest human predicament, let's make our ancestors proud and future generations even prouder.

> The sustainability revolution will be organic. It will arise from the visions, insights, experiments and actions of billions of people. The burden of making it happen is not on the shoulders of any one person or group. No one will get the credit, but everyone can contribute.
>
> — Donella Meadows, *The Limits to Growth*

14

A reimagined future for generations to come: Life on a healthy planet

Mamphela Ramphele

Co-President of the Club of Rome

I would like to reflect on what has changed over the last 50 years and how much more needs to change. My approach to these reflections is through the lens of my responsibilities to my two grandchildren, 13-years, and 11-months old. How would I respond to their questions about my contributions to championing humanity's harvesting the lessons of *The Limits to Growth* and the call by Aurelio Peccei, our founder, for a "human revolution"?

Much has changed in our world over the last 50 years, with an intensification of the addiction to endless economic growth and overconsumption of earth's limited resources. The rise of global movements for change, especially those driven by young people, is giving rise to demands for fundamental transformation of our socio-economic and political systems. Transformative impulses are inserting themselves into the threads of our relationships at the personal, professional, and political levels.

Changes in both our world and the Club of Rome (CoR) reflect a slow but growing reawakening of humanity's consciousness of the interconnectedness and interdependence of the web of life. Indigenous knowledge systems the world over are anchored on this truism, and the wisdom embedded in them is increasingly becoming a well from which humanity is drinking.

What has also become clearer today is that however well-researched and written the scenarios in *The Limits to Growth* were, its greatest weakness was

the lack of attention to the human and social dimensions that are fundamental to social transformation. Human beings are rarely moved to change their behaviours through scientific knowledge without tugging at their emotional strings.

My contribution focuses on the following three issues:

1. What does it take to shift mindsets in a world with growing tensions between change and resistance?
2. What are likely implications of young people's insistence on values coherence between careers and personal aspirations for global equity for a healthy planet?
3. What are the risks of decoupling of Most of the World's vision of the future from that of the dominant Global North?

Mindset shifts – Tensions between change and resistance

The lack of awareness of the distance between priorities of Most of the World and the preoccupations of the Global North is illustrated by the differences in reactions of members of the CoR to the significance of the 1972 publication of *The Limits to Growth*. This publication was not even a flicker in our consciousness as a generation of young people in South Africa engaged in a titanic struggle for life to be a free people. Our whole focus was on the struggle for justice to restore our human dignity as indigenous people with rights and responsibilities. We were battling the arrogance of colonial conquest that had imprinted itself on our mindsets making us acquiesce to being identified as non-whites and non-Europeans on our own African continent. Our energies were totally committed to mindset change and re-embracing the ethos and values of Ubuntu that was a critical success factor in our freedom struggle that ended with the triumph of constitutional democracy in 1994. *The Limits to Growth* was not on our agenda then. On our agenda was transformation towards social justice and equitable sharing of the abundant riches of our beloved country.

The last 50 years have seen changes in the world that partly reflect the growing awareness that planetary boundaries cannot be ignored any longer without devastating consequences, not just for future generations, but for present ones as well. The establishment of the Intergovernmental Panel on

Climate Change (IPCC) by the United Nations in 1988, to do scientific assessments of climate change, its implications, and risks, as well as to put forward adaptation and mitigation options, is the most enduring acknowledgement of the impact of *The Limits to Growth*.

The Covid-19 pandemic seems to have forced even the most fervent denialists to acknowledge that breaching planetary boundaries threatens not only poor countries, but all countries. An insignificant biological fragment has shown us that no national boundaries are high enough to protect the privileged against the risks facing the rest of humanity. Aurelio Peccei's dream of a human revolution may be upon us at last.[1] What scientific evidence and modelling could not accomplish, could well unfold from a different impulse.

The high mortality and morbidity from Covid-19, estimated as of end of 2021 at 5.4 million and 262 million respectively, including the under-reported debilitating nature of "long Covid", have shaken the core of resistance in many quarters across the globe. Even the high and mighty have no place to hide. Only dictators and narcissists who are beyond the reach of reason have continued to resist change. Consciousness of our interconnectedness and interdependence is forcing itself into everyday life. We are being forcefully reminded that we are part of nature and her intricate web of life.

The Club of Rome has also seen changes that have made it more responsive to the changing world around us. The introduction of strategic discussions, four years ago, by its Executive Committee, ushered in the reimagination of the CoR as a "platform" that leverages the diversity of its members' expertise, interests, and perspectives to enrich its deliberations and actions. The platform concept has considerably reduced the tendency of members to compete among themselves as experts, by promoting collaboration within and between Impact Hubs. We have witnessed a significant rise in the number of members who are actively engaged across the five Impact Hubs according to their interests.

The Impact Hubs are:

- Planetary Emergency and Action Plan
- Reframing Economics
- Rethinking Finance
- Emerging New Civilisation Initiative (ENCI)
- Global Youth Engagement (Rebranded The 50 Percent in 2021)

The coining of "Emergence from Emergency" as a unifying theme of our work, has created opportunities for collaboration and coherence between the Hubs.

Another significant development has been the growing opportunities for partnerships with other engaged global citizens, leading to a network effect. Each of the Hubs has attracted partner organizations that are forming networks of networks across various interests. For example, the Planetary Emergency and Action Plan hub has more than 350 partners, whereas ENCI has five key partnerships, but leverages its rapidly growing partners and weaves together large networks of networks across many spaces. For example, the Learning Planet Platform has 180 members that expands our reach and enriches our perspectives. Asia–Africa conversations between members have taken off with mutual support across regions to tackle burning issues affecting Most of the World. A seminal outcome of these deliberations has ended in some of the papers published on our website.[2]

The profile of the membership has changed significantly from the traditional Euro-American male dominance towards greater inclusion of women and people from Most of the World. The most visible case of male dominance is the continuing undervaluing of Donna Meadows' contribution to *The Limits to Growth* and the systems thinking she embodied in her work subsequently. It is telling that she died in 2001 without being invited to become a member of the Club of Rome. She had wisdom we need to keep drawing from to emerge from the emergencies we brought upon ourselves: "The world is complex, interconnected, finite, ecological–social–psychological–economic system. We treat it as if it were not, as if it were divisible, separable, simple, and finite. Our persistent intractable problems arise directly from this mismatch."[3]

Reshaping the profile of the Club of Rome membership is underway to recognize the importance of the feminine perspective and the added value it brings to transformative processes. We agreed in 2020 to lift the total membership ceiling from 100 to 150 to enable an orderly shift towards greater diversity. In 2021, the CoR has a total of 111 members, with Europeans remaining as the most dominant segment with 57, of whom 16 are women. Americans total 19, of whom 2 are women. The number of Africans have increased to 15, of whom 5 are women. Asia has 14 members, with 5 women. Australia and Latin America are the most underrepresented with 4 members each. The most visible change is the Co-Presidency of two women – one African and another European.

The changing profile of the membership has resulted in a shift from universalist tendencies of Euro-American perspectives to acceptance of

pluralistic viewpoints.[4] The assumption that Anglo-Saxon perspectives set the standard of what is universal has come under sharp critique. Of more fundamental importance is the grudging recognition of the *Stolen Legacy*[5] of Africa that constitutes the first human civilization. Greek philosophy owes its rise to Egyptian priests who developed their knowledge system from systematic observations and reflections on nature's intelligence on earth and in the cosmos. Indigenous knowledge systems from communities across the globe are also gaining currency as complementary to modern science.[6]

There has been a radical shift in the quality of conversations at our annual meetings. The traditional use of the Annual General Meeting as a space where individual members showcased what they are doing in their various fields of expertise has given way to a greater focus on the business of the Club as an operational platform for thought leadership across a variety of issues. The ego has been supplanted by the eco.

The introduction of an Annual Conference in 2018 in Rome, at the celebration of the 50th anniversary of the Club of Rome, to reflect on pressing global issues, has evolved into a space for high-quality discussions. The Annual Conference also includes invited guests who are non-members of the CoR to expand our horizons and enrich perspectives. In addition, what started as a Youth Summit in 2019 in Cape Town has grown into a vibrant youth-run and -led Global Youth Engagement Platform (rebranded as "The 50 Percent" to reflect the 50.2% of global population being 30 years and younger). Intergenerational conversations have become a key ingredient of our Annual Conferences.

The Emergence from Emergency thematic frame bears, within it, tensions between focusing on urgent action within existing political and economic systems while also engaging in the slow but essential work of championing systems transformation. Recognition and management of tensions between focusing on policy reforms and engaging policy makers, while investing in the necessary engagements with other changemakers to promote conversations that hold the promise of transformative systems change, is essential to reduce the risk of the urgent pushing out the important transformative work. Roman Krznaric raises this issue in his excellent book *The Good Ancestor*, cautioning us that focusing on "deep adaptation" involving championing policy reform to enhance "resilience, relinquishment and restoration" within existing systems to address planetary emergencies, might distract attention from more radical societal transformation.[7] Jeremy Lent also identifies this tension in his highly acclaimed book *The Web of Meaning*.[8]

Transformation in the epistemology and learning arena remains a major challenge. Tensions are intensifying as the dominance of Euro-American cultural and philosophical orientations are being increasingly challenged by those from Most of the World. It is often difficult to engage those who have blind spots about their Euro/American biases. One has to constantly remind them of the impact of their blind spots on others. It is a tough job that requires the patience of Job. Understanding at the intellectual level, without letting go of deeply held worldviews, is unlikely to lead to the transformation needed at the personal, professional, and political levels. But we soldier on in the interest of mobilizing a critical mass of active global citizens to engage in promoting wellbeing in our interconnected and interdependent world.

The idea of what it means to be human is being reframed across the globe, especially by young people who see the risks posed by competitive, overconsumption-driven lifestyles. Young people, like their ancient ancestors, are pushing back against the primacy accorded to material possessions. They are privileging relationality as the defining core value of what it means to be human. *Ubuntu* – the "I am because You Are" – is challenging the individualism that drives the "me, myself and I" culture that has triggered, and sustains, the planetary emergencies upon us.

Young people and value coherence

Young people from across many regions of the world seem to be diverging from the values and philosophical orientations of their parents. They are increasingly raising the alarm about the importance of global equity for a healthy planet. Ecological considerations are becoming paramount for a growing number of them.

The plethora of international youth climate movements, such as Ashoka Young Changemakers, Global Student Forum, KIDsforSDGs, Kruzhok Movement, World's Largest Lesson, Fridays for Future, Climate-KIC, Extinction Rebellion, Amazon Warriors, The South African Youth Climate Action Plan, etc., all attest to the awakening by young people to the need for them to shape the future they would like to inhabit. They can no longer entrust the future to waiting for current global leaders to rise to the responsibilities to future generations.

More and more young professionals in both the public and private sectors are making choices between career success and the values of interconnectedness and interdependence within a healthy biosphere. Many are leaving

lucrative jobs in the corporate sector or senior public service to start afresh by engaging in livelihoods and pursuits that allow them the space to live by coherent values at the personal, professional, and political levels.

The quest for value coherence is a major departure from the complacency of previous generations of young people following the rebellious period of the 1960s and 1970s. Successive generations after those who participated in anti-Vietnam War protests, Civil Rights Movement in the USA, student revolts in Europe, and anti-colonial liberation struggles in Africa and Latin America seem to have become too focused on making the most of their new-found freedom and material benefits.

In my conversations with young men and women in my own country, and on my 2021 trip to Europe, the passion for values coherence is palpable. Many young people are leaving their lucrative jobs and are prepared to spend time reflecting on what they could do next to ensure the values coherence they treasure in life. A significant number of young people have come together to start enterprises that utilize their considerable skills to address one or other key social problem in the communities they live and work in.

I was particularly struck by conversations with professors at the IE University's Business School in Madrid, Spain, who are amazed by the reluctance of a significant number of students to compete with their colleagues for better grades and award. More students insist on collaborative projects rather than competitive ones. It seems that the rat race of "being better than" is being jettisoned in favour of "together we can learn better and do better" to address the complex problems the world faces. This is a major shift.

How are business schools to deal with this shift? Are they just going to treat it as a passing phase or are they reflecting seriously on the implications of this values-based rejection of competition – the cornerstone of capitalism? Are business schools at risk of going out of business? Perhaps not tomorrow, but what about a decade from now? The demand for transformative learning spaces is growing louder across the globe.

There are also calls by young people for fundamental transformation of education to enable them to prepare for the complexities of the 21st century. Many are rejecting the industrial revolution era models of economics, politics, and social systems. The University of St Gallen in Switzerland, where one of the earliest seminars was held to discuss the then newly released *The Limits to Growth* report, is actively seeking collaboration with the Club of Rome to explore how their curriculum and spaces for learning could be transformed to meet the needs of graduating leaders, who lead with future generations in mind.

Decoupling visions of the future of Most of the World from dominant Global North?

The growing awareness of the power of numbers in global politics is opening young people's eyes to their potential to shape futures that reflect what matters for them and their communities. For example, young African people are waking up to the wealth and richness of their heritage as citizens of the cradle of humanity. There is growing pride in their own cultural heritage. Many are using their talents to leverage their cultural assets to develop vibrant businesses in textiles, agribusiness, cuisine, music, poetry, sculpture, and other art forms. There are strong voices rising to demand the return of stolen art treasures by colonial Europe that adorn many museums in the North.

Imagine the impact of the demographics of Africa with its growing youthful population estimated to become 2.5 billion by 2050 with 60% under 25 years old. The view in the Global North that this growing youthful population is a problem, stems from the assumption that the current socio-economic development model will continue to dominate into the future. Growing youthful populations are only a problem in inequitable national and global systems. Equitable transformative education, health, and welfare services within sustainable ecosystems unleash creativity and energy that promote wellbeing for all and shared prosperity. The signs on the ground in much of Africa point towards this different future. If we assume the trends referred to above will continue, then very different development models are likely to emerge.

Young people in many parts of Africa are drifting towards entrepreneurship leveraging their cultural heritage and other natural endowments to promote vibrant agribusinesses, art and cultural enterprises, entertainment industries, heritage trails, wildlife stewardship, and tourism industries. The importance of these developments is their potential to promote intra-Africa trade and complementary exports of the unique, rich, cultural assets to other regions in Most of the World.

China's rise as a global power has also created opportunities for a huge proportion of young people, not only for the Chinese. Asians from the wider region and African young people are increasingly looking east for opportunities. It may be in the not too distant future that the Chinese Yuan will outcompete the dollar as the dominant foreign exchange currency given the strong pillars on which the Yuan rests compared to the US dollar (USD). The USD floats on a mountain of credit and imaginary financial instruments.

After all, the Chinese are the greatest holders of the USD! Decoupling the dollar from international trade would be a transformative moment for the global community that would free Most of the World from the strangulation of foreign-denominated debt.

The challenge for Most of the World is to not replace dominance by the Global North with dominance by anyone else, particularly China. China has major challenges of transforming its high fossil fuel-driven socio-economic system into the "ecological civilization" it touts. The practice of externalizing China's resource needs, including land and marine resources, poses a danger to poorer parts of the world in Africa and Latin America. Africa, Asia, and Latin America must dig deeper into the wisdom of their own indigenous heritage to champion global equity for a healthy biosphere.

Conclusion

The Club of Rome's most important contribution to the world remains its understanding of how living systems change, thanks to contributions by Donna Meadows, among others. Most projections and models of what the future might look like unfortunately tend to continue to assume that there is a linear connection between today and 2050. Living systems evolve differently. Evolutionary change over the next 50 years is unlikely to track the last 50 years. Only those open to learning from nature and indigenous knowledge systems, complemented by modern science, are likely to enjoy the ride into the future.

The Club of Rome's unique value proposition derives from this understanding of how living systems change. Our role as members and leaders is to collaborate with partners to enhance our catalytic role in transformative systems change. My engagement to enhance this catalytic role of the Club of Rome is the least I can do to help secure a future that my grandchildren and their grandchildren would be proud of.

15

The Limits to Growth rebooted: From patriarchal ignorance to collective stewardship of vital futures – A feminist perspective

Dr Petra Kuenkel

Founder of the Collective Leadership Institute

Nobody enjoys living in a downward-spiraling world development scenario that other people had predicted 50 years ago. But with minor aberrations, this is what the world population is experiencing in the year 2022, knowingly or unknowingly. We see the effects of the climate crisis, forest fires, floods, biodiversity losses, inhuman migration conditions, unstable societies, military clashes, and more. Are we on the route to losing the human development we gained? The famous and heavily criticized report to the Club of Rome *The Limits to Growth* warned this would happen.[1] It has appalled many, who felt threatened by its clear message: we need to alter humankind's development model. But it has also inspired many. Even though global actions and political decision-making has not drawn the consequences suggested in the report, the underlying message was heard by lots of people. It inspired teachers to change their curriculum, students to focus on environmental studies, companies to shift their business model, and activists to create political parties. Yet, despite these widespread mindset shifts, the decisive turnarounds in how humankind approaches its future has not yet happened at the scale needed.

The world has grown more complex, technology has achieved some of the advancement the report had hoped for, societies have advanced socially, but the underlying drumbeat remained the same: economic growth has been further idolized and measured as if it was the only trusted promise of human progress. Yet, *The Limits to Growth* not only had brilliantly modeled predictions but an even more astute vision of a "dynamic equilibrium state" that societies or the world should achieve. A state in which, among other aspects, population would remain as stable as industrial capital flows, ecosystems would be cherished and taken care of, and wealth would be fairly distributed. What if the report, with all its scientific brilliances and wide-reaching conclusions, overlooked what kept the wrong drumbeats going, what determined the trajectories of societies in dangerous directions, and still does so today?

This article takes a feminist perspective and explores the self-destructive and collectively destructive features of societies as an outdated patriarchal mindset of extraction. The continuous exclusion of women as empowered architects of societies and economies perpetuates structures that create social disparity and alienation from nature, lets technological inventions become more dangerous than helpful, and furthers the accumulation of power by a few at the expense of the many. Without overcoming patriarchy, the future looks grim.

This article shows that exclusionary patriarchal mindsets and structure keep pushing the world into dangerous trajectories. Egalitarian, feminist-inspired mindsets, systems, and processes can engender what is so urgently needed: a collective stewardship approach to taking responsibility for our blue planet. This would mean taking the predictions from *The Limits to Growth* as guidance, expanding the vision of vital societies, and driving collective action to not only halt dangerous trajectories, but ensure female expertise in designing and co-creating futures. Only this will help us organize the turnarounds at scale. Or as Donella Meadows, the deceased co-author of the report, suggested: "The sustainability revolution will be organic. It will arise from the visions, insights, experiments and actions of billions of people. The burden of making it happen is not on the shoulders of any one person or group. No one will get the credit, but everyone can contribute."[2]

Remembering our collective past

Our blue, fragile, and beautiful planet has brought about an astonishing variety of creative forms of life, all interconnected in relationality and

interdependent in emergence and development. Some scientists call this vast complex alive system Gaia[3] in honor of ancient religious traditions who render the female goddess as the source of Life.[4] For thousands of years, humankind has had an in-depth intuitive reverence towards such a powerful creative force. In the attempt to grasp some principles of how this force works, they connected with symbols and myth that helped to explain beauty, processes, and constellations. Among those is the spiral, most obviously displayed in shells, that symbolizes an evolutionary process of emergence and expansion in iterative circles – the past always connected to the future.

Another symbol apparent everywhere in nature and displayed in the arts, but also in ordinary craft, are patterns in unending varieties of connections that, if the human eye is exposed to them, create a feeling of happiness and harmony. The degree of Life in a given space, as the architect and systems thinker Christopher Alexander,[5,6] a lover of ancient art and architecture, suggests, is directly dependent on the holonomy of patterns consciously, or unconsciously, arranged.

Yet another symbol and myth that has carried through human consciousness development is the balance of healthy opposing features, most famously pictured in the Ying and Yang – two elements that make up a circle, if they swing together, overcoming their binary nature. And finally, throughout human history, in myth and real-life societies, the negotiated balance between the individual and the collective that is a lived reality in nature has also been part of all ancient and modern governance systems. The African lived philosophy of Ubuntu, which has become more known around the world more recently, is a brilliant example of the reverence towards human interdependence that is ingrained in so many traditional cultures.[7]

But Life has also brought about a species that has embarked on a strange and increasingly pathological detour away from the ancient reference for its creative force and aims to become the creative force itself. Not long ago in comparison to the entirety human history, it has abolished the insights behind the Yin and Yang and invented patriarchy, legitimizing many forms of exercising power by some people over others. It has pushed the spiral into the background and adopted linear growth models. It has begun to see more benefits in dissecting patterns into disconnected parts, disconnected itself from healthy natural patterns, and asserted dominion over planetary resources. More recently, it gave the individual primacy over the collective. Although it is the same species that loves and longs to be alive, it has optimized the capacity to destroy each other and seriously diminish the planetary life support system – the very basis from which this species has developed.

Moreover, humankind has seriously forgotten another feature of evolutionary processes – wherever power monopolizes resources at the continuous disadvantages of other forms of life, overall deterioration, and finally self-destruction, is not far away. Many people have become oblivious to the fact that we are part of nature, part of the evolutionary process with its creative force, and that we are just a stage in this ongoing process of evolution. Technology has turned out to be a helpful advancement in many instances but is simple in comparison with life's ingenuity of functional ecosystems, from bodies to forests, from deserts to oceans, of which we, so far, know too little, despite the enormous advancements of science. Yet, the protagonists of an unlimited confidence into human-made scientific and technological development adore a seemingly male god of artificial creation. They would identify themselves as the most advanced species that evolution ever produced, so advanced that in moments of godly omnipotence some would claim that they could steer evolution into a different direction. And indeed, this is what humankind is doing now, but probably by no means with the envisaged outcomes. Before technological advancements will have enabled Earthly people to settle on Mars, the human impact on our blue planet, manifesting as climate change, irreversible biodiversity loss, and ecosystem destruction, will remind us that we are not separate from nature and part of the overall evolution. It is time to remember the collective and interdependent past, in which female expertise in leading roles at all levels has been designing and co-creating realities alongside male colleagues.[8] This is what we need for thriving futures: to become humble partners of evolution and lead into the future collectively.

The paradigm shift towards thriving futures

Holistic and globally responsible thinking seems to emerge when emotional inwardness and rational awareness of the larger system become connected.[9,10] This connection is important if we take our responsibilities for future generations seriously and actually embark on stewarding sustainability transformations towards thriving futures. The shift in thinking and perception, from identifying and dissecting objects in a linear cause-and-effect logic, towards recognizing the world in dynamically interacting patterns, is a crucial element of the paradigm shift Donella Meadows called for in her famous article on leverage points for world change.[11] The limitations of everyday consciousness, life experience, and the prevailing scientific paradigm that encourages

dissecting rather than connecting, make it hard to grasp the creative force of *the whole* as an entity that can be perceived, studied, and experienced. Yet, the question "what gives life to the system?" will become the central question in partnering with Life for the future vitality of people, ecosystems, and societies. The results will never be perfect and need to always be open for negotiation and new learning. But stewarding many small interlinked systems at the same time in many different places in the world will move our planet Earth out of the danger zone and into the "safe operating space,"so many scientists are suggesting.[12] A mindset shift towards reconnection with Life, both intuitively and rationally, is like a North Star or Southern Cross; it's a guiding force for working towards a world that works for 100% of humanity and our planetary home. This will happen differently in different contexts but serve the overall integrity of Life.[13,14] Despite the encouragement of future thinkers, it is difficult for the average person to see the coherence of the whole and the vast interplay of patterns of vitality between the whole and all parts – those constellations that keep life going. It is much easier, much more operational, and much more livable to concentrate on certain issues, focus on fragments, and ignore the scientific insight that each fragment actually entails the whole.[15] But even with a radical shift in consciousness towards the planetary integrity we can stay pragmatic and practical. With reference to the most often ignored vision that was embedded in *The Limits to Growth*, Donella Meadows[16] summarized the rules that would guide thriving futures in simple and rather technical terms:

1. Renewable resources should be used no faster than they can regenerate.
2. Pollution and wastes shall not be put into the environment faster than the environment can recycle them or render them harmless.
3. Nonrenewable resources shall not be used at all, and renewable substitutes should be developed.
4. The human population and the physical capital plant have to be kept at levels low enough to allow the first three conditions to be met.
5. The previous four conditions have to be met through processes that are democratic and equitable enough that people will stand for them.

The farewell to patriarchal omnipotence

None of these rules is illogical, outrageous, unrealistic, or impossible. On the contrary, all five are so self-evident that the question arises, how could we create structures and systems that deliberately ignore them? How could have anybody assumed we wouldn't harm Life, the planet, and people by ignoring them?

From a feminist perspective, the element of care for planet and people runs through all five rules and has been advocated for not only by feminist ecological economist writers such as Maria Mies and Vandana Shiva,[17,18] Susan Griffin,[19] or more recently Marjorie Kelly,[20] Kate Raworth,[21] Katherine Trebeck,[22] Hunter Lovins,[23] or Mariana Mazzucato.[24] The ignorance towards such rules that should have become standard operations of every government or business long ago, is a historic pathology and prevalent feature of the patriarchal disease: the mindset of unlimited extraction, unlimited growth, and monopolizing power at the expense of others (women, people, nature, minorities, etc.). Population growth, worldwide, is always related to a combination of poverty and patriarchal dominance, in which women neither have sufficient access to education, nor the freedom to decide whether they want to become mothers or not. It is important to remember that patriarchy is not simply unjust because we organize societies so that over 50% of the population are seen as unworthy or less capable of taking charge of the future; it is a system of extraction that does not stop at gender boundaries. Men (some more than others) have superficially benefitted, and subsequently expanded widespread omnipotence symptoms, because nobody stopped them furthering destructive trajectories. Many of the results of a dissecting worldview, not least in science, have actually advanced humankind. And this is the conundrum: collective stewardship of thriving futures requires us to abolish an outdated patriarchal worldview of the past, reconnect with a holistic view for our future, and sort out the present, so that taking care of Life is the day-to-day task of everybody. But stewarding a thriving future also requires us to make choices. Which technological, social, and societal achievements can we integrate into a thriving feminist future? Which structures, rules, laws, and governance systems are useful and which need to be amended? We are the great-grandchildren of ancient cultures and religions in which women were worshipped as goddesses, and they ruled societies in a deeply democratic way.[8,25] The beauty and wisdom of nature was acknowledged, and humans seen as part of nature. Which of these memories of our global

history do we need to unearth, cherish, and revive? What can be integrated into a modernity that begins to see that reality is infinitely broader, deeper, and much more pluriverse than the current industrial worldview suggests? How can we begin to understand and appreciate this wealth as our common heritage that the prevalence of patriarchy has obscured?

Collective stewardship for systems vitality

What has been clear for many centuries, and more urgently today as we are confronted with the many effects of the extractive mindset, is that the future of our planet and humankind requires women to move into the driver's seat of transformations and fill at least 50% of influential positions. They need to build a female reference system, which can guide transformation efforts to integrate feminist values: the balance of ecological and social needs and values of self-determination, freedom, equality, diversity, and responsibility for future generations. They need to orchestrate change in feminist networks and collaborate with those that are prepared to let go of the outdated patriarchal mindset that has been the constant drumbeat behind decades of a strange mix between human advancement and human destructiveness. It is time women become co-architects of our planetary future and integrate our collective past in the design of a world we can all enjoy living in. It is time for stewarding our societies together towards a thriving that makes use of technological, societal, and scientific advancements, yet revives the reverence for Life's creative force.[9,26] Collective stewardship takes a multifaceted and holistic approach. It is built on insights into ancient and modern knowledge about patterned life principles as well as success criteria for leading transformative change collectively in partnerships, alliances, and networks.[27] The feminist stewardship approach integrates and combines answers to practical, yet fundamental questions.

What are the stories that inspire transformative change?

Emergency narratives are important, yet new thinking and collective action works best with *narratives* that encourage, inspire, and show pathways to more holistic and thriving future possibilities. We need a fundamental shift in worldview beyond all the technical and administrative solutions we know. Women need to adopt a strong "Yes We Can" mentality for transformative change processes. The story must be one of overcoming patriarchy by integrating ancient wisdom with women's empowerment and modern technical

and social advancements. The narrative of care for the planet is a deeply feminist value that has already begun to create resonance and commitment to drive change together.

How do we engage for collective stewardship of change?

The fundamental transformations needed call for collaboration, impact through networks and alliances, as well as strong citizen engagement. New *structures* will emerge – across institutions, cultures, and societal sectors. Based on a new story of a thriving future, well-orchestrated engagement processes bring out the best in people, invigorate the human spirit, and create tangible results in complex collaborations. This might range from regenerating organizations to improving the governance mechanisms, or to fostering local and global transformation networks that empower people to orchestrate local change. What might be perceived as impossible becomes doable when we bring stakeholders together in a clear structure – capable of engendering a culture of collective action and fostering result-oriented partnerships.

How do we guide innovations towards regenerative futures?

Human inventiveness is unlimited. The inventiveness of women has been ignored, forgotten, stifled, or sidelined for centuries. Yet, connecting transformative change with emerging *innovation* is paramount because it is through technological, social, digital, and scientific breakthroughs that we create and strengthen pathways to sustainability. This means nurturing particularly those emerging ideas that come from women and amplifying pioneering approaches. When innovation turns into collective design, integrating collaboration and input from various stakeholders, it moves from being an isolated improvement or a brilliant invention into a tool at the service of the future of humankind.

How do we measure progress?

Metrics may be perceived as part of the outdated patriarchal mindset of mechanistic thinking. But this is true only on the surface. Measuring progress is a useful human faculty and as old as humankind. The question is what gets measured, who measures, and who analyzes which data. If Donella Meadows' rules above had been translated into a variety of societal progress metrics, societies would not have embarked on the current dangerous trajectories. A feminist approach to metrics means to not only make them science and evidence based, but also create metrics that resonate with people and

emotionally connect with their humanity. Appropriate metrics can empower stakeholders at multiple levels to shift thinking and behavior, and to see progress happening.

How do we learn collectively and negotiate differences?

A deeply feminist value is the acknowledgment of difference, diversity, and intersectionality. It is the respect for people and nature that engenders forms of *governance* based on dialogue and negotiation. Collective stewardship for transformations leverages collective intelligence and collective sense-making that furthers behavior change. Governance refers to multiple ways of collectively stewarding transformative change in societies, local communities, and global issues – towards agreed-upon goals or away from danger. Multi-stakeholder collaboration and structured dialogue of various societal groups in policy development and implementation are important for overcoming complex societal or global challenges.

How do we safeguard the commons and planetary life-support systems?

The care that not only the planet needs, but also our societies, requires us to strengthen guiding *regulations* so they harness a balance between individual and collective interests. In a feminist approach, guiding agreements and resource allocations safeguard life's wholeness and integrity at all levels. Without setting rules, transformations to sustainability do not move forward. Guiding regulations steward the way resources are allocated, access is managed, taxes are distributed, or investments are focused. Transformative change requires a combination of voluntary and binding agreements.

Conclusions

We can get out of the impasse if we recognize that patriarchy has been an unhelpful reduction of life's beauty and complexity. Yet, as with all evolutionary processes it is a phase that is ending. The sooner it ends, the higher humankind's chance to steward people and planet into a safe operating space[28] and find the implementation strategies and the many manifestations of the rules Donella Meadows put so simply. Reconnecting with the female-driven consciousness of our past will help to incorporate the depth that human consciousness transformation needs. It will help us overcome patriarchal ignorance and its deteriorating power structures. It will open up

windows of opportunities into regenerative civilizations in which nature is sacred, people are cared for and empowered, and the future is treated in the most responsible way, supported by scientific and technological advancements. Part of this meta-modernity[29] will be images of balance, such as the Yinyang, or images of the spiral symbolizing our willingness to partner with evolutionary processes, and images of patterns, as we begin to understand that the entire universe is made of patterned constellations that bring about the many degrees and manifestations of life. Seeing human development through these glasses, nature is no longer a mere resource. It is a wise teacher whom we honor and guard. People are not consumers, but seekers on the journey into the depths of their minds, their hearts, their potential, and their souls. This feminist worldview is the prerequisite for a regenerative civilization that can become reality on our blue planet – our home – so that we can live at ease, in peace, and happily in partnership with the biosphere.

16

The Limits to Growth in the Asian Century

Chandran Nair

Founder and CEO of the Global Institute For Tomorrow (GIFT)

Introduction

"It is unequivocal". These are the first three words of the sixth IPCC report on the climate change challenge, published in August 2021. Governments are being called to take dramatic action immediately. These viewpoints do not exist in isolation; other international reports, conferences, and institutions support the view that the current global economic model is incongruent with a sustainable future.

To many, this dawn of a global consciousness with regards to the climate change challenge is considered progressive, even if real global progress is hard to come by due to issues of global equity. This was palpable during the last session of the 2021 United Nations Climate Change Conference (COP26) in Glasgow, during which country representatives were invited to make their final remarks about the draft agreement. The divide between the developed nations – led by the European Union and the US – and the others, especially India, China, and African states, was laid bare, with no enforceable agreement being reached.

This divide is important to bear in mind given that 50 years ago, the Club of Rome published its seminal *The Limits to Growth* report to widespread criticism; its conclusions were ignored at best and vilified at worst. Some of those criticisms persist to this day. The concept of thresholds on consumption and wealth creation were anathema to the thinking of the time. Today, despite there being entire fields of economics and public policy on the subject, not much has changed in the way the global economy works.

In the half century since the publication of *The Limits to Growth*, rich countries have hugely expanded their ecological footprint, while poorer countries have been shunted to develop along the same lines, and in the process, both have adopted mass-consumption-driven economic models, thereby further reinforcing the idea of unfettered rights of individual choices, and normalizing the concept of externalizing the true costs of economic activity. This has occurred despite accurate scientific data and economic projections of the effects of rising atmospheric carbon dioxide levels, resource constraints, and ecosystem damage.

Still, most public- and private-sector leaders seem incapable of acting on this information in a positive manner for fear of being seen as working against the other two global movements of our time. The first is the belief in the need to keep growing the economic pie as a solution to address all developmental issues. The second is, again, the notion of widening the scope of unfettered individual freedoms and rights, especially regarding lifestyle choices, irrespective of the consequences. Instead, there has been a worldwide mainstreaming of constructing disingenuous public relations exercises that betray the evidence and fall well short of the radical shifts needed.

Perhaps most worryingly, the global economic views still do not see perpetual growth as being inherently flawed; the overriding belief is that the world economy can – and must – continue growing indefinitely. Attached to this belief system is the view that technological innovations that enable business as usual without the associated damages will be a panacea, because this is far easier than confronting the need to curb consumption. It is especially a challenge to ask those who overconsume in rich Western countries to make sacrifices in the interest of global equity; this requires political interventions and transformations to the so-called "rules based" global system that are too radical for the rich nations of the world to accept.

Yet most climate scientists recognize that the current model is inoperable. Earth system dynamics are not linear but are bounded by thresholds and interlinked via feedback loops; pass a certain point, and entire structures can collapse. Thus, if progress on addressing the climate change challenge

has been missing, what lessons can be learnt from the last 50 years since *The Limits to Growth* was published, and how can it factor into discussions on future solutions to rising environmental catastrophe?

An answer may lie in that oft-used term, the "Asian Century".

While this phrase is traditionally used to describe the rise of Asia as the global economic, consumption, and cultural powerhouse along Western lines of development, it should be repurposed to frame the political objectives and complexities of both the challenges and the solutions of climate change as well as sustainable development.

Why and how? Because the real contest exists in the developing countries of Africa, Latin America, and Asia (foremost) where 87% of the world's population resides. There is an urgent need for these countries to find a balance between the basic needs for their massive (and often poor) populations, and the reality of resource constraints on a finite planet. Thus, although Europe, the US, and China are the heavy hitters today, it is the developmental path taken by the global majority that will determine our fate. This is a path that should also be weaned off the idea of financial and technical aid from the developed countries – unlikely to be forthcoming – and mainly because it is often underscored by the desire to ape the unsustainable economic model of the Western world.

Despite largely unbridled economic growth over the last 50 years, the drudgery of daily life for billions in the developing world is yet to be eased through sanitation, potable water, affordable housing, and secure food supplies. How can they be empowered and become economically productive while avoiding the adoption of developed-world habits that will result in environmental catastrophe? The harsh reality is that the Asian population is predicted to reach 6 billion by 2050, and it is physically impossible for them to achieve the same consumptive lifestyle as a middle-class Westerner. Therefore, clear political objectives about development will need to be determined, which will involve enacting new ideas that the world has not been willing to embrace, given the parallel global drive led by the West to spread free market capitalism tethered to ideological obsessions with democracy – both of which are unsuited to the challenges of the 21st century.

China, India, Indonesia, Pakistan, and the Philippines are some of the world's largest nations and are still growing, although China is the most advanced. These countries will therefore become the centres of global economic activity over the next several decades, meaning it is far more important for them to navigate a clear path through the complexities of the 21st century than, say, the much smaller economies of Europe. Their very survival may

depend on taking large-scale actions that hitherto have been unseen, especially as Asia cannot rely on the luxury of exploiting global resources in the drive to develop, and nor can it leverage post-colonial networks that enable capital and resource inflows.

This is the challenge of our times, which the original *The Limits to Growth* did not properly account for and understandably so. Fifty years ago, Asia's development and contribution to climate change and other environmental issues was hardly on the radar and viewed almost entirely through a Western economic lens. Today, environmental narratives are still largely controlled by richer Western nations, but Asia will have to confront the brutal reality of the path it has taken to date – and change course. Can it?

If it is to try, any attempt will have to be anchored to political positions that are a sharp departure from Western ideas about growth, development, and governance systems. China appears to be the one country willing to take this difficult course, and it is interesting to note that it has become the subject of collective Western antagonism. After all, if its model succeeds, then where does it leave the neoliberal Western model and its notion of superiority and the desire to continue to dominate the world? With a distinctly non-Western inclination, countries across Asia are realising that governmental intervention is increasingly needed to protect public goods, with the implication that this responsibility cannot be abdicated to free markets, private interests, or technological revelations.

The pandemic has made this very clear and therein lies an opportunity for Asian governments to change course and build truly equitable societies. China, for example, has already begun implementing strict standards, firm bans, and heavy investment to support sustainability, while India, as of COP26 in 2021, has set its first-ever goal to achieve net zero carbon emissions by 2070. India's challenge will be whether its current messy democratic system will be able to deliver results to address this existential threat or if it will need to reinvent its system of governance.

This is where *The Limits to Growth* can have great renewed utility. By including Asia's cultural, economic, and political preferences into new renderings and theoretical understandings of future limits (as opposed to largely Western-sourced parameters), an entirely new trajectory for the climate challenge may be discovered. While the context of the climate challenge has shifted over the last half century, the core values of *The Limits to Growth* remain the same: intellectual honesty that speaks truth to power in a way that works to transform the status quo for actionable change to sustain the

health of human societies across the world. The impending Asian Century can still be shaped in this way.

Divergence from the Western centuries

In order for the Asian Century to move along its path, there must first be a frank recognition that the Western Centuries have sown the seeds for our current predicaments, and thus its ideologies of growth are both outdated and need to be rejected. Not that the Western Centuries are to be solely criticized, rather, a critical but flexible viewpoint should be taken with regards to the Western origins of contemporary economic models.

When one looks back at *The Limits to Growth* report of 1972 and reflects on its impact in Asia and its relevance today, it is crucial to be mindful of five things:

- In 1972, the world's population was less than half that of today (around 3.7 billion) and the Asian population was 2.1 billion.
- Much of the region was still in turmoil and enduring wars, e.g., Vietnam, Cambodia, and Indo–Pakistan.
- Resource pressures were significantly less stressed than today.
- Most countries were undeveloped, and poverty was widespread.
- Growth was a commonly held dream, while limits were an alien concept.

At the time, many Asian countries had just emerged from a period of colonization and aspired to use their new-found freedom to enter the global system set up by select Western countries to develop economically.

In the subsequent 50 years, the population of Asia exploded, and now stands at 4.7 billion – more than the global population of 1972. In the rush to develop, Asia adopted the "growth at all costs" model exported by the West and mimicked the political and economic systems installed and employed by former colonizers. Asia's elites, while keen to see their former masters leave, wanted to simply take their place and often followed the same exploitative practices.

While this approach has helped modernize large areas of the developing world, the results have also been catastrophic on many fronts, not least because of the modern economic idea that we can all aspire to be rich or

middle class: a belief that is simply impossible for the billions in Asia. So, it is essential for Asian countries to recognize this great challenge ahead.

This is not a small feat, given that inappropriate ideological concepts have been continually informed, implemented, and legitimized at the behest of influential Western multilateral organizations. These ideas continue to be promoted and taught by the business schools of the West as if no other options exist. Due to age-old subservience to Western thought, these schools have continually attracted the best and brightest; many of Asia's leading executives are often trained in schools such as Harvard Business School, London Business School, and INSEAD. While many curriculums impart valuable lessons, they also facilitate the continuation of economic theories that favour growth at all cost and crude ideas about competitive advantage. Often, they are in denial of the scientific evidence about limits and pander to concerns about existential threats with seductive arguments about the ability of markets to correct themselves and offer technology as a solution for every possible eventuality.

However, these economic theories, as first demonstrated by *The Limits to Growth*, are at odds to the sustainable preservation of stable climatic systems and healthy ecosystems. The economics of growth and profitability are only possible by means of a free ride on negative externalities. Two contemporary examples include ever-expanding food delivery services and smart phone production. The former is a global business model that thrives on underpricing of carbon, food production, plastics, and labour throughout its value chain. For the latter, tech companies have built business models premised on planned obsolescence, incentivizing a cycle of frequent product launches in order to sustain artificially inflated market valuations. In this case, carbon emissions are the tip of the iceberg; these devices also rely on a host of raw materials, including rare earth metals, many sourced from developing countries where labour is underpriced and exploited or where conflicts are a result of competition to control resources.

Despite these concerns, the current economic model remains largely unchanged. However, there is little appreciation that this idea is instead leading to a great "era of divergence", as we see an expanding and perhaps necessary or even inevitable (for now) split between Western liberal thinking and the reality in much of the developing world, Asian countries included.

The first divergence naturally manifests as national movements away from the post-colonial economic model. The belief that all developing countries will eventually emulate the developed world, provided they follow its prescriptions, is being recognized as outmoded. But this divergence is

not necessarily only between the "haves" and the "have-nots". It is also between those that benefit from overconsumption, and those that suffer its consequences. The latter group are particularly susceptible to challenges to their basic needs, such as reduced access to sources of potable water, and adequate nutrition. Without a way to resolve this system-wide market failure, the current model of economic growth will offload its costs onto vulnerable communities.

The second divergence comes from the push to Westernize societies, especially in Asia. Current models of development argue that if countries embrace Western economic ideas, they will simultaneously develop along a Western political and cultural path. However, as this model is perpetuated through consumption, its approach to development will only accelerate economic divergence. In addition, the active attempt at cultural "convergence", driven by political ideologies and economic imperatives, has often instead fostered the reverse: a fervent, sometimes violent resistance against what is perceived to be the West's overbearing nature.

The third divergence comes from the narrative that innovations in technology, especially hyperconnectivity, will increase economic opportunity and social welfare. As these appealing claims get mainstreamed, it is often forgotten that the promoters of today's hyperconnective innovations live and work in rarefied environments, have strong financial incentives to promote connectivity, and are often isolated from the on-the-ground needs of the world's majority. Imagine if interconnectivity priorities shifted to include water supply and sanitation systems, which in most parts of the world lag far behind digital connectivity!

Even when communities have access to these networks, they have not proved sufficient to overcome the stresses of current economic models and policies. For example, a smartphone is little comfort to the Syrian or Iraqi refugee in Europe. Although they are transformational technologies, the internet and the smartphone are no cure for a society unable to provide universal access to basic needs, such as safety, clean water, good nutrition, and health care.

Connectivity can even accelerate divergence. As the internet eases access to goods, the cost of consumption paid by the individual is reduced even further, only adding to external costs. This encourages overconsumption and expands the gap between those who receive its benefits and those who bear the burden of its costs.

Political and business leaders – especially those in the developing Asian countries – risk burgeoning societal challenges when they ignore these

divergences. As such, Asian governments should talk more about "divergence": how the gulf between what the "trickle-down" approach predicts and the outcomes it achieves has only grown greater over time. They must focus on the one convergence that really matters: achieving the basic rights of life for all the world's population. In the Asian Century, this can unlock real economic opportunity by freeing people from the drudgery of destitute living.

The climate solution is the climate problem

When one understands the history of the current economic model and its drawbacks, it is possible to see how this links to the problems inherent in current solutions to the climate change challenge, given that all climate change solutions are fundamentally driven by economics and politics. The core values of *The Limits to Growth* impart a moral imperative to continue pointing out such risks.

The first example of this is the belief that markets will help address climate change. The assumption is that companies with the right policy incentives will be able to generate effective solutions to climate change with guidance from the "invisible hand". Historically, unregulated business activities do not take into account environmental externalities and consequently this is one of the key contributions to the world reaching its current precipice.

As a result, even if the free market encourages business activity to become more sustainable, it does not address root problems. Corporations do not do "sustainability", which is a public good, they do "more". Markets disguise the failure to achieve actual reductions in externalities such as greenhouse gas emissions or levels of energy consumption through carbon offsetting – by planting trees, for example.

The carbon offset market is an example of a market-based approach that is constructed around pseudoscience but is accepted in order to preserve business as usual. Fundamentally, there is no equivalence between emitted CO_2 and CO_2 that has been offset. This is because it is not possible to equate absorption of atmospheric CO_2 by trees (or other sequestration organisms) with the CO_2 emitted from burning fossil fuels. Trees are part of the active carbon cycle, while fossil fuel reserves are inert. Trees take decades to absorb carbon, while fossil fuel use releases it instantly. Even more glaringly, there are not enough trees in the world to offset society's carbon, and nor will there ever be, and especially if the majority seek lifestyles taken for granted by the minority.

Tech-based climate solutions may not be replicable in developing countries because they may be wholly unaffordable or may not be suited to local conditions. This is seen in solutions like biofuels and bioenergy with carbon capture and storage (BECCS – one of the more recent "saviour" technologies), which would demand between 0.4 and 1.2 billion hectares of land, which equates to 25% to 80% of all the land currently under cultivation. This is simply not possible when global demand for food in 2050 will be between 30–50% higher than at present – mostly from large developing countries like Nigeria, Indonesia, and India. The reality is that the governments of these countries will need to focus on feeding their people first and foremost.

For example, China is often portrayed in global media as the world's carbon "enemy", given it is the largest CO_2 emitter. But the global minority, the rich countries of the West, released the vast majority of emissions as it progressed over the last 200 years and continues to emit many times more than the global majority. The US, for example, has emitted far more CO_2 than any other country; a quarter of all emissions since 1751 have occurred there. Despite China's huge rise in emissions over the past decade, emissions per person still sit at less than half those of the US. Meanwhile, the one billion people living in sub-Saharan Africa each emit one-twentieth of the emissions of the average person in the US.

By not clearly attributing responsibility of the climate crisis to the over-consumptive lifestyles in minority countries, political refuge is provided, and inaction is allowed, enabling the situation to worsen and impact the entire planet for the sake of pleasure for the minority. This means that growth of consumption in the rich world must plateau; developed countries must scale back their levels of resource consumption and pollution output in order to give room for the rest of the world to grow to deliver moderate levels of prosperity.

Shared prosperity in the Asian Century: The role of the state and redefining progress

The post-colonial economic model that existed when *The Limits to Growth* was first published still persists today, hampering the possibility of real solutions to climate change. The Asian Century should progress beyond these fundamental obstacles, and this can only be achieved if new economic, political, and cultural options are explored. In particular, we need an enhanced role of state intervention and cultural plurality with the goal of delivering a shared prosperity for all in the Asian Century and thereby a more sustainable future.

First and foremost, developing countries have a unique dilemma: they need to improve living standards and spread access to the basic rights of life for their largely poor majorities while consuming resources sustainably. This should be the basis for any discussion about, or definition of, progress in the Asian Century. As such, Asian countries must imagine a future in which expanding consumption based on the presumption of unfettered individual rights is not seen as the only recipe for economic wellbeing and political stability.

Asian governments must take decisions on some fundamental questions. What level of per capita energy consumption is viable? Should urbanization be seen as inevitable and necessary, especially when the outcome is often squalor? How to pay for sustainable food production and ecosystem services? How should transport systems be built for public mobility, not car ownership? How can universal healthcare be provided? What technological tools can facilitate the best outcomes to these questions?

All these political objectives regarding governing a society equitably will, in turn, affect assumptions about freedoms and rights.

There is a real need to understand that the sustainability crisis is ultimately caused by a lack of governance over the economy and resource exploitation. Thus, for the developing world, the answer – which is far removed from current Western schools of thought – is that only greater and stronger governance can meet the challenges they face.

This, in turn, can only come from the state, which is the only entity with the legitimacy, authority, and convening power to intervene in the national economy and protect both public and private goods. Local community empowerment without state support ultimately only scratches the surface or, once fully frustrated, turns into movements of defiance. In contrast, when melded with the state, they can create permanent change. On the other hand, global governance and international accords are currently a convenient mechanism for rich countries to avoid making tough decisions at home. Indeed, they shift the adjustment burden disproportionately to poorer countries, which demonstrates that efforts towards sustainability go nowhere if national governments are unwilling or unable to act.

Importantly, a strong state should not be confused with an authoritarian one – policies achieved using propaganda, suppression, or even violence are the acts of a weak state, unable to garner the support of its own people. A strong state that can resist private and vested interests is fundamental to counter the threat posed by the "growth at all costs" economic model. Free markets and corporations are not built to tackle the sustainability crisis,

which will ultimately require societies to produce and consume less, and use fewer resources. Companies and markets encourage greater consumption and production, and so will only work otherwise if governments make overconsumption of resources and overproduction of waste unacceptable.

Imagine what would happen if governments, rather than allowing markets to be manipulated – thereby widening inequalities – instead focused their efforts to seriously spread access to basic needs, such as sanitation, housing, education, and healthcare, to their populations. Another necessary aspect of the movement to the Asian Century that strong states will be able to facilitate is the minimization of assimilation to different cultures stemming from Westernization, or the "assault of modernity". Global culture – insofar as one can talk about it – is really driven by a very small number of countries: the United States, a few European countries, and possibly Japan (and now South Korea). Regional cultural powers, such as India, China, Indonesia, and Nigeria, do not yet have the global cultural presence that the US does. Despite this cultural monopoly, attempts to preserve local culture (such as China's strict approval system for foreign media) are often portrayed as evidence of parochialism.

The threat to cultural pluralism is bad in itself, but there is an economic effect as well. Currently, the only global vision of "the good life" is the Western one: a two-storied house in the suburbs, with two cars, the latest appliances and gadgets, an expansive meat-based diet, and so on. This is, essentially, one of the most consumptive lifestyles of all cultures. Even countries that follow very different economic and political models, such as China, still sadly see the American way of life as the symbol of modern prosperity. This is why, after 50 years since the publication of *The Limits to Growth*, it is critically important that as the world addresses the challenges of the 21st century. In the Asian Century, this could appear as an "eco-civilizational revolution" led by the nations of the developing world, where the majority of people live.

Returning to China, the country has promoted an eco-civilization approach since 2007, and is now seen, perhaps begrudgingly, as the leader of the global effort to combat climate change. At a national scale, China has set up the world's largest carbon trading market; at a city scale, it has mandated all public transport (taxis, buses, trains) in Shenzhen to convert to electric-powered vehicles. But there is also a cultural argument that is missed by commentators: China is a much older civilization and culture than the US, and predates today's consumerist, resource-intensive, and materialist cultures.

Even as China embraced capitalist practices to help lift its people from poverty, it now seems to understand its limits. Deng Xiaoping first used the term "moderate prosperity" in 1979, connecting the idea to Confucian principles, and was echoed by later Chinese leaders. In 2013, Xi Jinping, the president, called for "ecological civilization reforms" to account for the environmental repercussions of China's development. In 2021, China added the concept of "common prosperity", a major policy push to create a society that is fairer and where inequalities will be narrowed.

India too has expressed its support for tackling climate change. Narendra Modi, the prime minister, stated that "exploitation of nature is not acceptable to us". Mr Modi too referred to India's long history and culture when he stated that "for the last 5,000 years, even when I was not born, it has been the tradition in India to protect the environment". Like China, India has a long history steeped in wisdom and knowledge that predates today's industrial economies.

Conclusion

Fifty years after *The Limits to Growth* was first published, the most significant challenge facing the world will be how to balance the necessities of development and providing basic needs for poorer countries without succumbing to the excesses of rich countries, while at the same time preserving cultural plurality by avoiding a blinkered chase of a homogenous globalized Westernized approach.

Encouragingly, discussions have started about the need to curb global consumption, even if participants balk at pursuing the logical policy conclusions. More leaders must grapple with the true scale of the crisis, beginning the difficult task of searching for solutions.

The challenge is to redesign our economic system and reward its captains for confronting this existential threat. It requires puncturing the myths at the core of our economic system and confronting hard facts. This will probably see contemporary capitalism being reshaped: a ground-up transformation of how the private sector serves society, with mandates for businesses to value sustainability, conserve resources, and prioritize social stability more than shareholder value or short-term profits. If they fail, licences to operate must be revoked.

This might sound revolutionary, but the alternative is gambling with accelerating large-scale socioeconomic and environmental destruction.

Governments must take responsibility for social welfare and basic needs and cannot assume optimal outcomes from free markets and the pursuit of growth agendas based on trickle-down economics. This requires reversing the economic trends of the last 50 years and the subduing of winner-take-all approaches, which have resulted in the state falling captive to strong vested interests.

Governments must prepare for a sustainable future, or they can expect people who lack access to what they see as "basic rights to life" to rebel. Indeed, this is no more important than in the largest countries in the world that, except for the US, are all developing economies. In particular, the two Asian giants of India and China tower over the rest. These large and growing countries, where the majority are still poor, will need to find development trajectories that are appropriate to their socioeconomic and cultural contexts. They will be the vanguards leading the creation of an eco-civilization, based on new political systems, sets of rules to promote collective welfare rather than individual rights and thus paths to moderate prosperity. Asia has a key role to play. The Asian Century will determine the fate of our planet.

17

Prosperity in resilience

Yi-Heng Cheng

Member of Club of Rome, Fellow of World Academy of Arts and Science, Adjunct Professor of College of Design and Innovation, Tongji University, Shanghai

Historical background

My connection with *The Limits to Growth* started in 1974 before I left Taiwan for overseas study in Germany. I first read about this book and the Club of Rome, formed by a group of futurists, in a column in *Time* magazine. It took me quite a long time to seriously look into what problems human beings were facing. After study, I joined a multinational chemical company and worked in chemical industries for over 20 years. My solutions had been always based on ordinary chemical processes, technologies, and conventional business models. In 2004, I was firstly awakened by Ernst von Weizsäcker's *Factor Four* during his visit to Beijing and shocked by Bio Schmidt-Bleek's[1] idea of Factor 10 when we met in Fukuoka. Both have opened my eyes to *The Limits to Growth*.

The Limits to Growth was the first real study that utilized dynamic models to analyze the future. The main variables applied then were Resources, Population, Food, Industrial production, and Pollution. Since then, the data of

the past 50 years has shown that the forecast has closely matched the reality. We are heading into the final scene predicted 50 years ago.

The book *2052*, published in 2012, has been recognized as the follow-up study with an improved World3 dynamic model and the summary of data contributed by many countries showed its acceptance and joint efforts. However, despite the forecast, the impact of overuse of land, water, excess of solid wastes, especially plastics, gene-modified food, and accelerated diminishing of biodiversity are still unavoidable. We are running into the fate which was predicted 50 years ago and warned about again ten years ago.

The year 2030 is not far away, even with 50% reduction of carbon emissions globally now slowly committed to across the world, it will not solve the crisis caused by climate change, due to the continuous impact of the "10 tipping points series" listed by the Potsdam Institute of Climate Impact Research. On the one hand we are to implement ways to deal with one of the main culprits, carbon dioxide, on the other, we also have to prepare to face the consequences of the ever-increasing frequency of "natural" crises, such as typhoons, snow storms, floods, droughts, and forest fires. This includes the powerful example of the pandemic triggered by Covid-19, which as of 2021 it is still ongoing and may continue for years. Facing any crisis is becoming more than a question of emergency rescue systems being in place, or the guaranteed financial backups for risk insurance, it is more about the resilience of the society.

To address these complex issues, this article will base its arguments on five elements, each represented by two extreme "states" described by key terms derived from basic common values found within multiple, long-standing cultural contexts, such as: Individualism and Collectivism (Freedom, Metal); Negotiation and Decentralization (Equality, Water); Populism and Plurality (Democracy, Wood); Consumption and Sufficiency (Legality/Law – human and nature, Fire); Sovereignty and Cultural Heritage (Belief, Earth). Each of the pair represents an opposite and yet supplementary (or complementary) metaphor that is needed to balance itself and among/between each other. Apart from applying dynamic models as World3, another model based on Chinese traditional 5 Elements will be suggested: Metal, Water, Wood, Fire, and Earth in a beneficial sequence, and Earth, Water, Fire, Metal, and Wood, representing a control sequence. Such a model may present a future that is more relevant to the Community and Societal Development for Prosperity in Resilience.

5 elements systems

Using Water, Wood, Fire, Earth, and Metal as the 5 Elements for judging the dynamic balance between Yin and Yang was founded in Traditional Chinese Wisdom. The original Chinese system was related to Individual Health, where the Meridian (not the organ) Kidney and Emotional Fright is represented by the Water Element, Liver and Anger by Wood, Heart and Delighted by Fire, Spleen and Worry by Earth, Lung and Sorrow by Metal. This approach and thinking have been specified as a representative of the Eastern System. They have been arranged in a "sequence of benefit". That means a well-functioning Meridian Kidney can yield a well-functioning Meridian Liver, a well-functioning Meridian Liver can keep Meridian Heart functioning, and so on. In the other corresponding sequence, Water, Fire, Metal, Wood, Earth, it shows control instead of benefit. E.g., Water controls Fire, thus, if Meridian Kidney is blocked, then the Meridian Heart will be affected, Wood controls Earth, the Meridian Liver then affects Meridian Spleen, and so on.

It is important to note that the Meridian Kidney is not only the organ Kidney, it covers the whole network related to Kidney and its overall functions, so are the other Meridians.

The 5 Elements can also be applied in Chinese traditional Bildung, specified as Chinese Bildung System (to separate vs. Chinese Health System), which is in the sequence of benefit:

1. Mindful Love, Water Element: To do things for others engaging One's Heart, and to treat others like Oneself.
2. Societal Order, described in 5 Ethics, Wood Element: Superior and Subordinates, Justification; Father and Son, Closeness; Older and Younger Siblings, Elderly Sequence; Husband and Wife, Difference in Functions; Friends, Trustfulness.
3. Mission, Fire Element: Starting from a pure and positive mindset of a person (that comes from inner self), to educate oneself, to build up a solid family, to manage a country (or a tribe) and finally to govern the world with peace.
4. Earth Element, Cosmopolitan (Ideal) Vision: World is for the Public; Fair Prosperity (Reality) Vision: Family is the World.
5. Oneness, Metal Element: Envisage the Nature Law and Constrain One's Desire, Human and Nature is in Oneness.

Correspondingly, we can take the 5 Western common values, such as Freedom, Equality, Brotherhood (Fraternity, Love to Comrades), Democracy and Legality as the Western Value System.

Comparing the Western Value System and Chinese Bildung System, it seems we can align with Love. Chinese Traditional Mindful Love comes from inner self, it can be represented by Water Element, whereas Western Fraternity it is from God, that's a Fire Element. Freedom in traditional Chinese means, "Starting work in the farmland when sunrises, resting when sunsets, how could the emperor bother me?" Traditional Chinese Democracy is, "People have the highest priority, then Country, thirdly, the Emperor." Both traditional Chinese Freedom and Democracy are part of the Societal Order that belongs to the Wood Element. So as Water benefits Wood and controls the Fire: Mindful Love yields Societal Order and improves the individual contribution (as a Mission) to the society. However, Freedom and Democracy in the Western Context are the result of power struggles. Western Freedom is a relief of all unfair conditions, and it concerns everywhere and impacts everyone, like Element Water; Western Democracy is the basis of a choice, where every decision is part of such a process, that's the Element Earth. Fraternity comes from God, same as Religion and Belief, which are the Element Fire. As Fire controls Metal/Legality, in the Western Context, the Belief in God has a priority to the Law made by human beings.

The differences between the Eastern (Chinese or Asian in broad sense) and Western (European, North American in broad sense) experiences not only about the wording, but also the meaning due to different contexts. Thus, when we think of the World Model through the Application of AI (acting as an information field), the traditional 5 Element Dynamic Balance may become a valuable tool, in addition to the standard Modeling, using big data banks and algorithms.

Societal values as metaphors

In the following we will take the 5 Common Values as our focus to develop such a model that is an alternative to AI. Each individual value in it can be divided into two values, that are most related, which might be opposite, but not necessarily, yet can be separated. Each one of these values can be further divided into 5 metaphors, again they can be separated, and may be very much in contrast however related. Let the expected state of the society

vibrate with the 50 metaphors and present its discrepancies as the driving force for Balance, then, the driving forces will become our focuses.

Figure 1. Five elements of Traditional Chinese Health (left), Chinese Bildung (middle), and Western Values (right)

Freedom/Water: Collectivism, Individualism

Freedom is valid for all, everything and everywhere, just like water can flow to anywhere and fill any hole. Collectivism and Individualism are the values behind Freedom.

Collectivism comes from culture, society, or history that have impacted the individual unconsciously. Below collectivism is Nationalism or Patriotism, and National Justice caused by war or historical damages. Above collectivism is a thinking that places the Human in center, and an engagement of Nature with Human as Oneness.

Individualism is based on individual needs, wishes, independent judgment and one's own values. Above individualism is self-realization and divine love, whereas below individualism there is heroism and self as the center.

Equality/Wood: Negotiation, Decentralization

Negotiation in this context consists of dialogs, exchanges, discussions, and meetings between parties with equal position. Above negotiation is compromise, a deal agreed upon with one side being winners and the other as losers, and a deal agreed between both being winners without losers. Below negotiation, there are lopsided conquering and competitions based on strength and weakness.

More recently, Decentralization is a word popularized through blockchain, as it represents true independence from centrally controlled and operational system. Below decentralization is self-organization – just like a biological cell with own functions of healing, immune, remediation, and rebuilding capabilities. Also co-existing, the original human's pure desire based on love, such as Ubuntu in Africa, and mindful love in China. Above Decentralization is sharing, with equally shared functions and utilization of goods, and symbiosis, harmonization in the overall ecological system.

Equality in this context has a broad meaning, instead of focusing on races, gender, job opportunities, performance evaluation and pay, a state among and between Dualism and Oneness shows that it is the element wood, growing and blooming.

Democracy/Fire: Plurality, Polarity

Eastern and Western thinking has different interpretations for democracy; however, the state can be similar. Plurality, keeping the common and looking for differences under the same goal is one, and following the main stream of the people as the goal, popularity, is the other.

Above plurality is interdisciplinary, accepting more goals with integration, and openness without border.

Above popularity is personal authority and idolatry/worship. Below popularity is personal charisma and absoluteness.

Democracy, the driver of the balancing between ruling power and human rights, and thus, is the fire element.

Governance/Earth: Sovereignty, Cultural Heritage

Sovereignty refers to the rights over people, space, and material and is formed due to historical reasons and/or by war. Below sovereignty is submission and occupied by force, both are done unwillingly. Above sovereignty is global values, and global citizen. Both are defined by the developed countries, arriving at this stage in history earlier.

Cultural Heritage starts with a belonging regardless of boarders, that could be created through being conquered or occupied, or evolving through years of settlement and engagement. Below cultural heritage is doctrine, rules without questioning, and discipline, rules for certain purposes. Above

cultural heritage is integration through natural development and emergence of new civilization.

Governance is the base of all ruling administrations going towards, it is an earth element.

Belief/Metal: Consumption, Sufficiency

Consumption orientation is double-bladed dilemma, creating demand on one side (good for economy), and consume resources on the other (bad for ecology). Below consumption is squandering as spending resources or even wasting without control and plundering via taking over by power. Above consumption is profit orientation and monopolizing via utilizing capital and market advantages.

Sufficiency is the basis of sustainability, below it is demand oriented and barter trade on goods and services. Above sufficiency is choice by rational and satisfaction on function.

Belief is the bottom line across religion and ism, the element is metal.

5 Variables from *The Limits to Growth*

When the Western world has been practicing capitalism to the extreme, resulting in competition, consumption and productivity with globalization, now confronting the crisis without (or with belated) solutions, turning around and watching Eastern world rushing and copying right behind. Whereas the West has started looking at the East from its own perspective, the East, after more than one century of Westernization, has also started reviving its own traditions. Eastern and Western values and wording may be the same, however, the emphasis might be different for certain time periods during developmental phases. Ultimately, outcomes of various states can be predicted by the state of Dynamic Balance of 5 Elements.

As described in the beginning of this chapter, 5 variables: Population, Resources, Food, Industrial Production, and Pollution, set in *The Limits to Growth*, were quantitatively dealt with. In viewing the unfolding of a crisis such as Covid-19, what are the most critical issues to symbolize the New Normal, that may also be viewed as the typical emergence of any living systemic process after great disturbances, will keep us prosperous in Resilience, not only quantitatively, but qualitatively?

Freedom/Water		Equality/Wood		Democracy/Fire		Governance/Earth		Belief/Metal	
Human and Nature in Oneness	Divine Love	Win-win	Symbiosis	Openness	Idol worship	Global Citizen	New Civilization	Monopoly	Functional
Human Based	Human Based	Compro-mise	Sharing	Inter-disci-plinary	Personal Authoriza-tion	Global Values	Integration	Profit oriented	Rational
Collectiv-ism	Individual-ism	Negotiation	Decentrali-zation	Plurality	Popularity	Sovereignty	Cultural Heritage	Consump-tion	Sufficiency
National-ism	Heroism	Competi-tion	Self-Organizing	Multi-Partisan	Personal Charisma	Submission	Discipline	Squander-ing	Needs oriented
National Justice	Self cen-tered	Conquer	Co-exist	Target oriented	Absolute-ness	Occupied	Doctrine	Plundering	Barter Trade

Table 1: Metaphors derived from Global Values

The following are answers from the TimeWaver,[2] via Energy Point Module, which are presented as Relevance 1–100%, Intensity 1–10, and Potency on material, mindset and psychology, in bracket respectively. Eastern and Western are not necessarily classified by boundaries or languages, it is in our consciousness.

Population: World population grown rationally, all humans live healthily and happily;

Western: Equality (76/10/D 2000), Monopoly (68/10/C 8), Sharing (74/9/LM XV), Multi-partisan (65/9/C 30), Human based (56/10/D 1E36);
Interpretation: Races equality on material basis and monopoly via mass effect are causing incorrect actions, need to be adjusted; Multi-partisan vision is correct, however, wrong actions based on human centered concept from ancestors on material level need to be corrected.

Eastern: Multi-partisan (86/8/LM IV), Personal charisma (71/10/C6), Personal authority (67/9/C 1E36), Governance (48/10/LM 1E12), Compromise (81/8/1E6), Profit oriented (58/9/C400), Sufficiency (38/10/LM CD);
Interpretation: Multi-partisan is a correct vision, however causing wrong actions. Through personal charisma and personal authority can help governance implementation and achieve compromise; Profit oriented thinking causing wrong actions; Sufficiency is a right vision, however, actions are lagging behind.

Resources: Function- and Service-based utilization of resources, ecological and circular exploration and treating rest material holistically;

Western: Individualism (94%/10/D 400), Win-win (82%/9/D 400), Openness (79%/10/D 24), Personal Charisma (62%/7/D 1E12); National Justice (52%/10/D 10000);
Interpretation: Individualism and Win-win caused wrong actions on material level, openness to all comments will help reduce them; Following personal charisma, keeping the traditional values from parents, achieving national justice can correct the wrong life theme on material level.

Eastern: Sharing (97/7/LM MM), Consumption (73/9/C 23), Idolatry (71/10/LM VI), Democracy (71/9/LM LX), Integration (65/8/LM MM), New Civilization (69/7/D 15), Multi-partisan (67/7/LM II);

Interpretation: Sharing is a correct vision, mindset on consumption will cause wrong actions; Idolatry, democracy, multi-partisan and integration are correct visions, that can adjust thinking errors.

Food Production: Ecological and technical application of regenerative agricultural production;

Western: Negotiation (83%/7/LM C), Equality (80%/9/LM XV), Plurality (77%/9/C10000), Governance (55%/10/D 50000), Discipline (47%/8/D2), Popularity (47%/7/C 1E24);
Interpretation: Negotiation based on equality is a correct vision, emphasis on plurality causes life theme confusion; Governance and discipline on material level cause wrong actions due to inherited thinking from previous generations (grandparents).

Eastern: Absoluteness (71/9/LM 1E36), Interdisciplinary (67/10/D 30), Individualism (54/9/C 50000), Discipline (52/10/D10,000), Consumption (48/10/LM XVIII);
Interpretation: Absoluteness coming from ancestors' passing on are still around; Actions through interdisciplinary ways are wrong, need to be adjusted; Individualism and consumption oriented behavior cause incorrect life theme;

Industrial Production: Limited by ecological capacity, via technical advancements, fully applying reuse, recycle and re-sourcing of products and wastes;

Western: Negotiation (88%/7/LM C), Individualism (77%/10/LM 1), Metal (77%/8/C1), Target oriented (74%/7/D 1E36), Monopoly (62%/7/C 30), Global Values (52%/8/C 3);
Interpretation: Equally based negotiation is a correct vision; Individualism is OK but to be adjusted mentally with bottom lines; Target oriented on material level is based on ancestors' tradition, leads to monopoly, can be corrected by global values.

Eastern: Target oriented (77/8/D 6), Self-centered (66/8/D 10000), Competition (63/10/LM CC), Openness (63/8/LM III), Popularity (30/10/LM 1E12);
Interpretation: Target oriented on material level causes wrong actions; Self-centered on material level causing wrong life theme; Corrections can follow Openness, Competition and inherited Popularity from parents.

Pollution: CO_2 level back to ecological balance tolerable and warming effect controllable range, no release of poisonous and harmful material, careful application of technologies;

Western: Self-organization (87%/9/LM 1E24), Absoluteness (79%/9/C 1E36), Occupy (72%/9/D1000), Compromise (76%/8/C 6), Cultural Heritage (76%/7/LM MM), Needs oriented (64%/10/C 15);

Interpretation: Self-organization is a correct vision, support of absoluteness inherited from ancestors is necessary; Occupying, needs oriented and compromise thinking causing wrong actions need to be adjusted by culture heritage that also improves lifestyle;

Eastern: Plurality (89/10/D 10000), Sufficiency (89/8/C 100000), Multi-partisan (76/8/LM VIII), Equality (69/8/D 4), Needs oriented (64/9/D 1E6), Sharing (49/8/1E12), National Justice (49/10/C 1000);

Interpretation: Plurality on material level causing wrong life theme, that can be adjusted by sufficiency mindset; Wrong actions caused by equality, needs oriented and national justice can be adjusted by visions of multi-partisan and sharing inherited from parents.

Implications for alternatives to AI information fields

Perhaps the current metaphors used are not well enough defined, including the relationships among each other are not explained or clearly separated, thus the results can't be precise. However, the expected states of the 5 variables from *The Limits to Growth* can be described, and the differences to current state can be analyzed. Also, the thinking, mindset and actions can be thus corrected and adjusted. For AI information fields that are based on reductionism, to do complex modeling that requires reconstruction of models, this study can serve as a preliminary set of metaphors for continued analysis.

In the value analysis, in either Eastern or Western contexts, Democracy shows the highest number of ticks. In the Eastern context, there are 10 metaphors involved, including Democracy as a value itself. Multi-partisan has occurred even in 3 variables out of 5; while in Western context, Idolatry/worship, Personal Authority, and Interdisciplinary have no impact on Democracy.

There are also different impacts for metaphors in one Value, such as in Value Belief: Monopoly occurs twice in Western context, whereas Consumption and Sufficiency occurs twice in Eastern context.

Thus, it is necessary for further examination of AI information fields to enhance the modeling for further analysis of these or additional metaphors.

Conclusion

It's almost impossible for us to avoid the increasingly higher frequency of global crises due to climate change or/and ecological imbalance. On the one hand, we cannot stop our efforts to reduce the risk of these crises, on the other, we need to prepare ourselves to confront any crisis or even to build up a New Normal different from the Old Normal, which has been dragging us back to the old paradigm causing the problems we are facing now in achieving prosperity with resilience. This article has discussed and presented key global values that are common in different contexts, through the Chinese traditional five elements dynamic balance thinking to offer a future that is beneficial to all. Should the world have a common expectation of the future, following 5 variables set by *The Limits to Growth*, through applying new techniques that approach new ways of accessing information fields holistically (such as time waver and other more advanced approaches) from now on, we have new capabilities for analysis and engagement with information fields that yield multiple series of results of the most relevant, with highest intensities, and greatest impact on material, mind, and life. These results show that we are able to sort out the metaphors that could help us build up new ways of living and thus, achieve prosperity based on resilience. We should reach the expected states what we are all wishing for, and not running to the fate which we were destined to. These metaphors can also provide further and different routes for a more precise study based on Alternative AI information fields.

Acknowledgement: The author would like to thank Susu Nousala (PhD), CSRP Institute, Director of Research, for her critical comments and fruitful discussions about this article.

Did we learn?
Will we?

18

I did a data check on World3 – Here's what I found

Gaya Herrington

Vice President ESG Research at Schneider Electric and author of the book Five Insights for Avoiding Global Collapse

"So here I am having my morning coffee when I read about you announcing the end of the world. Thanks for the buzzkill. (Seriously though, good work.)"

This friend's text last summer is how I learned that my research was being picked up by a lot of media. For several days, headlines on major US news pages stated that my research proved we are on the brink of societal collapse. A few days later, UK pages touted the same headlines. Then I saw my name popping up in languages I do not know, from Swedish, to Greek, to Chinese, to Sinhala. Even the popular American talk show *Morning Joe* invited me to come elaborate on our impending doom (I did not go).

The simplistic inaccuracy of my message in the media is, of course, nothing that *The Limits to Growth* (*LtG*) authors did not experience a thousand times more. Some of the criticism that the *LtG* books and the World3 model received had a validity; after all, no model is perfect and thus no conclusion drawn on its output indisputable. But a lot of criticism really wasn't very clever. As detailed elsewhere in this collection, critics claimed that "business as usual" showed a collapse from resource depletion by 1990, or that all scenarios ended in collapse, or that the models only ran to 2040. One would not even have had to read the *LtG* text to check these claims for accuracy. By simply looking at the pictures in the book, one could have concluded that,

in fact, all scenarios run to 2100, they do not all end in collapse, and the ones that do, show that steep decline setting in after 1990. Yet by the turn of the century, these claims had been so effective as to convince almost everyone that *LtG* had been relegated to, as Lomborg and Rubin put it in 2009, "the dustbin of history."[1]

Perhaps that is why almost no one bothered to check whether some of the *LtG* scenarios still aligned with recent empirical data. If they had, they would have found what I did: that some scenarios actually align uncomfortably closely to current data. The article on my research, published in Yale's *Journal of Industrial Ecology*,[2] contains the formulas and data sources, graphs, and numerical outputs per variable. Here, I will summarize my research findings and elaborate on their meaning. You will see that this message is, in a similar vein as with the original *LtG* works, a bit more nuanced than mainstream media had put it.

Only one person before me, Graham Turner, had conducted a comparison between World3 and observed data. His last comparison from 2014 indicated that the world was still following the "business as usual" (BAU) scenario, which ends in collapse.[3] Given this unappealing prospect, I decided to update Turner's work, and conduct a quantitative comparison between World3 scenarios and empirical data available in early 2020. Turner did his comparison on the World3 version of the 1972 book. I chose to use the most recent version of World3, the one that the authors recalibrated in 1990. Would, perhaps, this recalibrated, arguably more accurate, model fare better against observed data?

I compared four scenarios from this latest version of World3[4] with empirical data: the best-known "business as usual" (BAU), "business as usual 2" (BAU2), "comprehensive technology" (CT), and "stabilized world" (SW). (Also called scenarios 1, 2, 6, and 9, respectively, in the 2004 book.) The assumptions underlying each scenario span a range in technological, social, or resource conditions. Additionally, the cause of decline, which varies from a temporary dip to societal collapse, differs for each scenario (see Figure 1).

I chose BAU, BAU2, CT, and SW because together they form a comprehensive set of "stories." The BAU scenario was based solely on historic averages with no assumptions. It's the story in which we hang on to our "we can keep growing forever!" attitude that is tacitly ubiquitous in society. BAU2 is also business as usual, but with double the natural resources. This scenario was added by the *LtG* authors to address criticism that natural resources turned out to be more abundant than estimates in the 1970s indicated. More abundant resources do not avoid a collapse in the World3 scenarios; its cause

merely changes from a resource scarcity crisis to a pollution one. With the resource constraint relaxed, incentives to innovate and/or change societal priorities are reduced, so business as usual goes on for longer. This creates so much pollution that agricultural output and human health plummet after some breakpoint. BAU2 essentially tells the story of ecosystem breakdown from accumulated pollution, including from greenhouse gasses (i.e., climate change).

CT represents the technologist's belief in humanity's ability to innovate out of environmental constraints. It assumes unprecedented technological innovation in a world that otherwise does not change its priorities much. The new technologies do in fact help avoid an outright collapse. However, CT still results in some declines because the technology costs become so high that not enough resources are left for agricultural production, health, and education.

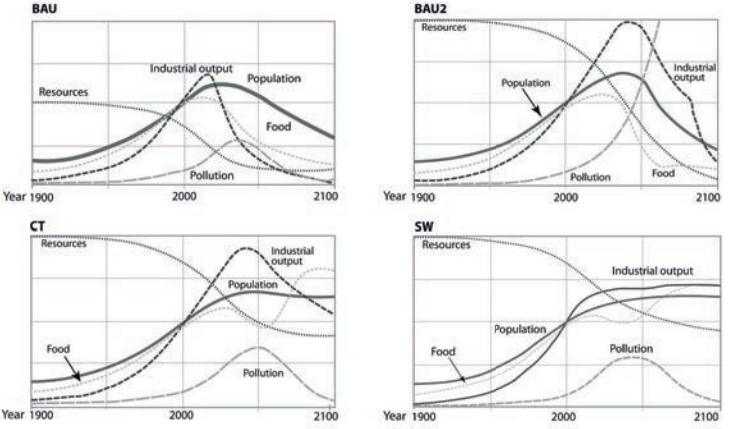


Figure 1. BAU, BAU2, CT, and SW scenarios of the 2004 LtG book. Graphs recreated by Hillary Moore.

In SW, humanity consciously lets go of expansionary growth as its ultimate pursuit. We shift societal priorities away from material consumption and industrial growth towards health and education services, as well as pollution abatement and resource efficiency technologies. This avoids collapse and leaves humanity with the highest levels of wellbeing. The four scenarios are summarized in the table below.

Scenario	Description	Cause
BAU	No assumptions added to historic averages	Collapse due to natural resource depletion
BAU2	BAU + double the natural resources	Collapse due to pollution (climate change approximate)
CT	BAU2 + exceptionally high technological development and adoption rates	Rising costs for technology eventually cause declines, but no collapse
SW	CT + changes in societal values and priorities	Population stabilizes in the 21st century, as does human welfare on a high level

I collected data for real-world indicators of the World3 variables: population, fertility, mortality, pollution, industrial output, food, services, non-renewable natural resources, human welfare, and ecological footprint. This data came from academia, government agencies, non-government organizations, United Nations entities, and the World Bank.

I plotted the empirical data together with the variable in each of the four scenarios made with the latest version of World3. These plots gave good impressions of the fit, but I also used statistical measures (a normalized root-mean-square error, and a combination of the value difference and difference in rate of change) to validate what I observed in the graphs.

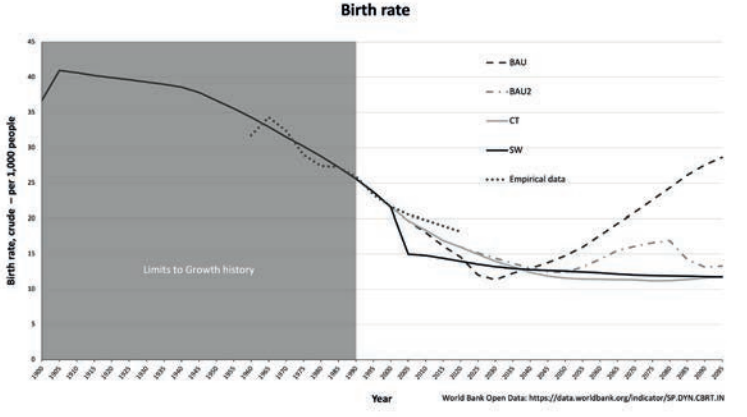


Figure 2. Empirical data for birth rate (births per 1,000 people) and the variable for each scenario.

The graphs for every variable can be found in my journal article,[1] but most of them show an image similar to the one opposite (Figure 2): an overall close alignment of empirical data with each of the four scenarios, least closely with SW and most closely with BAU2 and CT.

The overall close alignment of empirical data with each of the four scenarios is a testament to the accuracy of World3. On top of the criticism that I mentioned earlier, the modeling technique itself (i.e., system dynamics modeling) was also heavily criticized, with some accusing it of being unscientific. But as someone with a degree in econometrics and years of work experience in finance and strategic consultancy, I could not tell you another model that has forecast this accurately several decades into the future.

I should note that for several variables the scenarios only diverge significantly after 2020 (as in the graph, Figure 2). This is especially so for BAU2 and CT, which is why it was not possible to differentiate between them. An update of this comparison in another few years might identify one specific closest fit to empirical data. Without major changes in societal priorities, this is unlikely to be the scenario showing a sustainable path; SW, in which a decline in human wellbeing within this century is minimized (Figure 3), aligned with the data the least.

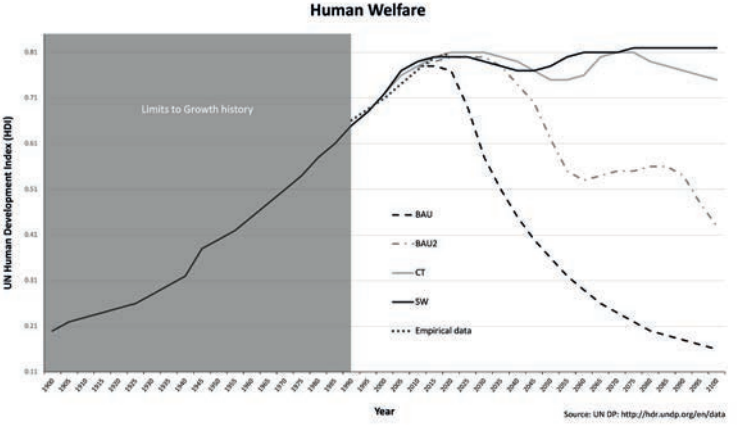


Figure 3. Empirical data (UN Human Development Index) plotted against human welfare variables for all four scenarios.

My research findings indicate that based on the World3 model, global societal collapse cannot be ruled out; one of the best fit scenarios, BAU2,

shows a collapse pattern. The other best fit scenario however, CT, shows only a moderate decline. Both scenarios show a slowdown in industrial and agricultural output. My research results at this point thus indicate that we can expect a halt in economic growth within the next two decades, whether or not we consider that a good thing. However, my research results also leave open whether the subsequent declines in industrial and agricultural output will lead to sharp declines in population and welfare levels.

Personally – and I'd like nothing more than to be wrong about this – I think humanity's current path is more likely to be following BAU2 than CT. It is simply more in line with others' observations, such as from the Intergovernmental Panel on Climate Change,[5] the planetary boundaries studies by Steffen et al.,[6] the ecological footprint by the Global Footprint Network,[7] and much other research. This is also in line with what to me has always been one of most important lessons from the *LtG* study: the plural of "limits" in limits to growth. Yes, humanity can innovate itself out of one limit, like to some extent it has with the resource constraint. But in a system like our global society, creating a solution to one limit inevitably causes interactions with other parts of the system, sooner or later giving rise to a new limit which then becomes the new binding constraint to growth. This new constraint today is pollution, from greenhouse gasses but also plastics and toxic chemicals in our air, water, food, buildings, furniture, and consumer products.[8,9,10] Innovating out of the pollution constraint, if even possible, will almost certainly expose us to a new one. We can either choose to abandon perpetual expansionary growth as a goal or have the impossibility of holding on to it imposed on us. It seems as if humanity so far has chosen the latter path, marching towards having limits forced upon us.

But perhaps you're more optimistic, looking at this research thinking that we can bet humanity is following the CT scenario. Maybe you think we can hold on to growth as a pursuit while basically being fine with only a temporary dip in welfare levels around 2050. I could point out that the assumptions underlying the CT scenario are highly optimistic given historic figures. For example, CT assumes technological progress rates of 4% a year which, amongst other things, should lead to reductions in pollution emissions of 10% from their 2000 values by 2020 (that did not happen) and 48% by 2040. Compared to our performance record of reducing global CO_2 emissions, the CT assumptions seem unrealistic. However, a technologist might argue that technological developments are ever accelerating, and a solar-technology boom or nuclear-fusion breakthrough are around the corner to completely change our trajectory. We could keep going back and forth for a long time

with our arguments, none of which would change the fact that ultimately the future is unknown.

Much more important, however, is that whether we are following the CT is not the right discussion to have. Is the only thing that can motivate humanity an impending collapse? I would argue not, in fact, I would argue the opposite. One just needs to look at the climate change debate and realize that if impending doom was enough motivation for society to make the necessary changes, we would have made them by now. The overwhelming threats of climate change and other sustainability challenges seem to not scare people into action so much as they scare them into the arms of economists, technology gurus, and spiritual leaders who promise that some force, be it the invisible hand, human ingenuity, or surrender to a higher power will solve our systemic problems for us.[11] I typically, and very much intentionally, avoid delving into all the details of why I think the CT is unrealistic, because it would obscure the question we really should ask: do we want to be following the CT scenario in the first place? Why would we use our innovative powers to invent robot pollinators to replace the bees, if we also have the choice to invent agricultural practices that do not have the side effect of insecticides? Why use drones to plant new trees when we could also restructure our economic priorities so that existing rainforest is not cut and burned down? Now that humanity has attained truly global reach, now that we have an unprecedented power to shape our own destiny, limits to growth force upon us the question: who do we want to be and what world do we want to live in?

We can choose different societal priorities for other reasons than looming collapse. Moreover, the possibility that collapse will not happen does not mean that humanity should not choose a more sustainable path. The close alignment to empirical data and the fact that the scenarios have not diverged yet, together form a call to action. Hidden behind a seemingly ambiguous outcome of two best-fit scenarios that marginally align closer than the other two, hails the message that it's not yet too late for humankind to change course and alter the trajectory of future data points. Global society does not have to settle for CT as a best-case scenario. We have another choice. Although SW tracks least closely, my research indicates that a deliberate trajectory change is still possible. But this window of opportunity is closing fast.

This choice, in fact, was the true message of *LtG*: humanity can indeed reach a global dynamic equilibrium, but it will require a fundamental change in our values and priorities. I believe my research supports this message, although it also suggests that this choice today is one of the "now or never"

kind. But even that is still not a cry of desperate hurry; it's a vision. Letting go of expansionary growth as humanity's ultimate pursuit hardly means a capitulation to grim necessity. A world in which human activity is regenerative instead of rapacious is not just one in which collapse is avoided, it is a world where our natural surroundings are full of life. The *LtG* graphs show how society would be more stable in the SW scenario, but not how much more its citizens would be thriving. World3's equations do not capture how we hurt when we see people suffer from the results of climate change or lose yet another species to extinction. By the time the next data comparison may be able to show one best fit, more will be lost, and a course change will be more difficult or even impossible. Now is the time for a sustainability revolution – a deliberate choice to let go of the "never enough" mindset and preserve the natural abundance we have. Not because we cannot survive without parts of nature, although we very well may not, but because we love life more than growth.

19

How do we grow socially?

Chuck Pezeshki

Professor of Mechanical and Materials Engineering, Washington State University

In the 50 years since *The Limits to Growth* was published, a lot has changed. Are we still in a dire situation? Yes. Do we still face many of the material resource issues modeled in the book? Absolutely. But so much has changed in our understanding of the most important aspects of the planet, and indeed, the universe, that is time to reflect on how we understand not just the knowledge that guides our decision-making processes, but ourselves – the makers of that knowledge – as we chart a path into an increasingly uncertain future.

As a complex systems scientist (my background is in nonlinear dynamics and chaos theory) and an aspiring memeticist – someone who looks at how information is created and spread in social networks – my role at the start is to understand the perspective behind the conclusions from 50 years ago.

The *Limits to Growth* model, while complex for its time, is primarily a model of constrained linear equations. Coupled with feedback loops, such models initially lead to exponential solutions, then flattened by depletion and the effect of pollution, leading to collapse. Published in 1972, it was a work of its time. It was likely that the simulations were completed on a computer smaller than the one that runs a child's toy robot today. Graduate students had to carry long decks of punch cards down to the card reader in the MIT computing center, anxiously staring as the hopper emptied all that punch-coded knowledge into the enormous machine.

The fields of mathematics and physics that would more accurately cover our finite world existed only in their infancies in 1972. Nonlinear dynamics and chaos theory, which allow for multiple solutions from similar sets of coupled equations, had been briefly explored. The Lorenz system, the originator of the famed "butterfly effect," had only been published eight years prior. None of the complex patterns derived from different starting points – "initial conditions" – were even able to be discovered. Doing so would have turned our poor graduate students into wandering wrecks, attempting to decode the myriad solutions that would emerge.

And our collective overmind, the internet, did not exist in any public form. Input into the model certainly did not come from Facebook or Twitter. The authors were aware of this. In the text itself, the authors state, "The present model considers only man in his material system because valid social elements simply could not be devised and introduced in this first effort."

In spite of all these obvious problems, certain concepts held true. We're in trouble if we don't change. Material concerns matter and often frame the outcomes. We live on a finite planet. But without considering a more complex view of the social equation, the solutions from the original modeling fall into the line of "just stop consuming stuff." Or "stop making more people."

The answers to our problems must be generated by people. The way out of the box created by advancing technology is very likely not going to be solved by more technology – or rather, technology devoid of the social connection that the authors left out of the first study.

How might social transformation occur, and how might we compose the roadmap that will take us where we want to go? We can start by understanding the coupling between the social and the technical sides of our current crisis.

Albert Einstein famously said, "No problem can be solved from the same level of consciousness that created it."

How do we understand levels of consciousness? First, we need a new model of how we collectively think.

Conway's Law

In 1967, Mel Conway, an independent thinker with a PhD in mathematics, coined his eponymous law, which says:

> Any organization that designs a system (defined broadly) will produce a design whose structure is a copy of the organization's communication structure.
>
> — Melvin E. Conway

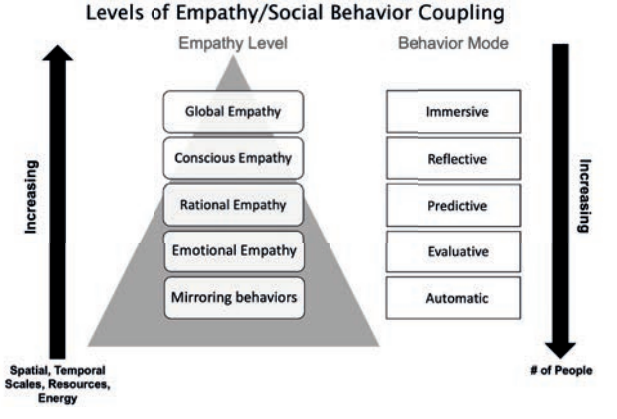
This means that social structure will map to the design structure of the object that a particular social structure created. It's no surprise that the social structure that designs, and eventually runs, a nuclear power plant looks and acts like a hierarchy. It's a baked-in feature. It's also a barrier to designing decentralized power systems. The social structure couldn't design it, and in fact, might not even see the advantage in the robustness a distributed network might provide.

Pondering Conway's Law in 2014, I coined a term called the Intermediate Corollary, that knowledge created is an intermediary between social structure and design structure. Hence:

Social Structure <=> Knowledge Structure <=> Design Structure

The various relational ways of connecting will directly influence how knowledge is created inside an organization. And the fidelity of the information shared in the organization will be keyed to a function of the personal development of all the individuals in the system – their developed empathy.

Empathy is more than just giving someone a hug. It's the way humans connect with each other, on all different levels of our brain function. It is both intrinsic to how we function at small scales, while being a developed capacity as we move up to higher forms. Empathy can be represented in a pyramid – the diagram below is based on Frans de Waal's work, with some important changes.



Not all connections between people have the same information coherence. The same network topology can yield different outcomes dependent on the level of empathy development between the participants inside.

This is a powerful tool to show how both organizations, and the individuals in those organizations, think and develop perspective. Perspective – quite literally the reach in both space and time of how people view things – is generated by looking at the empathy in the organization that given individuals inhabit. And it's a feedback loop. Empathy can be increased in an organization's people, dependent on how that organization reinforces relationships. Then, people and their empathetic development will directly influence the actions of the organizations they inhabit.

Higher levels of empathy inherently imply a two-way street when it comes to speaking up. And higher feelings of safety inside an organization enable trying new things. Organizations with lower levels may only assume mimicry of leadership, or a transfer of emotional states. Higher-empathy organizations turn their members into profound and accurate sensors, as well as people capable of taking action.

This matters because it directly relates to the evolution and connection of the people conceiving those models and solutions. If we want to understand the potential downstream effects of large-scale interventions on global problems like climate change, we must first understand how we conceived of the thoughts produced in the first place. Were they the process of rational deconstruction, with shared contribution? Or were we being swept up in herd-mentality thinking?

Previous solutions were generated by rigid hierarchies of experts, organized around tribal knowledge, sets of rules, or a charismatic leader. But one size almost never fits all on a global scale. Large-scale solutions to our pressing problems will not be conceived by one savior sent to deliver us. It will come out of an assemblage of individuals connected across countries and cultures.

The topology of those connections will matter. Consider how primitive our current models are of how people act in concert. We have coarse-grained culture, anchored in the 17th century Westphalian nation-state model. Aggregated and averaged, anyone in any society can hide behind that cultural representation. And this can be finely scaled. Americans => African Americans => Urban Poor African Americans. And so on.

But the complicated nature of those conversations offers little hope for solutions that will consider both the local voices and their various needs with the larger needs of the planet. Cultural boxes may be a start. But who

is the authority that decides who gets to represent any given box? The path forward will be a trap.

The topologies of our social connections matter profoundly in how our responsibility manifests for the different parts. Those rigid hierarchies, triangular in shape, with limited connections and rooted in paradigms of power and control, generate a "hierarchy of status." If you are higher status – an arbitrary concept, dependent heavily on what has been enshrined inside a culture as important – you deserve more.

Currently, the tools of social media on the internet reinforce this paradigm. Your voice doesn't matter so much just because you are accurate in understanding our current predicament. What matters is how many followers you have in your tribe.

What is needed is a profound shift to a "hierarchy of responsibility." You have more followers? Fine. You are more responsible for those that follow you. Your burdens must be heavier. You must know more, as well as have more self-doubt. You need more awareness of what is not known, combined at the same time with the understanding that there will be hard shots that must be called to help larger society meet its goals but also to preserve the dignity and information flow upward inside your social network.

And you will also be more responsible for their growth, developing more people to carry heavier burdens, and more development of minds to replace your own. Connections must be authentic and grounded. It will do no good to indulge in decontextualized mythmaking to make different parties happy. Instead of always speaking, you're going to have to listen.

That is why empathy is vital. Duplex connection inherently drives that shift away from status and towards responsibility. We naturally become more responsible for the things we are connected to. Their pains and joys become ours. And that changes us and evolves the social structures we inhabit. Awareness increases, with multiple sets of eyes that see the outside world more clearly.

It also redefines the concept of evolution. Modern society has framed evolution as "survival of the fittest." The path forward, fraught with peril, will only be traversed by those who are more "fit" – an arbitrary construct, only obvious in hindsight. The old way to see evolution, "survival of the fittest," is fundamentally exploitative, and non-cooperative in framing how organisms interact. A better take is "non-survival of the unfit." The door opens to a more comprehensive understanding of how symbiosis occurs.

Consider a closed system, like a zebra herd. The strongest and fastest zebra may indeed survive to pass on their genes. But once the system is

opened up, outside those narrow boundaries, it's actually the zebra that can work with the other zebras, and manage the organization of the herd, find food, and monitors changing outside conditions, like where the lions might actually sleep, that will be the one that lives another day. Competition must be leavened with interagent coordination. The first – competition – is about the individual. The second – coordination – is about the group.

And human existence has always been bound to how we relate to each other. From the beginning, we were never solo individuals on this planet. Any such humans rapidly ended up as food for saber-toothed cats.

Why the dominant perspective has focused on the first factor, instead of the second, comes from understanding perspective and how knowledge is created. Scientific hierarchies of observers competing for status will emphasize the notion of "nature, red in tooth and claw." It's a dog-eat-dog world inside a rigid hierarchy, and inherently the view of how evolution works gets projected outward. Rigid hierarchies have little empathy, and so the notion that connection and collaboration might actually matter, let alone be a driving force in moving humanity, or all of creation, forward, gets missed by the very organizations we have tasked with creating the knowledge to solve our problems.

Which now returns full circle to finding the path forward. Increasing robust complexity involves evolving our organizations, with more connections, with more shared information, and more people capable of talking, listening, acting, and making connections themselves. More people, more aware of their surrounding conditions, appropriately, humbly empowered, and connected to others will yield new, richer ways of knowing. And that in turn will drive the solutions both people and planet need.

And that new level of interconnection will drive that evolved set of consciousness, which will prove able to master the problems of the lower levels. Finally, we may not know exactly where we are going. But we will finally have an emergent compass.

The road map

Alice: Would you tell me, please, which way I ought to go from here?
The Cheshire Cat: That depends a good deal on where you want to get to.
Alice: I don't much care where.
The Cheshire Cat: Then it doesn't much matter which way you go.

Alice: … So long as I get somewhere.
The Cheshire Cat: Oh, you're sure to do that, if only you walk long enough.
— Lewis Carroll, Alice in Wonderland

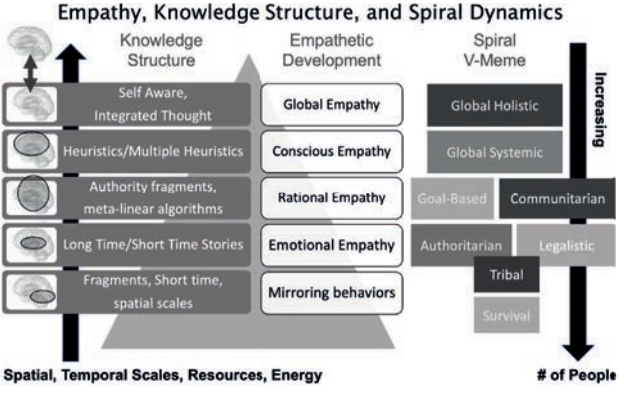
Once we recognize that increased complexity is inherent in any solutions for the problems outlined in *The Limits to Growth*, a framework for that complexity is required. But as the Cheshire Cat warned us in the scene above, not knowing, even in a meta-format, won't necessarily get us to a sustainable lifestyle on earth. But we will get somewhere. And that somewhere might not exactly be where we want to be.

Conway's Law couples increasing societal complexity to knowledge complexity. If we do this with a canonical set of social structures, mathematically defined as the simplest form able to capture all the information at a given stage of development, we can start understanding the complexity of our own thoughts.

A model I am fond of – Clare Graves' and Don Beck's Spiral Dynamics – lays out a map of social structures for increasing societal complexity. Moving from rigid hierarchies to self-determining, fluid, agency-driven arrangements, just like the phases of matter, leads to a meta-map of knowledge structures, with social structures. As one moves up in complexity, social structures can embody, within their structure, simpler, lower-level structures.

Underlying these social structures are social dynamics, embodied in what are called value memes, which are the underlying deep codes driving the emergence of the given social structures. There is no one straight evolutionary map for complex information.

The final step is to link this to our humanity, with neural function, in a Theory of Everything, from our basic brain wiring, through to how societies self-organize in an emergent fashion.



The path forward

> Don't listen to the person who has the answers, listen to the person who has the questions.
>
> — Albert Einstein

Stopping this essay with the knowledge construction theory above would be much the same as announcing the Law of Gravity, and waving one's hands and declaring, "Okay, figure out the combined movements of all the celestial bodies in the universe. It's on you."

While explaining every aspect is beyond the scope of this piece, it is important to leave with some knowledge that, by interpreting and adjusting our worldview, prevention of the multiple crises outlined in *The Limits to Growth* is possible.

First, realize that knowledge generated by the social structures in the bottom part of the chart is going to be more permanent than perceived experience listed in the top. We, as a society, have made tremendous progress in understanding many of the basic sciences in the last 150 years. Mathematics, physics, thermodynamics, and chemistry have driven the technology that runs the modern world, and they reside in the social structures at the bottom of the picture above. Design solutions come out of the higher levels, integrating individual circumstance together with other social and psychological factors. None of this implies that the various disciplines, nor the solutions they generate, are above intelligent questioning regarding outcomes. The question is when.

That important "when" corresponds to how sure we should be about consequences. There are two simple rules that can guide that thought process.

Rule 1

> If a physical model has been established inside a *functional closed system*, then empirical science can be used to validate that model. And the knowledge of the larger physics can be used with relative confidence in designing solutions for our problems.

A closed system has clearly discernable, solid system boundaries. The cylinder bore inside your automobile engine is a great example. We know how much force is exerted on the head of a cylinder for a given amount of

gasoline. Someone's opinion of how the cylinder works functionally does not matter. Such problems are often solved, or refined, by stacks of experts in rigid hierarchies. Rigorous education, and advanced degrees, are often required.

Rule 2

> Physical models of *functional open systems*, where boundaries are either poorly or arbitrarily designated must include our knowledge of physics established in closed-boundary systems, plus the input and experience of people affected by the heart of those systems.

Our knowledge construction model can shed light on future solutions, as well as make a plea for developed empathy. Laws like the United States' National Environmental Policy Act (NEPA), which guides how an Environmental Impact Statement must be developed with a public process that incorporates public input, are examples.

But these processes can only be as good as the people running them. Honest intent matters, and the professionals running them typically come from low-empathy, legalistic hierarchies. High-conflict individuals with little interest in positive resolution can sabotage them. Gaming NEPA is also a problem and will continue to be a challenge unless we address the final issue.

Developing all our people

None of this will work to head off the collapse predicted by *The Limits to Growth* – even with road maps, complexity development, or breakthrough technology – without a concerted effort to grow the magnanimity of the human spirit. That will require a focus on a very different set of principles in education than our current model. Focused on obedience, as well as rating and ranking our young people is a collapse of long-term vision. Young people must be raised to have agency, make decisions for themselves, and learn how to connect with others. They cannot learn how to do this with overbearing programs, constructed by academic elites, intent on elaborate systems of categorization.

Students must be given shared activities and experiences, with as broad and diverse a group of other students as possible. They must be trusted

to come up with integrated experiences, within some set of sidebars, on their own.

The Scandinavian countries are leading the way, with a revival of *bildung* – an integrated set of experiences focused on building moral character, and decent treatment of others, along with appropriate skills-based curricula. The spread of this model will rest on educators focused on creating smaller versions of our larger world, where students can learn from teachers and each other. Some of these worlds will be constructed in the virtual space provided by the internet, which can enrich the face-to-face experience. The movement is still in its infancy. The challenge will be to spread these models across the socioeconomic spectrum. We must avoid the creation of memetic/complexity-equipped haves and have-nots.

In all of this, understanding empathy will be paramount. It is our sincere hope that this chapter starts a larger discussion, not just about how to get people to do the right thing on its own, but to have people generate the right thing to do from where they view the world.

20

What is relevance in a changing world?

Nora Bateson

President International Bateson Institute

This contribution in commemoration of *The Limits to Growth* explores the topic of economy, arguably a relevant one in ongoing debates about the role of "growth" in human societies. A revisiting of interdependency in ecological terms seems to me to be a good starting place. It is all too easy to simply refer to an ecological system as "interconnected." There is rigor needed to dive into an inquiry of those relational processes that give a meadow or an ocean or a forest its integrity, only some of which humanity can now perceive. In an ecology every organism is relevant to many others, in different ways – and there is no singular purpose in an ecological system. A description of ecology's distinctive type of complexity was once given by my father, Gregory Bateson, through the example of a deer's antlers.[1] The deer's antlers are multi-determined, and multi-relevant. They are useful for defense in fights with other stags and mountain lions, and they are appealing to the female deer. When rubbed against the bark of a tree the antlers make a particular home for insects. When the antlers drop, they become food to teeming throngs of small animals on the forest floor whose poop carries the minerals into the soil. The minerals in soil give life to the organisms that, in turn, nourish the trees and other flora. Beyond the first order of relations described here are the many other organisms that branch out in interdependency from the ones reliant upon the antlers. What and where is, then, the relevance of the deer? This is not an aggregate of transactions and trade-offs; this is life making life

in many directions simultaneously. As societal and political pressure escalate to create response to the violence of current economic systems, it is necessary to consider what might be implicitly held as relevant. What sort of ecology of institutions and ideas are conjoining to fit and re-fit the relevance of the current economic systems into daily life? We can learn from the deer's antlers how relevance is produced through what Ashby once called a "requisite variety" of relationships.

When people point to the global economic system as if it were an obvious reality of how life *is*, I am eager to point back to the trickiness of the way perception reveals more about the observer than that which is being observed. After decades of teaching systems thinking and complexity it is increasingly clear that perception of relationships has gotten very confused by repeated reductionistic approaches to the study of just about everything, but it is not absent. On the contrary, children of the modern world learn early how to name and observe the ecologies of their survival. The issue is that people are learning to be in their world in ways that are destroying their world. There is a well-worn meme that shows how kids can recognize hundreds of corporate logos, but only a few plants. To be in the world it is important to learn how to navigate apps, how to separate and compartmentalize everything, how to presume everything is measurable and manageable. As children it is necessary to learn how to find one's identity in something called "the economy" – whatever that may be. Likewise, the economy is not only in the economy. The economy is a consequence of the relationships that each of us is within every day. It is cultural, familial, historic, political, ecological, and educational. The economy cannot be changed at the level of money, or crypto, or NFTs or any such currency, because it is a consequence of an entire ecology of relational processes. The change must be in the premises of the entire culture. As with the story of the antlers, the patterns of relevance within the economy, its edges, and relationships, are impossible to draw.

There is a paradox here. In order to continue the existing economic patterns there must be a numbness that allows for the sort of objectification necessary to exploit human beings and the natural world. But, in order to maintain that numbness there must be keen sensitivity and nuanced attention to the relationships that justify the economy. In order to not feel the relationships that are being destroyed by the economy, it is necessary to be sensitive to relationships that depend upon it. Why is a handbag from Prada more expensive than a handbag made by a local leather worker? Relationships.

In a world that is undergoing rapid, transcontextual change, the pace of shifting relevance is … relevant. As traditions are challenged by changing

demographics and climates, foods and ceremonies are substituted and modified to adjust to the changes of conditions in situ. Certain plants no longer grow where they used to, fish are no longer available, rituals are borrowed, bent and rewritten to fit multicultural communities. Change is a requirement of life. All systems and organisms must change in order to continue – this is a basis of evolutionary process. With these changes come shiftings in relational interdependencies; shiftings in relevance. Relationships once relevant become irrelevant, those that appeared to be irrelevant become relevant. Obsolete know-how is a good example. Previous generations were taught to use rotary phones, to fold maps, to drive stick-shift cars, to send greeting cards, to use phone books – the relevance of that know-how has been shifted into another realm of relevance. Economic patterns as they have been developing over the last centuries have depended upon inherently exploitative relationships. In a changing world these relationships cannot continue without discontinuing the survival of thousands of species and vast destruction. The question of what is becoming relevant is a nontrivial indicator of new directions of change, made into pathways through relational perception.

While it may appear that the modern human being is unable to perceive relational process and is therefore disrupting those vital interdependencies that life is contingent upon – the issue is better described as a conditioning to a communal context that decontextualizes. In other words, what does it mean to learn to survive, or thrive, in the established system of institutions? To step over each other, to market our wares, to become somebody requires a loyalty to a set of relationships that erase other relationships. If it were just a matter of teaching systems thinking to create a culture interested in ceasing exploitation that would be fairly explicit. But this issue resides in a more implicit realm.

Let me explain. As living organisms, human beings have and will continue to perceive in relational ways. We have no choice. To perceive anything at all – a ball, an ice cream, a kiss, a song, a bank statement, or a new shirt – the perception of comparison, (i.e., relationships) is necessary. The retina of the eye moves quickly up and down to receive the information around a seemingly static object. The sense of touch is informed by a comparison between textures, temperatures, and rhythms; the notes and chords of a piece of music are discerned through their difference and the silence between them; and taste is also comparison. Gregory Bateson referred to this way in which the living organism receives information as "the difference that makes a difference." That human beings must perceive in relational ways is a given, but the question is, which relationships?

Which relationships are the ones that are dominating the landscape of our days? In different eras and in different cultures different relational processes are more featured. These featured relationships find expression through language, education, food, shelter, art, religion, and more. They are the pivots around which the society forms a second order of relational processes like skills and respect for people who excel at those skills. Relationships build relationships around them in ramifying and recursive ways which build on each other. These entanglements are very difficult to undo with a new model or map because they are wound into too many aspects of the organism. (Yes, human society is made of organisms.)

What to do when the relationships that have been deemed by the collective to be dominant are destructive to the relationships of life? When it is easier to justify the dystopia of a tech-frenzied collective psychosis than it is to imagine unplugging the internet, or when it is easier to imagine millions of people suffering in refugee camps than how to get tax money out of hidden offshore accounts to help pay for increased social services … when it is easier to imagine vast waste of natural resources than to imagine stopping planned obsolescence in products.

The question of "how to teach people to see their world of relational process" is a distraction from the question of "how to wrest the perception of the relational process out of the existing set of patternings which are pivoting around a devitalizing set of relationships." If people could not see relational process, Prada would not have value and the stock market would not matter. It is precisely because there is a perception of relationships that these things have a position in a field of other relationships. Prada is expensive because the consumer sees the Prada name in a collection of relationships. The stock market is of no use whatsoever to the deer mentioned above, but to those of us committed to a world of brands and companies the Dow Jones and such are a communication of critical relations. A fancy university degree is only impressive to those who share its relational significance. The justification for the high-yield crop that destroys the soil is felt to be adequate because it upholds the system that upholds the other components of the system.

All of these are viable in a world in which the relevance of the individual is material success. I want to be seen as credible, respectable, want-able, and the way in which I am rewarded by the economic system helps to prove my expertise, and my worth (in all senses of that word). The problem is not that there is no love in the world, but that the patterns of industrial consumerism are wrapped into wanting to be lovable. One could say that the economy is a star-crossed love story.

In a context in which the underlying question in most interactions is "what's in it for me?" the logic of economic transactions is tacitly pervasive everywhere. This hungry ghost sneaks into everything, and leaves exploitative destruction in its wake. The lurking question of "what's in it for me?" is a resonance running through "why" anyone does almost anything. As a tone of a bell is resonant, the "what is in it for me?" is tinging and ringing through the epistemological basis of spirituality, education, family, politics, health, art, agriculture, tech, and so on. This logic makes transactions out of all sorts of interactions and attunes to the sense-making of acquisition. If you meditate an hour a day you will get something, if you walk 10,000 steps a day you will get something, if you work 50 hours a week you will get something, if you achieve good grades in school you will get something. If you are beautiful you will get something, if you are ambitious you will get something, if you are disciplined you will get something. The meta message is that getting something is what makes a person relevant. This is a deep undertone within our way of learning to be alive, because to be irrelevant in a living system is to be obsolete. This is true in a society, a family, or a forest. So the pursuit of relevance becomes the pursuit of acquisition. To survive, one must be relevant in one's environment. The twisted irony of that relevance being produced by nurturing those relationships that destroy relationships is an unspeakable tragedy.

Fortunately, or unfortunately, many of the most life-giving relational process have been rendered invisible to the market. These are the unseen practices of care and attention that defy the appetite for fast, high-yield productivity. For me, the most interesting aspect of the concept of economy is a consideration of what is not for sale. This is the silent conversation amongst those people whose work is not counted, not named, not seen by the measuring sticks of productivity.

This is the work of the teacher whose time spent with children over the years has given her the nuance in perception to give the lonely child in class a smile without thinking of it. This is the fisherman who knows by the chill in the air and the dampness of the soil that it is time to put the line in the water. This is the knowing that a master wood carver has when touching the grain of the wood, that tells the story of which side of the mountain the tree grew, which plane to use, which way the wood will turn in time. This is the treasure of the gardener who knows when to tend the soil, when to plant which seeds. This is the improvisational ability that comes with the rigor and patience of long, slow learning. The approach is one of careful comparisons between colors, patterns, and papers combined with their place in society,

history, and the evolution of printing technologies over the centuries. Most of the people who enter a room with those wallpapers on the wall will not know any of the information relevant to its careful production. But, they may sense it.

The wallpaper studio that my husband and son work in every day is one such place. It is piled in every direction with rolls of history, color, dust, and patterns. Each roll tells a story of a wall on which someone has found a scrap of historical paper, stuck there by past generations, and sent it to my husband to have it redone. He knows, in ways I cannot begin to know, where and when that paper originates. He knows the colors that it was when it was fresh, sometimes as long ago as the 1700s. He knows what bones the glue was made from, and what methods of printing were used. He knows how the block print was carved, what tree the wood came from, and perhaps even the conditions in which the tree grew. And when he gets ready to print it anew, his hands know the paper, made by the papermaker, he senses the moisture in the air, the thickness of the paint and calibrates to be sure the chemistry will dry without shrinkage. It smells of distemper and old books. The accomplishment of the finished wallpaper is not the amount of productivity, or the efficiency of the production.

This is an artisan approach. It is an effort that is sourced from attention to an extremely honed perception of relational detail. It is a depth of knowing and ongoing discovery. The scale is small, and the warmth is large. The relevance in this kind of work is placed and tended to in ways that are nearly incoherent to the question of material acquisition.

> He who would do good to another must do it in Minute Particulars: general Good is the plea of the scoundrel, hypocrite, and flatterer, for Art and Science cannot exist but in minutely organized Particulars.
>
> — William Blake[2]

Relevance in the artisan, or the care giver, or the teacher is unpaid for. Perhaps it is appreciated, but it is not measured, or defined beforehand. With any luck it will be celebrated at least a little bit. The point here is that there are filters through which the notions about such things as integrity are produced. These filters obscure the relata – they guide and slide perception into cultural cul-de-sacs that perpetuate the problems. Trying to re-create the economy is one such paradoxical problem. The task itself is rife with the thinking that produced the destruction in the first place.

I chose to use the word "integrity" instead of "value" above because "value" is a word that latently beckons measurement again. Language traps its users in familiar grammars. Habituated ways of describing life's daily deeds shape the perception of life and vice versa. David Olsen was speaking recently about the time when people used to say, "I am going to the market AND buying bread," or "I am going outside AND picking peaches." But with the literacy that came with the industrial model of the education system, the grammatical structure changed. It became, "I am going to the market TO buy bread," or "I am going outside TO pick peaches." And in that shift came an expression of the embodied relevance of strategic linear productivity. This is, of course, one of thousands of examples of ways in which the minutiae of language and things we do in a day are reconfirming the relevance of the economic systems as they are. In the first example, the action of going to market has its own complexity, anything could happen going to market, and buying bread too has its own cloud of possibility. But in the second grammatical expression there has been a significant shift in which the joiner word is changed from AND to TO. To go to market and NOT buy bread becomes a failure. What got lost was possibility, flexibility, complexity, and nonlinear stochastic processes of generating life. What replaced it was productivity, efficiency, success, control, and measurement. Economically speaking, this may have been a bad deal. The extension of this same logic is found in the spirit of changing the structure of the economy TO stop the climate emergency. The existing ecology of ideas, which bring with them the epistemology of the industrial model, are still right there. These are the ideas that created this destruction. They will not be the ideas that un-create it. What would it look like to think about it through a lens that asks how to change the structure of the economy – AND stop the destruction? The distinction may be hard to see at first, but it is a profoundly different approach. One is guided and propelled by a goal, the other asks for an entirely different ecology of ideas to find relevance within, the consequence of which is likely to be another relationship with each other and the natural world.

> We are beginning to play with ideas of ecology, and although we immediately trivialize these into commerce or politics, there is at least an impulse still in the human breast to unify and thereby sanctify the total natural world, of which we are. … There have been, and still are, in the world many different and even contrasting epistemologies which have been alike in stressing an ultimate unity, and, although this is less sure, which have also stressed the

notion that ultimate unity is aesthetic. The uniformity of these views gives hope that perhaps the great authority of quantitative science may be insufficient to deny an ultimate unifying beauty.

I hold to the presupposition that our loss of the sense of aesthetic unity was, quite simply, an epistemological mistake.

— Gregory Bateson[3]

21

Learning what we already know

Carlos Alvarez Pereira

Vice President, The Club of Rome

Are we on a good course?

On 11 November 2016, two days after the election of Donald Trump as President of the USA, Dennis Meadows addressed the Annual Conference of the Club of Rome in Berlin with a speech titled *Why Didn't We Learn: Will We?* The provocative question was indeed well chosen, and not only because of the political circumstance. The feeling that the messages conveyed by the Club of Rome since its creation have not been heard, or not enough as to change the course of human affairs, was quite widespread among the attendants. It still is today.

At the beginning of this book Ugo Bardi rightly points out that human behaviour was not included in the modelling exercise underlying *The Limits to Growth*. And hence, by construction, the simulated scenarios could not display the effects of human learning. Was it not a self-fulfilling prophecy? If we discard learning in the first place, no learning happens. Of course, the purpose of the authors of *The Limits to Growth*, and of the Club of Rome, was to provide conceptual tools for humanity to ask better questions and explore pathways towards a balanced configuration of wellbeing within a healthy biosphere. But what kind of learning was necessary and how would it happen? For all

its outstanding merits, *The Limits to Growth* did not address that question. The way the controversial debate about the book was shaped did not offer much help either. As Bardi also points out, the quality of the debate was poor, especially from the scientific point of view. But most importantly, it did not address at all the issue of learning because the discussion was captured by the denial of the main conclusion of the book, i.e., that humanity might face a very serious issue if we continued on the same path of unlimited growth in consumption and pollution. The winning side in the debate, particularly after the coming to power of Mr Reagan and Mrs Thatcher, said that the problem simply does not exist. So, if there is nothing to learn, why worry about the process of learning?

Aurelio Peccei and the Club of Rome took good note of the ambiguous reception of *The Limits to Growth*. On one side it got a lot of attention, sold millions of copies, and built a strong reputation for the Club (positive or negative, but strong in any case). On the other, the medium-term outcome was disappointing: public debates did not shift their conventional framing about "growth", "development", and "innovation". And public and private policies continued along the same exploitative and consumerist model developed decades earlier, greatly expanding it and making it run faster through the financialization and globalization of the economy. Years later the consecration of the concept of "sustainable development" provided some comfort that the issues the Club of Rome and many others had been talking about were being addressed. But this was done such that the very nature of "development" was not questioned, and the issues were considered as "collateral" effects to be fixed by an otherwise virtuous evolution. This is very clear in the words of UN Secretary General António Guterres on 6 November 2017, at the inauguration of the Web Summit in Lisbon:

> In the last decades, we have witnessed an enormous impact of innovation, science and technology combined with globalization… Globally it is clear that our world has been moving for the good but there was some collateral damage: climate change and growing inequality.[1]

With these words in mind, could we say that humanity learned after all? Is the Club of Rome too concerned about issues already addressed by the global consensus on the Sustainable Development Goals and the Paris agreement? Are not we seeing that existing governance frameworks combined with technological innovation and market mechanisms will be able to face and solve our existential challenges? Well, besides the many arguments put forward

by this book's contributors to refute that optimistic thesis, António Guterres himself answered the question three years after the above declaration. On 2 December 2020 he spoke at Columbia University in New York and said:

> To put it simply, the state of the planet is broken. Humanity is waging war on nature. This is suicidal… Making peace with nature is the defining task of the 21st century. It must be the top, top priority for everyone, everywhere.[2]

Most probably this dramatic shift in perspective was nurtured by the Covid-19 pandemic and the lack of progress in tackling the "collateral" challenges of climate and inequality. In any case, it illustrates that we do not have a direct, objective access to reality, we give meaning to our perceptions through the lenses of frameworks of interpretation, almost never explicit, most of the time not even conscious, always dependent on context. Three years is not enough time for the state of the planet to shift so dramatically; the change is in the interpretation, and in this case, it certainly has a political intention. It also reflects that after Covid-19, bolder statements can be openly made which would have been considered as politically incorrect in the context of multilateral institutions not so long ago.

The human gap

The two interpretations by Guterres in 2017 and 2020 give voice to different ways of thinking about the world and our role in it. The first reflects a belief in status quo: there are some big issues, but we can address them by taking care of unintended damage. And, as he explained in another part of his discourse, technological innovation would play a key role in that. The second discourse is a wake-up call in which optimism is dampened and our relationship to nature acquires critical importance. There is an explicit statement that human actions can provoke the destruction of the very conditions sustaining our lives, which is exactly the main message of *The Limits to Growth*. The consequences of our actions do not only go beyond our intentions and produce "collateral" harm; through large feedback circles they can be lethal for ourselves.

The Covid-19 pandemic gave a new impulse to these reflections. It revealed the fragility of human systems, induced into global collapse by the tiniest piece of primeval life. Although we try to find more comfortable explanations, it is clear that our accelerated destruction of ecosystems, while

making sense in the short-term and extractive mindset, created the conditions for a worldwide tragedy. And even after the development of vaccines the pandemic also reveals how little we know about life and its complexity and unexpected feedback loops, so much so that we should write the word with a capital L. What it invokes is not only much larger than humanity, but it also continues to be a mystery within our usual frameworks. For instance, we have to admit that at some level viruses are intelligent and able to learn, while we tell ourselves that intelligence is an exclusive attribute of the human species. The humiliating experience of Covid-19 might give us the humility required to learn more and understand Life a bit better.

Of course, none of this is new. The distance between Guterres 2017 and Guterres 2020 resonates with what Aurelio Peccei defined in the 1970s as the "Human Gap", i.e., the difference between our capacity to act and our ability to understand the consequences of our actions. A contemporary of Peccei, Gregory Bateson, went a little further by saying that *"the major problems in the world are the result of the difference between how nature works and the way people think."* "Bridging the Human Gap" was the subtitle and purpose of the Club of Rome report *No Limits to Learning* (1979), a valuable attempt at responding to the challenges identified in *The Limits to Growth*. The book explored what characteristics our learning processes should have if we were willing to face the existential challenges of humanity. Unfortunately, it did not have the success it deserved. More recently, Gro Harlem Brundtland and her co-authors put it bluntly in the report *Imperative to Act*: "The human ability to do has vastly outstripped the ability to understand."[3] But is it so? Aren't we instead dealing with a persistent unwillingness to learn what we already know?

This question raises many more. If we invoke a process by which human civilizations will change significantly and ensure equitable wellbeing for all within a healthy biosphere, what kind of process would that be? Will it happen through the intelligent design of "solutions" by an enlightened elite and their worldwide deployment through a combination of political enforcement, appropriate regulations, and market mechanisms? Indeed, taking into account the deluge of scientific discoveries and technological innovations we are told about in the media, we cannot pretend that human societies in the 21st century are not learning and evolving. Will digitalization and the much-publicized 4th Industrial Revolution do the job? Do we not already have the right mechanisms for purposeful human genius and mastery of nature to provide the technical solutions to the new challenges humanity is facing? This approach is dominant among many thinkers and practitioners

of "sustainability", and for sure it is the option of choice for decision-makers, both public and private. It would be nice if it could be the response to our questions, but does it have a chance?

In our perspective, the fundamental issue of this approach is that "the map is not the territory", as Alfred Korzybski put it. Conventional frameworks we use to make sense of what happens, to identify "problems", and design "solutions" are inadequate for the complexity of Life. A good example is the metaphor of war that we abundantly use when confronted with undesirable realities. Somehow it gives comfort because it designates enemies (cancer, drugs, terror, the virus…) and mobilizes our energies as only wars do. But it is completely inappropriate to deal with the evolution of ecosystems of which we are part, as is the case with all the "enemies" mentioned above. War is the ultimate expression of separation and exclusion, and if we apply it to anything we do not like, we end up waging the suicidal war on nature as Guterres talks about. Interestingly, Donella Meadows, co-author of *The Limits to Growth* and a brilliant systems thinker, titled her very last article "Dancing with Systems".[4] How do we engage in dancing with Life instead of waging war?

An inadequate lens

We posit that the learning ladder towards more desirable futures will be insurmountable if we do not dare to question how we think about the world, our role in it, and the relationships among humans, with Life at large and with time. The Scientific Revolution of 17th and 18th centuries opened the space for the technical developments leading to the first Industrial Revolution and an unprecedented capacity to shape our environment and impose "modern" views on whoever would not agree, people as well as nature. This was the starting point of "Modernity", the way of thinking and acting that has shaped the world we live in. Science at the time was more diverse than we remember, but its relationship with power meant that some ideas would be heard and others forgotten. For example, Napoleon promoted Laplace and ignored Lamarck, whose outstanding insights on how nature works were not useful to legitimize a hierarchical notion of society. Since the beginning of the 19th century and as a consequence of the self-reinforcing loop between science, technology, and power, mechanicism acquired a disproportionate influence on the way we think. We know that the paradigm is not useful to understand living systems, and yet it is still the overarching framework of

our institutions, in governance as well as in education, research, innovation, or the economy. Separation as a central tenet, dualism of mind and matter, objectivity, individualism, rationalism, reductionism, linearity, and determinism are the tools we continue to use to make sense of our perceptions. All together they contributed decisively to build a dominant culture obsessed with order, equilibrium, hierarchy, and control. And in economic and political terms it led to the consecration of quantification, productivity, and performance and to the justification of colonization and exploitation of people and nature in the name of progress.

This is the culture from which the socio-ecological disasters originated in the first place. It still uses the same lenses of early Modernity and hence has the same blind spots. It believes in simple chains of causes and effects, which is why unintended consequences are always deemed as "collateral". It fundamentally ignores that in most systems, even very simple ones, all components react to changes in their environment. And the flow of actions and reactions, like questions and responses, creates an endless stream of evolution. Both climate warming and Covid-19 are responses to previous human actions, which were reckless enough not to care about consequences. And at critical points the evolution of a system can produce a dramatic reconfiguration into completely different patterns. This is the well-observed phenomenon of emergence and creativity. But the culture we live in still believes in linear change, driven by a clear purpose. It believes in the capacity to decide on a complex matter from an external and objective position and then impose that decision on all beings involved in the matter of analysis. And it fundamentally ignores that all living beings are sentient and not parts of a mechanical device.

In other words, the dominant way of thinking dispossesses living beings (human or not) from their characteristic of being alive. They are treated as inanimate objects, or at best controllable subjects, not as autonomous and interdependent beings in constant co-evolution with their environment. This also gives some humans not only the position but also the legitimacy to pursue and expand multiple forms of colonization and extractive exploitation of people and nature. And it is a violation of the rule of interdependency, the key feature of all ecosystems, including the biosphere at large. At whatever scale, ecosystems do not change by following a directional imposition from outside, they learn new patterns of behaviour, which will, most of the time, not be those we expected. We might act as if not knowing, but then we should remember the warning by José Ortega y Gasset: "every ignored reality prepares its revenge". Simply put: by using mechanistic thinking, a

way of mapping largely blind to what we know about Life, we inevitably create tragedies that we tend to ignore until it is too late.

To illustrate what we mean, let us take the example of climate change, which is now a priority in most public agendas. The identification of the use of fossil fuels as the main contributor to climate warming made it possible to frame the issue in a simple cause-effect logic. This is also true for its solution: let us shift to renewable energies, and the issue is solved! Then the challenge is of a techno-economic nature, it is a matter of mobilizing resources to develop the appropriate technologies and promoting the investments to deploy them. There is no questioning of what kind or how much energy do we need, nor of the huge imbalance in patterns of consumption between "developed" and "developing" countries. It is assumed that the trajectory leading to human wellbeing requires an ever-growing amount of energy per capita, particularly for the largest part of world's population to "catch up". It is assumed that outrageously high levels of energy consumption are legitimate, provided there is money to pay for them. The idea that equitable human wellbeing could be compatible with a dramatic reduction in the total consumption of energy is simply unthinkable. But then humanity is doomed anyway: for all the merits of renewables energies, they still do not allow for infinite growth in a finite planet.[5] Though, for now we keep the formulation of the issue in the same terms, hoping that we will be lucky and have time to implement some other artificial sources of energy without such restrictions. At most we try to explore how the rise in GDP per capita could be "decoupled" from the consumption of energy and other resources, without much success. And we tie our future to the rigid association of wellbeing with high levels of energy consumption. In this conception, humanity is reduced to its metabolism; rather than a function, energy consumption becomes a role, in which maximization is given a positive meaning. This is not how nature works.

Other formulations could be tried for this fundamental challenge. For instance, we could ask what drives human health and wellbeing. The obsession of Modernity with the maximization of production and consumption made us ignore that our health and sense of a meaningful life are not driven by consumerism. Science has rediscovered what we knew since the beginning of time: the quality of our relationships with others, humans and non-humans, is the secret of a good life.[6] This crucial point could lead to other ways of innovating and learning, in which relationships and interdependencies played the dominant role. But it is close to impossible to explore these ways while in existing institutional frameworks. The appropriate questions cannot be asked from existing disciplines of research and, on top of everything else,

too many stakes (financial, industrial, geopolitical) would be at risk in any scenario of dramatic reduction of energy consumption.

This brings us to the misleading role of "stakeholders" in debating and designing any kind of transformative strategy for the future of humanity. By definition, stakeholders will defend their stakes rather than question them. Not even the most innovative organizations – whether universities, research centres, or corporations – dare to question the fundamentals of their own existence and setup. Their primary mission is to persist, and hence, except for lip service they only do what reinforces their persistence. But all stakes are at risk in our suicidal trajectory! Using lenses where present stakes are crucial is almost a guarantee that discussions on climate change, social inequalities, or other challenges will actually be focused on how to best preserve the status quo. What to preserve and what not is a central question, of course. Every culture must make choices on what it wants to preserve for the future. What heritages from the past do we think are worth bringing with us for the journey into the uncharted territories of the future? In the current version of the culture of Modernity, it seems we feel legitimized to question and render obsolete all heritages, all except one: the centrality of capital.

What heritage means

Capital has become the totem par excellence of human societies on which we place all our expectations. At this stage of the 21st century, characterized by an extreme degree of financialization, it is the ideal recipient of past achievements and the central element of our relationship with time: we all expect to accumulate it and receive future returns to ensure our welfare, protect our lives from hardship, and, not least, give meaning to what we do, for ourselves and our offspring. The concept was originally grounded in living processes: land and animals can constantly produce resources useful to humans and that feeds the idea that future returns can be expected. But this requires a lot of human work and the sun, water, wind, and soil materials to contribute (no coincidence: these are the Four Elements of ancient traditions). Nowadays legal practices enforce attributes of capital unrelated to living processes, according to a very specific conception of its role, which has been and could be otherwise.[7] As a characteristic of present Modernity, capital is given more and more abstract forms, for instance, the ownership of algorithms of artificial intelligence. And in its dominant encoding it imposes enclosure (the opposite of the commons) and a high level of control over means to produce

monetary flows in the future, whether they be productive efforts of people, the exploitation of natural resources, the royalties of intellectual property, or the future time of debtors. Capital is probably the most powerful social construct we have invented; it governs not only biophysical realities but also our minds and time. And it does so in an increasingly detached manner; expressed in the one-dimensional language of money, it is more and more decontextualized from any geographical, human, or cultural circumstances, and it becomes infinitely mobile at the stroke of a computer key.

Consequently, the evolution of capital in the previous decades has contributed to expanding the domain of the "rentier economy". The portion of monetary flows coming from rents on whatever form of capital has been growing significantly faster than the outcomes of human work.[8] This has not only made the deepening of social inequalities a structural, non-collateral feature of our economies, it has consolidated a culture in which the individual accumulation of capital, rather than the quality of relationships, is seen as the main mechanism for future welfare. All this becomes truly problematic when it makes us ignore the tragedies we are creating due to a dangerous combination: capital is increasingly detached from social and biophysical realities, and at the same time it aspires to control them all to get returns. In spreadsheets almost all figures look rational, and we feel entitled to assign future returns to whatever form of capital we have created and legally encoded. But this is a violation of what we already know about how Life works: the second law of thermodynamics says that decline, not growth, is the norm. If growth happens it is due to a delicate combination of ingredients and circumstances, not the least the intake of energy from outside the system. So, capital cannot create returns per se; if it consumes more energy (in whatever form) than it receives, it will necessarily decline.

In this respect, the example of land mentioned above is quite illustrative. For land to produce returns, we have to ensure that the soil stays healthy, the appropriate combination of sun, water, wind, and human work come together, and the risks of poisoning, drought, storms, frosts, heat waves, and others are kept at bay. A lot of care is required for Life to do what we would like. Industrial agriculture does not completely ignore that, but its focus is on the return on capital, not on the relationships between the components of the ecosystem to ensure it remains healthy. This is problematic, not because the concept of capital is useless per se, but it would be better understood as a synonym of "heritage". This emphasizes the fragility of past achievements; they require care and depend on the health of all contributors (human, non-human, and inanimate) and on the quality of their relationships. And

quite obviously, heritage is pluriversal. It means different things in different cultures, and capital should be so as well. All of this is far away from the disconnected, monetized, infinitely mobile, and ultimately blind version of capital we deal with most of the time.

Severing the ties of capital from the contextual and grounded richness from which it originated is a dangerous trick. It implies that the perception of reality through the current lens of capital is doubly misleading: it identifies value where it should not and does not identify the value where it is. In 2022 the accounting books of corporations and investment funds, both public and private, still show a huge amount of monetary value related to fossil fuels. So, the main practice responsible for the existential threat of climate warming, severe enough to make our civilizations collapse, is still worth a lot of money. Also, according to the official version, Africa is heavily in debt to the "developed" world. After centuries of colonization and enslavement this is a tragic irony, to say the least. So many arguments can be found to explain why the situation should be the reverse.[9] This is the elephant in every room where the future of humanity is discussed: the valuations of capital in accounting books reflect more the past and present distribution of power within and among societies than the heritage which will be of value for future generations. If we ignore this, we will keep feeding incoming tragedies. On the other hand, if we implement a gigantic write-off tomorrow, the economies and societies will instantly collapse. Both options are scary, but if we pretend that there is no issue with our lenses, we will not find the appropriate manner to reconnect with Life.

The nature of power

Long ago, Karl Deutsch said: "Power is the ability not to have to learn anything." To what extent is the power of existing stakes impeding the learning we need? Very much so, as the abundant evidence indicates. But, what about the institutionalized ways of learning that we already have? We are not living in static societies, after all. Crises make us learn something, in the sense of changing the course of our lives. In particular, crises make capital valuations change dramatically, and sometimes very rapidly. The main script for the scenario of "green growth" is that investments in fossil fuels and other unsustainable practices lose their value in stock exchanges, while the valuation of renewables grows fast. This is already happening to some extent. And the market can develop assessment mechanisms with the intention to

give signals in the right direction, such as the ESG tool evaluating companies and countries according to the Environmental, Social, and Governance consequences of their actions. However, there is a chance that these tools only produce cosmetic changes or even act as a "dangerous placebo".[10] And change is way too slow compared to the timelines of inequalities, climate warming, and other challenges.

At the same time, speed is not the essential issue. As Gandhi said, "It is irrelevant if we go in the wrong direction." In 1979, Aurelio Peccei formulated our challenge as a riddle: "What we all need at this point in human evolution is to learn what it takes to learn what we should learn – and learn it." This means there are different levels of learning. The act of learning new patterns of behaviour does not guarantee per se that we start creating more Life than we destroy. It could be the contrary. If we take the example of Covid-19, what did we learn? For one, that being human has become more difficult than before. Now it requires more separation from others (social distance), being vaccinated (a technical fix), and abiding by additional layers of technology and bureaucracy imposed to better control the pandemic and Covid-like disruptions in the future. Most probably these were the only sensible responses our present systems were able to produce. We also learned that a tragedy of such a scale and impact ruins whole sectors of activity, but it creates a huge amount of private "wealth" in others, like pharma and the digital industry. And for now, we have not learned so much about the craziness of destroying ecosystems as a structural feature of "development". Are we asking if reconnecting humans to themselves and nature could help in avoiding future Covid-like scenarios? After the pandemic the world in which we live is different but is it more attuned to Life? Or more and more disconnected from it because of the framing of our responses to the crisis?

If we do not change the framing through which we formulate the questions and their responses there is little chance that the general orientation of our relationships (among humans, with Life, with time) could change. If we stay within the separatist framing of Modernity, characterized by extreme individualism, the industrialization of competition, the disconnection from social and biophysical realities, and an exploitative mindset towards the private accumulation of ethereal capital, shifting from fossil fuels to renewables will not make a world of a difference. The conscious understanding of something new but still within the same rules of Modernity is not enough. The kind of learning we need is more than that. It is a change in our patterns of behaviour and in how we think that is required to deal with the consequences of what we know (consciously or not, individually or collectively). Can it

be produced by existing institutions through their usual way of operating? With great difficulty, since the way these institutions are designed already encodes the questions they are able to ask and hence the learning they are able to produce.

Let us take a look at the social process of research and innovation (R&I) on which we place so much expectation to bring positive responses to our pains. Technology being the standard response of Modernity to any issue, it would be fantastic if it could go beyond the limitations of its own framing. But currently, the institutions involved in R&I efforts (research institutes, universities, corporations) shape their own agendas and actions, deemed to be "disruptive", in ways preserving at least two basic premises: knowledge is essentially divided into separate disciplines and it is only helpful if it is part of a process leading to "solutions" on which financial returns on investments can be expected. Our institutions of R&I and the process leading to technological development are not based on what science knows about Life. They might use and produce leading-edge science but the ways they are organized and operate follow the outdated framework of Modernity we described above. Hence, acting as they do in ways opposed to how Life works, they are essentially unable to ask the questions which would be useful to address our big challenges. At the same time, public and private sectors expect R&I to deliver economic profits and keep alive the centrality of capital, as it is presently understood. As a consequence, the overall result of the current deployment of inventions is simply to reinforce the political and economic framework under which technologies are being created.

This is particularly clear in the case of digitalization. While its inventions are of course wonderful in many ways, framed as it is in the culture of Modernity it is actually contributing to the destruction of social fabric and creating more inequality, dehumanization, and a greater distance between the ethereal creation of financial wealth and Life at large. Moreover, the subtext in "artificial intelligence" (AI) is that people are problematic, they should behave more like robots and our technical creations can be "better" than ourselves. AI is telling us that we can, and we should, get rid of humans. In the self-defeating process of human civilizations, ecological catastrophes could combine with radical robotization to achieve the destruction of ecosystems and humanity at the same time!

Living in 2022 we might complement the definition of power by Karl Deutsch: power is the ability to choose what has to be learned in order to avoid learning anything undermining the existence of power. Power structures shaping and being shaped by human societies are for now effectively

self-reinforcing. Modernity reframes the crises it creates in a way leading to further levels of abstraction and disconnection from Life, and then to a formulation of "problems" for which it can convoke its own capacities to design "solutions" avoiding deeper learning. There is lot of pressure from decision-makers trapped in the dominant way of thinking to find "solutions" instead of raising uncomfortable questions. The problems should be formulated in a tractable way and have solutions that are easy to understand and to explain to people, who are usually deemed as stupid or at least uneducated and problematic. This is nonsense. Life is complex, emergent, intractable, and impredicative; it cannot even be expressed with words without referring to itself. We know much more about how Life works than we use in the way we organize society. By using certain lenses of interpretation we create blind spots and we tend to see only what reinforces our preset conceptions. So much of what we see happening today is the revenge of ignored tragedies imposed on peoples and nature. There is probably no way to get completely rid of blind spots, but being aware that they exist makes a huge difference.

The human revolution

As argued, the quality of relationships among humans, with Life, and with time should have the central role in human cultures if we want to have a chance of reconciling human development and wellbeing with the health of the biosphere. To use an expression from Nadia Sandi, "let us allow Life to be again". In this conception human wellbeing has to be equitable, and not only to avoid the breakdown of societies and the outburst of large-scale wars (of whatever kind). Equity is also mandatory if we want to live within a healthy biosphere. As the title of the Club of Rome Annual Conference in 2021 put forward, we need "global equity for a healthy planet". Though, for the moment this is not where we are going overall. In 1984, in the book *Before it is Too Late*, Aurelio Peccei and the Buddhist philosopher and poet Daisaku Ikeda concluded that "humankind is on the wrong course" and a Human Revolution is needed in order "to live at peace with nature".[11] Decades later, we have not yet made that peace. Learning new patterns is now even more urgent than it was to change the course of human societies.

And if Modernity is only able to learn whatever reinforces its own foundations, we face a daunting challenge. How do we create conditions for the kind of learning we need? Institutional ways of addressing planetary emergencies are not delivering the expected results. At the same time, a myriad

self-organizing communities, usually catalysed by outstanding individuals, are exploring other ways of dealing with the destructive patterns of conventional "development". These attempts share some commonalities: they trust the fundamental humanity of everybody and allow people to liberate from helplessness and learn by themselves. They mobilize capacities and knowledge – individual and collective, traditional and modern, artistic and scientific, verbal and embodied. Also, they face challenges in contextual settings, usually local communities where belonging can be revitalized. They do not aspire to "save the world", rather to "serve the world"; humility, respect of ancient wisdom, and often invisibility are part of their tools. Ultimately, they aim at rehumanizing humanity.

Effectively addressing the self-destructive trends manifest in climate change, rise of inequity, loss of biodiversity, and exhaustion of resources will not be possible if we continue using the same lenses of separation and disconnection. At the same time, we need to take a leap into a higher order of magnitude in terms of speed and effects of the appropriate kind of learning and change. It is our conviction that this can only be done by betting on emergence, as a mostly spontaneous process, which could be accelerated through catalysis, pollination, and fructification – and not "scaling up". It cannot be planned and definitely not from far above the ground. And a centralized, top-down approach does not activate the latent capacities and enthusiasm of everybody; the catalysis has to allow people to formulate better questions in their own contexts and to learn by themselves to provide a rich variety of decentralized responses that are best suited to local ecological and social contexts. This is what we see already happening in many seed processes around the world. In Dennis Meadows' speech in November 2016, which we mentioned at the beginning, he outlined that the Club of Rome had missed the criticality of cultural change for the course of humanity to shift. The usual response by many is that we do not know how to create cultural change and anyway, it would take too much time. But again, the obsession with speed could be misleading.

Indeed, what if cultural change is already here, all around us, in the energy and commitment of so many people, the dispossessed everywhere, women clamouring to be heard, youth aspiring to a liveable future? Maybe the Human Revolution is already happening, not in public media nor social networks but in human minds and souls, in plain sight and yet invisible, playing a "silent melody", as Karima Kadaoui puts it. Reconnecting with our fundamentally relational nature should not be so difficult. After all, everybody is able to do it. And from there we can repair artificially broken

interdependencies, welcome the re-emergence of relationships, and regenerate whole ecosystems. This is how we can give a renewed meaning to what we already know and how we might learn new ways of becoming human in the 21st century. As Hölderlin said, "where the danger is, also grows the saving power". So, if the reconciliation with Life is a silent melody, how do we make it audible to everybody? Our invitation to humanity is a call to slow down and listen carefully, to each other and to Life, for the sake of ourselves and generations to come.

Acknowledgements

A book is always a collective adventure and this one even more so. It is made up of contributions by many authors who have been so kind as to respond in no time to the demanding petition from the co-editors. Our gratitude goes to all of them, and particularly to the Co-Presidents of the Club of Rome, Mamphela Ramphele and Sandrine Dixson-Declève, who promoted a whole programme for the celebrations of the 50th anniversary of the publication of The Limits to Growth, of which this book is a manifestation among many others.

A big thank you also goes to Rob Worth, our publisher at Exapt Press, who has shown a relentless capacity to streamline a necessarily complex process that could have derailed many times, and to make our lives much easier. With him we were fortunate enough to experience how publishing can be an inviting journey. No small feat!

Needless to say, we are very grateful to people around us who in one way or another have lived the conception of this book as if giving birth to it was also part of their duty. This includes the staff in the Secretariat of the Club of Rome, and in particular Philippa Baumgartner and Till Kellerhoff.

Last but not least, a special note is required to recognize the role played by our interlocutors in so many ongoing conversations related to the topics of this book. We cannot mention all of them, and hence this citation is necessarily unfair, but here are some of their names: Aline Frankfort, Cintia Jaime, Karima Kadaoui, Kristina Lanz, Lydia Maher, Nadia Sandi, Roseann Stempinski, Samantha Suppiah, Sarah Dubreil, and Sijin Chen. All of them and many others are actually doing what we talk about in this book: opening the space of possibilities for desirable futures

— The co-editors, Ugo and Carlos

Notes

1. Ugo Bardi

1 Bardi, U. 2011. *The Limits to Growth Revisited*. New York: Springer. doi:10.1007/978-1-4419-9416-5. 119 p.
2 Attinger, P. 1998. "Inanna and Ebih." *Zeitschrift für Assyriologie und Vorderasiatische Archäologie* 88 (2): 164–95. doi:10.1515/zava.1998.88.2.164.
3 Bardi U. 2015. Chimeras: Inanna and Ebih: A report of an ancient ecological catastrophe? [Internet]. Chimeras. [cited 2021 Nov 9]. Available from: https://chimeramyth.blogspot.com/2015/08/inanna-and-ebih-report-of-ancient.html
4 Seneca LA. *Letters to Licilius*, n. 91. 1st century AD.
5 Fukuyama, F. 1989. "The End of History?" *National Interest* (16): 3–18.
6 Goeller, H., and A. Weinberg. 1978. "Age of substitutability: What do we do when the mercury runs out." *American Economic Review* 68 (6): 1–11.
7 O'Neill, G. 1974. "The Colonization of Space." *Physics Today* 27 (9): 32–40. doi:10.1063/1.3128863.
8 Dyson, F. J. 3 June, 1960. "Search for Artificial Stellar Sources of Infrared Radiation." *Science* 131 (3414): 1667–68. doi:10.1126/science.131.3414.1667. PMID:17780673.
9 Jevons, W. S. 1866. *The Coal Question*. 2nd revised edition, Macmillan and Co. [Internet], Available from http://www.econlib.org/library/YPDBooks/Jevons/jvnCQ.html.
10 Hubbert MK. 1956. Nuclear Energy and the Fossil Fuels. In: Spring Meeting of the Southern District, American Petroleum Institute, Plaza Hotel, San Antonio, Texas, March 7–8-9,. San Antonio, Texas.
11 Hardin G. 1968. The tragedy of the commons. *Science*. 162 (13 December):1243–8.
12 Catton W. 1982. *Overshoot, the ecological basis of revolutionary change*. Chicago, Il: Illinin Books Edition.
13 Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge, UK: Cambridge University Press. doi:10.1017/CBO9780511807763.
14 Bardi U, Perissi I. 2020. *The Empty Sea. What Future for the Blue Economy?* Springer.
15 Forrester, J. 1994. "System dynamics, systems thinking, and soft OR." *System Dynamics Review* 10 (2–3): 245–56. doi:10.1002/sdr.4260100211.
16 Larham R. 2012. The Legend of the "Fixed" Japanese Wargaming of the Midway Campaign. [cited 2021 Nov 11]. Available from: https://www.researchgate.net/

publication/299597657_The_Legend_of_the_Fixed_Japanese_Wargaming_of_the_Midway_Campaign_slides_presented_at_the_DSTL_Historical_Analysis_Symposium_2012
17 Times LSS to TNY. SCHOLARS FAVOR GLOBAL GROWTH. The *New York Times* [Internet]. 1976 Apr 13 [cited 2021 Oct 9]; Available from: https://www.nytimes.com/1976/04/13/archives/scholars-favor-global-growth-members-of-club-of-rome-say-further.html
18 Sprott, J. C. July 2004. "Dynamical models of love." Internet *Nonlinear Dynamics Psychology and Life Sciences* 8 (3): 303–14. https://docplayer.net/23926625-Dynamical-models-of-love.html cited 2020Dec13 PMID:15233877.
19 Perissi, I., and U. Bardi. September 2021. "The Sixth Law of Stupidity: A Biophysical Interpretation of Carlo Cipolla's Stupidity Laws." *Systems*. 9 (3): 57. doi:10.3390/systems9030057.
20 Cipolla CM. 2013. The Basic Laws of Human Stupidity [Internet]. Wayback Machine. [cited 2020 Dec 15]. Available from: https://web.archive.org/web/20130216132858/http://www.cantrip.org/stupidity.html
21 Meadows, D. H., J. Randers, and D. L. Meadows. 2004. *Limits to Growth: The 30-year update*. White River Junction: Chelsea Green.
22 Meadows D, Meadows DH, Randers J, Behrens W Jr. 1972. *The Limits to Growth* [Internet]. Potomac Associates. [cited 2021 Sep 28]. Available from: https://www.clubofrome.org/publication/the-limits-to-growth/
23 Meadows DH, Meadows DL, Randers J. 1992. *Beyond the Limits*. Post Mills, Vermont, USA: Chelsea Green.
24 Bardi U. 2017. *The Seneca Effect. Why Growth Is Slow but Collapse Is Rapid*. Springer Verlag.
25 Tainter, Joseph A. 1988. The collapse of complex societies
26 Hall C.A.S. 2017. The History, Future, and Implications of EROI for Society. In: Hall CAS, editor. Energy Return on Investment: A Unifying Principle for Biology, Economics, and Sustainability [Internet]. Cham: Springer International Publishing. [cited 2021 May 30]. p. 145–69. (Lecture Notes in Energy). Available from: https://doi.org/10.1007/978-3-319-47821-0_12
27 Koheler J.E. Book Review: The Limits to Growth. J Polit. 1973;35:513–4.
28 Myrtveit M. 2005. WORKING PAPERS IN SYSTEM DYNAMICS.
29 Cole HS. D. 1973. *Models of Doom: A Critique of The Limits to Growth*. New York: Universe Books
30 Saltelli A. 2002. Sensitivity Analysis for Importance Assessment. Risk Anal. 22(3):579–90.
31 Cuypers J.G.M., Rademaker O. 1974 . An analysis of Forrester's world dynamics model. *Automatica*. Mar 1;10(2):195–201.
32 Nordhaus, W. D. 1973. "World Dynamics: Measurement Without Data." *Economic Journal (London)* 83 (332): 1156–83. doi:10.2307/2230846.
33 Forrester, J. W., G. W. Low, and N. J. Mass. 1974. "The Debate on "World Dynamics": A Response to Nordhaus." *Policy Sciences* 5 (2): 169–90. doi:10.1007/BF00148039.
34 Nordhaus, W. 1992. "Lethal Models." *Brookings Papers on Economic Activity* 2:1–59. doi:10.2307/2534581. PMID:12287537.
35 Robert, Costanza, Segura Bonilla Olman, and Martínez Alier Juan, and the International Society for Ecological Economics. 1996. *Getting down to earth: Practical applications of ecological economics*. [Internet] Island Press; Available from https://www.goldonomic.com/tainter.htm, cited 2018 Jun 10.
36 Bailey, R. 1989. "Dr Doom." *Forbes Magazine*. (Oct): 45.

37 Passel P, Roberts M, Ross L. 1972. Review of "The Limits to Growth." New York Times Book Review. 1972 Apr 2;
38 McGarity, T., and W. E. Wagner. 2008. *Bending science: How special interests corrupt public health research*. [Internet] Cambridge, Massachusetts and London, England: Harvard University Press; Available from http://books.google.it/books?hl=en&lr=&id=Ah6-__otORAC&oi=fnd&pg=PR7&dq=McGArity+Wagner&ots=TnfuhvQbrt&sig=WC-X7xkCkOjBxru6sTQGrrFHkgw, cited 2014 Jan 3.
39 Michaels, D. 2008. *Doubt is their product: How industry's assault on science threatens your health*. [Internet] New York: Oxford University Press.
40 Oreskes N, Conway EM. 2010. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. New York: Bloomsbury Publishing USA. 368 p.
41 Groshong K. The Noisy Response to Silent Spring: Placing Rachel Carson's Work in Context. 2021 Sep 18;
42 Mann M.E. 2013. *The hockey stick and the climate wars: Dispatches from the front lines*. New York: Columbia University Press; 423 p.
43 Nebbia, G. 1997. "Bisogno di storia e di futuro." *Futur New Ser Gorizia*. 4:149–82.
44 Schoijet, M. 4 October, 1999. "Limits to Growth and the Rise of Catastrophism." *Environmental History* 1999 (4): 515–30. doi:10.2307/3985399.
45 Peccei, A., and D. Ikeda. 2008. Before it is too late. Ed. R. L. Gage. London, New York: I. B. Tauris.
46 Rindzeviciute, E. 2015. "Toward a Joint Future beyond the Iron Curtain: The East-West Politics of Global Modelling." *In The Struggle for the Long Term in Transnational Science and Politics: Forging the Future*, ed. J. Andersson and E. Rindzevičiūtė, 115–143. London, New York: Routledge. doi:10.4324/9781315717920-6.
47 Orlov D. 2011. Reinventing Collapse: The Soviet Experience and American Prospects [Internet]. New Society Publishers. Available from: https://www.amazon.com/Reinventing-Collapse-Experience-American-Prospects/dp/0865716854
48 Tupy M, Pooley G. 2021. How Much More Prosperous Would the World Be Without China's One-Child Policy? [Internet]. *HumanProgress*. [cited 2021 Sep 22]. Available from: https://www.humanprogress.org/how-much-more-prosperous-would-the-world-be-without-chinas-one-child-policy/
49 Campbell, C. J., and J. F. Laherrere. 1998. "The End of Cheap Oil." *Scientific American* (March): 80–86.
50 Bardi, U. 1 February, 2019. "Peak oil, 20 years later: Failed prediction or useful insight?" *Energy Research & Social Science* 48:257–61. doi:10.1016/j.erss.2018.09.022.
51 Bardi, U., A. Lavacchi, and L. Yaxley. December 2011. "Modelling EROEI and net energy in the exploitation of non renewable resources." *Ecological Modelling* 223 (1): 54–58. doi:10.1016/j.ecolmodel.2011.05.021.
52 Simmons M. Revisiting 2000. The Limits to Growth: Could the Club of Rome have been correct, after all? An energy white paper [Internet]. [cited 2014 Jan 1]. Available from: http://www.greatchange.org/ov-simmons,club_of_rome_revisted.html
53 Bardi U. 2008. Cassandra's curse: how "The Limits to Growth" was demonized [Internet]. The Oil Drum Europe. [cited 2021 Sep 18]. Available from: http://theoildrum.com/node/3551
54 Gardner, T. 2004. "Limits to growth?–A perspective on the perpetual debate." *Environmental Sciences (Lisse)* 1 (2): 121–38. doi:10.1080/15693430512331342592.
55 Busby J. 2006. Pure Charity [Internet]. [cited 2021 Sep 19]. Available from: http://www.after-oil.co.uk/charity.htm
56 Heinberg R. 2010. Beyond the Limits to Growth. Post Carbon Inst Foundation Ser.

57 Noorgard J, Peet J, Ragnasdottir K.V. 2016. The History of The Limits to Growth. Solut J [Internet]. 2016 Feb 21 [cited 2021 Sep 19]; Available from: https://thesolutionsjournal.com/2016/02/22/the-history-of-the-limits-to-growth/
58 Herrington, G. June 2021. "Update to limits to growth: Comparing the World3 model with empirical data." *Journal of Industrial Ecology* 25 (3): 614–26. doi:10.1111/jiec.13084.
59 Turner, G. August 2008. "A comparison of The Limits to Growth with 30 years of reality." *Global Environmental Change* 18 (3): 397–411. doi:10.1016/j.gloenvcha.2008.05.001.
60 Raugei, M., S. Sgouridis, D. Murphy, V. Fthenakis, R. Frischknecht, C. Breyer, Ugo Bardi, et al. 2017. "Energy Return on Energy Invested (ERoEI) for photovoltaic solar systems in regions of moderate insolation: A comprehensive response." *Energy Policy* 102:102. doi:10.1016/j.enpol.2016.12.042.
61 Leger, Dorian, Silvio Matassa, Elad Noor, Alon Shepon, Ron Milo, and Arren Bar-Even. 29 June, 2021. "Photovoltaic-driven microbial protein production can use land and sunlight more efficiently than conventional crops." Internet *Proceedings of the National Academy of Sciences of the United States of America* 118 (26): e2015025118. https://www.pnas.org/content/118/26/e2015025118 doi:10.1073/pnas.2015025118. PMID:34155098.
62 Bardi U, El Asmar T, Lavacchi A. 2013. Turning electricity into food: the role of renewable energy in the future of agriculture. J Clean Prod. 53(15 August 2013):224–31.
63 Bardi, U. 2014. "The Sower's Strategy: A Way to Speed Up the Energy Transition." In *Disrupting the Future: Great Ideas for Creating a Much Better World*, ed. W. Visser, 15–19. London: Kaleidoscope Futures.
64 Sgouridis, S., D. Csala, and U. Bardi. 1 September, 2016. "The sower's way: Quantifying the narrowing net-energy pathways to a global energy transition." *Environmental Research Letters* 11 (9): 094009. doi:10.1088/1748-9326/11/9/094009.
65 Bardi, U., and S. Sgouridis. 2017. "In support of a physics-based energy transition planning: Sowing our future energy needs." *Biophysical Economics Resource Quality*. 2 (4): 14. doi:10.1007/s41247-017-0031-2.
66 Saunders, H. D. 2000. "A view from the macro side: Rebound, backfire, and Khazzoom–Brookes." *Energy Policy* 28 (6-7): 439–49. doi:10.1016/S0301-4215(00)00024-0.
67 Steele D.H. Andersen R, Green J.M. 1992. The Managed Commercial Annihilation of Northern Cod. Nfld Labrador Stud [Internet]. 1992 Jan 1 [cited 2020 Jan 2]; Available from: https://journals.lib.unb.ca/index.php/NFLDS/article/view/919
68 Incropera, F. P. 2015. *Climate Change: A Wicked Problem: Complexity and Uncertainty at the Intersection of Science, Economics, Politics, and Human Behavior*. [Internet] Cambridge: Cambridge University Press; Available from https://www.cambridge.org/core/books/climate-change-a-wicked-problem/3C884366BF604812E3B715418367241A, cited 2021 Sep 29.
69 Heinberg R, Campbell C. 2006. The Oil Depletion Protocol [Internet]. Trowbridge: New Society Publishers. Available from: http://www.indiebound.org/book/9780865715639
70 Moxnes, E. 2000. "Not only the tragedy of the commons: Misperceptions of feedback and policies for sustainable development." *System Dynamics Review* 16 (4): 325–48. doi:10.1002/sdr.201.
71 Meadows D.H. 1999. "Leverage Points: Places to Intervene in a System". donellameadows.org.
72 Baedke, Jan, Alejandro Fábregas-Tejeda, and Abigail Nieves Delgado. May 2020. "The holobiont concept before Margulis." *Journal of Experimental Zoology*. Part B,

Molecular and Developmental Evolution 334 (3): 149–55. doi:10.1002/jez.b.22931. PMID:32039567.
73 Margulis L, Fester R. 1991. Symbiosis as a Source of Evolutionary Innovation [Internet]. MIT Press. [cited 2020 Aug 19]. Available from: https://mitpress.mit.edu/books/symbiosis-source-evolutionary-innovation
74 Lovelock, J. E., and L. Margulis. 1 January, 1974. "Atmospheric homeostasis by and for the biosphere: The gaia hypothesis." *Tellus* 26 (1–2): 2–10.

2. Jorgen Randers

1 Meadows DH, Meadows DL, Randers J, Behrens WW. 1972. *The Limits to Growth*. Universe Books: New York. Available in 36 languages
2 See for instance Bardi, U. 2011. *The Limits to Growth Revisited*. New York, Heidelberg: Springer. doi:10.1007/978-1-4419-9416-5.
3 The 3 formal conclusions of LtG read as follows:
1. If the present growth trends in world population, industrialization, pollution, food production and resource depletion continues unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity.
2. It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realized his individual human potential.
3. If the world's people decide to strive for this second outcome rather than the first, the sooner they begin working to attain it, the greater will be their chances of success.
4 See for instance International, W. W. F. 2020. "The Living." Gland, Switzerland. https://livingplanet.panda.org/ *Planetary Report* 2020. https://livingplanet.panda.org/
5 Rockström, J., Will Steffen, Kevin Noone, Åsa Persson, F. Stuart III Chapin, Eric Lambin, Timothy M. Lenton, et al. 2009. "Planetary boundaries: Exploring the safe operating space for humanity." *Ecology and Society* 14 (2): 32. doi:10.5751/ES-03180-140232.
6 Randers, J. 2008. "Global Collapse – Fact or Fiction?" Dec *Futures* 40 (10): 853–64. doi:10.1016/j.futures.2008.07.042.
8 Randers, J., J. Rockström, P. E. Stoknes, U. Goluke, D. Collste, and S. Cornell. 2018. *Transformation is feasible!* Stockholm: Stockholm Resilience Center; http://www.2052.info/wp-content/uploads/2019/05/7017_02-SRC-Report_Achieving-the-Sustainable-Development-Goals_Low_5.pdf.
9 Randers, J., J. Rockström, P. Stoknes, U. Goluke, D. Collste, S. Cornell, and J. Donges. 2019. "Achieving the 17 Sustainable Development Goals within 9 planetary boundaries." *Global Sustainability* 2 (E24): 1–11. doi:10.1017/sus.2019.22.
10 It requires impossibly optimistic assumptions to create a sustainable world if one starts from real world conditions in 2002. See Meadows DH, Randers J, Meadows DL. 2004. *Limits to Growth – The 30 Year Update*. Chelsea Green Publishing: White River Junction, VT. Available in more than15 languages. This led one co-author to recommend increased global resilience as the main strategy for human well-being in the 21st century and beyond.
11 For the first famous attempt, see Turner, G. M. 2008. "A comparison of The Limits to Growth with 30 years of reality." *Global Environmental Change* 18 (3): 397–411. doi:10.1016/j.gloenvcha.2008.05.001.

12 For state of the art, see Herrington, G. 2021. "Update to limits to growth: Comparing the world3 model with empirical data." *Journal of Industrial Ecology* 25 (3): 614–26. doi:10.1111/jiec.13084.
13 Randers, J., and G. Maxton. 2016. *Ein Prozent ist Genug. Oekom Verlag: München*. Also available as Maxton G, Randers J. 2016. Vancouver: Reinventing Prosperity. Greystone.
14 Randers J. 2012. *2052 – A Global Forecast for the Next Forty Years*. Chelsea Green Publishing: White River Junction, VT. Available in 13 languages.

4. Sviatoslav Zabelin

1 Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrnes III. 1972. *Limits to growth. A Report for the Club of Rome's project On the Predicament of Mankind*.
2 Zabelin S. 1998a. "Lessons from the USSR Crisis. From "A time to seek, and a time to lose". (in Russian).
3 Herrington G. 2020.Update to limits to growth. Comparing the World3 model with empirical data, *Journal of Industrial Ecology*, 2020; 1–13.
4 Portanskiy A., Sudakova Yu., Larionov A. 2020. "Assumptions of the Global Economic Crisis and Its Inception in the Spring of 2020 Due to the COVID-19 Pandemic." *International Organisations Research Journal*, vol. 15, no 2, pp. 139–152.
5 Zabelin S. 1998b "Foreseeable Future – 1998–2008. Scenario of a likely accelerated collapse of the world economy. March 15, 1998". (in Russian).
6 Nick King, Aled Jones. 2021. "An Analysis of the Potential for the Formation of 'Nodes of Persisting Complexity'," *Sustainability*. 13(15), 8161; https://doi.org/10.3390/su13158161
7 Cohen. L. 2021 U.N. finds that governments are still planning to increase oil and gas production despite climate warnings. CBS News. 20 Oct 2021. https://www.cbsnews.com/news/climate-change-un-report-fossil-fuel-production/
8 Charles Digges, Key Democrat torpedoes Biden's most significant climate action. 2021. https://bellona.org/news/climate-change/2021-10-key-democrat-torpedoes-bidens-most-significant-climate-action#bio-5
9 https://www.washingtonpost.com/us-policy/2021/10/19/biden-democrats-reconciliation/
10 https://www.nytimes.com/2021/10/15/climate/biden-clean-energy-manchin.html
11 Pereira C. 2020. Learning New Ways of Becoming Human. The Club of Rome.
12 Mondragon Group, https://alki.fr/en/new/7485/The-federation-of-Worker-cooperatives/
13 Kew declaration on reforestation for biodiversity, carbon capture and livelihoods. 2021. https://nph.onlinelibrary.wiley.com/doi/10.1002/ppp3.10230

5. Ernst von Weizsäcker

1 John Maddox. 1972. *The Doomsday Syndrome*. MacGraw Hill
2 H. S. D. Cole and Christopher Freeman. 1973. *Models of Doom: A Critique of the Limits to Growth*.
3 Herrera, Amllcar & Scolnik, Hugo & Chichilnisky, Graciela & Gallopín, Gilberto & Hardoy, Jorge & Centre, International & Ottawa, & (Canada, Ontario & Bariloche, Buenos. 1976. Catastrophe or new society? A Latin American world model. XF2006174329.
4 https://www.goodreads.com/quotes/161363 The full quote is "There are no such things as limits to growth, because there are no limits to the human capacity for intelligence, imagination, and wonder."

5 Ernst Ulrich von Weizsäcker, Amory Lovins, Hunter S. Lovins. 1997. *Factor Four: Doubling Wealth, Halving Resource Use*. London: Earthscan. The German translation *Faktor Vier* was already published in 1995 and got onto the bestseller lists for nearly a year.
6 Graham Turner. 2008. "A Comparison of 'The Limits to Growth' with Thirty Years of Reality". Socio-Economics and the Environment in Discussion (SEED). CSIRO Working Paper Series. 2008–09.
7 Ernst Ulrich von Weizsäcker, Anders Wijkman. 2018. *Come On! Capitalism, Short-termism, Population and the Destruction of the Planet*. A Report to the Club of Rome. prepared for the Club of Rome's 50th Anniversary in 2018. New York. Springer.
8 Rockström, Johan, Will Steffens, Kevin Noone, et al. 2009. "Planetary Boundaries: Exploring the Safe Operating Space for Humanity." *Ecology and Society* 14 (2): 1–32. doi:10.5751/ES-03180-140232.

6. Gianfranco Bologna

1 Honorary President, Scientific Community WWF Italy; Secretary general Foundation Aurelio Peccei; Full member Club of Rome (g.bologna@wwf.it)
2 Meadows D.H., Meadows D.L., Randers J. and Behrens III W.W. 1972. *The Limits to Growth*, Potomac Associates Book.
3 See https://www.un.org/en/conferences/environment/stockholm1972 and https://sustainabledevelopment.un.org/milestones/humanenvironment
4 See https://landsat.gsfc.nasa.gov/
5 Ward B. and Dubos R. 1972. *Only One Earth. The Care and Maintenance of a Small Planet*, Norton.
6 Moll P. 1991. *From Scarcity to Sustainability. Futures Studies and the Environment: The Role of the Club of Rome*, Peter Lang.
7 Tinbergen N. (ed.). 1976. *Reshaping the International Order*, Agon Elsevier.
8 Ehrlich P. R. and Ehrlich A. H. 1970. *Population, resources, environment*. Freeman C., Holdren P.J. and Ehrlich P.R. (eds). 1971. *Global ecology*, Harcourt Brace Jovanowich.
9 Ehrlich P.R. and Holdren J. 1971. Impact of population growth, *Science* 171; 1212–1217.
10 National Research Council. 1986. *Earth System Science. Overview, A Program for Global Change*, National Academic Press
11 See https://council.science/
12 https://scope-environment.org/about
13 Revelle R. and Suess H. 1957. "Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO_2 During Past Decades", *Tellus*, 9, 1; 18–27.
14 Thomas W. L. jr. (ed.). 1956. *Man's Role in Changing the Face of the Earth*, University of Chicago Press.
15 See https://www.esrl.noaa.gov/gmd/obop/mlo/.
16 Steffen W. et al. 2004. *Global Change and Earth System: A Planet Under Pressure*, The IGBP Books, Springer Verlag; Steffen W. et al. 2015. The trajectory of the Anthropocene: The Great Acceleration, *The Anthropocene Review*, 2 (1); 81–89; McNeill J.R. e Engelke P. 2014. *The Great Acceleration: An Environmental History of the Anthropocene since 1945*, The President and Fellows of Harvard College.
17 Peccei A. 1969. *The Chasm Ahead*, Macmillan & Co.
18 Peccei A. 1977. *The Human Quality*, Pergamon Press.
19 King A. 2006. *Let the Cat Turn Round: One Man's Traverse of the Twentieth Century*, CPTM (Commonwealth Partnership for Technology Management).

20 Schellnhuber H.J. 1999. Earth system analysis and the second Copernican revolution, *Nature*, vol. 402 e Schellnhuber J. et al. (eds). 2004. *Earth System Analysis for Sustainability*, MIT Press.
21 See https://www.top500.org/lists/top500/2021/06/highs/
22 Peccei A. 1976. *The Human Quality*, Pergamon Press.
23 Meadows D. H., Meadows D. L. e Randers J. 1992. *Beyond the limits*, Earthscan; Meadows D., Meadows D. e Randers J. 2004. *Limits to Growth. The 30-Year Update*, Chelsea Green Publishing Company e Randers J. 2012. *2052. A Global Forecast for the Next Forty Years*, Chelsea Green Publishing.
24 See https://www.wcrp-climate.org/
25 See https://futureearth.org/
26 Seitzinger S.P. et al. 2016. International Geosphere-Biosphere Programme and Earth System science: Three decades of co-evolution, *Anthropocene*, http://dx.doi.org/10.1016/j.ancene.2016.01.001
27 Steffen W: et al. 2020. The emergence and evolution of Earth System Science, *Nature Reviews* 1; 54–63.
28 Crutzen P.J., and Stoermer E.F. 2000. *The Anthropocene*, International Geosphere Biosphere Programme, Global Change Newsletter n. 41; 17–18, see www.igbp.net; Crutzen P. J. 2002. Geology of humankind, *Nature*, 415, 23; Zalasiewicz J. et al. 2011. The Anthropocene: a new epoch of geological time? *Philos*. Trans. R. Soc. London A 369, 835–841; Ellis E. 2018, *Anthropocene. A very short introduction*, Oxford University Press.
29 See www.anthropocene.info and the Working Group of the International Commission on Stratigraphy http://quaternary.stratigraphy.org/workinggroups/anthropocene
30 Zalasiewicz J. et al. 2017. The Working Group on the Anthropocene: Summary of evidence and interim reccomandations, *Anthropocene*, 19; 55–60.
31 Wijkman A. e Rockström J. 2012. *Bankrupting Nature. Denying our Planetary Boundaries*, Routledge; Randers J., Rockström J. et al. 2018. *Transformation is feasible. How to achieve the Sustainable Development Goals within Planetary Boundaries*, Stockholm Resilience Centre.
32 Rockström J. et al. 2009. A Safe Operating Space for Humanity, *Nature*, 461; 472–475. Steffen W. et al. 2015. Planetary Boundaries: Guiding Human Development on a Changing Planet, *Science*, 347, doi:10.1126/science.1259855
33 https://www.stockholmresilience.org/research/planetary-boundaries.html
34 Raworth K. 2017. *Doughnut Economics: Seven Ways to Think Like a 21st Century Economist*, Random House. See https://doughnuteconomics.org/
35 See https://globalcommonsalliance.org/
36 See https://earthcommission.org/
37 Rockström J. et al. 2021. *Identifying a Safe and Just Corridor for People and the Planet, Earth's Future*, https://doi.org/10.1029/2020EF001866
38 See https://sciencebasedtargetsnetwork.org/
39 See also von Weizsacker E. U. and Wijkman A., (eds.). 2018. *Come On!*, Springer; Folke C. et al. 2021. Our future in the Anthropocene biosphere, *Ambio*, https://doi.org/10.1007/s13280-021-01544-8; Club of Rome. 2020. Club of Rome. 2020. Planetary Emergency 2.0. Securing New Deal for People, *Nature and Climate*, https://clubofrome.org/wp-content/uploads/2020/09/COR-PEP_Sep2020_A4_16pp-v2.pdf , see also the initiative Earth for All https://www.earth4all.life/

8. L. Hunter Lovins

1 Strauss, Mark. 2014. "Looking Back On Limits To Growth. *Smithsonian*. April 2014. http://www.smithsonianmag.com/science-nature/Looking-Back-on-the-Limits-of-Growth.html
2 Gaya Harrington. 2021. "Update to Limits to Growth." *Journal of Industrial Ecology*. 25: 614– 626 https://doi.org/10.1111/jiec.13084
3 U.S. Congress. Energy Reorganization Act of 1973: Hearings, Ninety-third Congress. First Session, on H.R. 11510 (U.S. Government Printing Office, 1973). p. 248.
4 William J. Ripple, et al. 2017. "World Scientists' Warning to Humanity: A Second Notice. *BioScience*. Volume 67. Issue 12. December 2017. Pages 1026–1028. https://doi.org/10.1093/biosci/bix125
5 Global Warming of 1.5 Degree C. Intergovernmental Panel on Climate Change. October 2018. https://www.ipcc.ch/sr15/
6 Meadows, Donella. 1992. "Beyond The Limits: Executive Summary." http://natcapsolutions.org/natcaptest2/beyond-the-limits-executive-summary/
7 Hansen, Mishko. 2007. "Note on Adam Smith as Theorist of Sustainability." Personal communication. October 2007. Cambridge University
8 Smith, Adam. 1759. *Theory of Moral Sentiments*. p 27
9 Michel, Matt. 2015. "Ten Reasons Why Capitalism Is Morally Superior." *Contracting Business*. 25 September 2015. https://www.contractingbusiness.com/residential-hvac/article/20868486/ten-reasons-why-capitalism-is-morally-superior#:~:text=Capitalism%20again%2C%20is%20more%20moral.&text=The%20capitalist%20believes%20that%20people,and%20make%20choices%20for%20people.
10 Oxfam. 2017. "Just 8 Men Own Same Wealth as Half the World." 15 January 2017. https://www.oxfamamerica.org/press/just-8-men-own-same-wealth-as-half-the-world/
11 Rothbard, Murray. 2008. "Freedom, Inequality, Primitivism, and the Division of Labor." *Mises Daily*. Mises Institute. 9 Aug, 2008. https://mises.org/library/freedom-inequality-primitivism-and-division-labor
12 Quoted in Campbell, Beatrix. 2014. "Neoliberal neopatriarchy: the case for gender revolution." 50.50 inclusive democracy. 6 January 2014. https://www.opendemocracy.net/5050/beatrix-campbell/neoliberal-neopatriarchy-case-for-gender-revolution
13 Ryken, Leland. "The Puritans and Money." A Puritan's Mind. http://www.apuritansmind.com/stewardship/rykenlelandpuritansandmoney/
14 Moore, David. 2017. "GOP tax cuts will strengthen our economy and drive Democrats nuts." Fox News. 13 December 2017.http://www.foxnews.com/opinion/2017/12/13/gop-tax-cuts-will-strengthen-our-economy-and-drive-democrats-crazy.html
15 This derived from the adaptation of agency theory by Michael Jensen, who was trained at Friedman's Chicago School of Economics.
16 Friedman, Milton. 1970. "The Social Responsibility of Business is to Increase its Profits." *New York Times*. 13 September 1970. http://www.nytimes.com/1970/09/13/archives/article-15-no-title.html
17 Ayn Rand. 1966. *Capitalism: The Unknown Ideal*. Signet.
18 Monbiot, George. 2012. "How Ayn Rand became the new right's version of Marx." *The Guardian*. 5 March 2012. https://www.theguardian.com/commentisfree/2012/mar/05/new-right-ayn-rand-marx
19 Mirowski, Philip. 2009. *The Road from Mont Pelerin*. Harvard University Press. June 2009. http://www.hup.harvard.edu/catalog.php?isbn=9780674033184
20 Lewis Powell. 1971. "Attack on American Free Enterprise System." *Reclaim Democracy*. 23 Aug 1971. http://reclaimdemocracy.org/powell_memo_lewis/

21 Lewis Powell. 1971. "Confidential Memorandum: Attack on the Free Enterprise System." August 23, 1971. quoted in Kim Phelps-Fein. 2009. *Invisible Hands: The Making of the Conservative Movement from the New Deal to Reagan*. (New York: Norton) p. 158. 160.
22 Sally Covington. "How Conservative Philanthropies and Think Tanks Transform US Policy." *Covert Action Quarterly*. http://mediafilter.org/CAQ/caq63/caq63thinktank.html
23 People for the American Way. 1995. "Buying a Movement." https://files.pfaw.org/pfaw_files/buyingamovement.pdf\
24 Jeffrey Toobin. 2017. The Conservative Pipeline to the Supreme Court. *The New Yorker*. 17 April 2017. https://www.newyorker.com/magazine/2017/04/17/the-conservative-pipeline-to-the-supreme-court
25 Tarnoff, Ben. 2016. "Donald Trump, Peter Thiel and the Death of Democracy." *The Guardian*. 21 July 2016. https://www.theguardian.com/technology/2016/jul/21/peter-thiel-republican-convention-speech
26 Monbiot, George. 2017. "Our democracy is broken, debased and distrusted, but there are ways to fix it." *The Guardian*. 25 January 2017. https://www.theguardian.com/commentisfree/2017/jan/25/democracy-broken-distrusted-trump-brexit-political-system
27 Fleming, Michael, Liu, Weiling. 1998. "Near Failure of Long-Term Capital Management." Federal Reserve Bank of New York. September 1998. https://www.federalreservehistory.org/essays/ltcm-near-failure
28 "Timeline: A chronology of Enron Corp." *New York Times*. 18 January 2006. http://www.nytimes.com/2006/01/18/business/worldbusiness/timeline-a-chronology-of-enron-corp.html
29 Romero, Simon, Atlas, Riva. 2002. "Worldcom's collapse: The Overview; Worldcom Files for Bankruptcy; Largest Case." *New York Times*. 22 July 2002. http://www.nytimes.com/2002/07/22/us/worldcom-s-collapse-the-overview-worldcom-files-for-bankruptcy-largest-us-case.html
30 Palley, Thomas I. 2007. "Financialization: What It Is and Why It Matters" The Levy Economics Institute and Economics for Democratic and Open Societies. December 2007. http://www.levyinstitute.org/pubs/wp_525.pdf
31 Jilani, Zaid. 2011. "CHART: Top 'U.S.' Corporations Outsourced More Than 2.4 Million American Jobs Over The Last Decade." Think Progress. 19 April 2011. https://archive.thinkprogress.org/chart-top-u-s-corporations-outsourced-more-than-2-4-million-american-jobs-over-the-last-decade-2ea66dfc0e35/
32 Glen Hendrix. 2020. "Economists Have Been Lying to Us for Decades. *Medium*. 25 August 2020. https://medium.com/age-of-awareness/economists-have-been-lying-to-us-for-decades-a08d8e67a5bd
33 Sean Wilentz. 2002. "A Scandal for our Time. *The American Prospect*. 31 January 2002. http://prospect.org/article/scandal-our-time
34 Pia Lee-Brago. 2011. "ILO: Recession, massive job loss threaten global economy." *The Philippine Star*. 2 November 2011. https://www.philstar.com/headlines/2011/11/02/743385/ilo-recession-massive-job-loss-threaten-global-economy
35 Robert L. Nadeau. 2009. "Brother, Can You Spare Me a Planet? Mainstream Economic Theory and the Environmental Crisis." SAPIENS Journal. 2.1 | 2009 : VOL.2 / N°1. https://journals.openedition.org/sapiens/806
36 Wilson, David Sloan. 2016. "The Tragedy of the Commons: How Elinor Ostrom Solved One of Life's Greatest Dilemmas." Evonomics. 29 October 2016. http://evonomics.com/tragedy-of-the-commons-elinor-ostrom/
37 Darwin, C. 1909. *The Descent of Man and Selection in Relation to Sex*. New York. Appleton and Company. page 50

38 Darwin, C. 1909. *The Descent of Man and Selection in Relation to Sex*. New York. Appleton and Company. Page 101.
39 McFarlane, Robert. 2016. "The Secrets of the Wood Wide Web." *The New Yorker*. 7 August 2016. http://www.newyorker.com/tech/elements/the-secrets-of-the-wood-wide-web
40 Lawrence, Paul. 2010. *Driven to Lead: Good, Bad, and Misguided Leadership*. Jossey-Bass.
41 Minard, Anne. 2006. "Early Humans Were Prey, Not Predators." National Geographic News. 7 March 2006. http://news.nationalgeographic.com/news/2006/03/0307_060307_human_prey.html
42 Huff, Chad. et al. 2009. "Mobile elements reveal small population size in the ancient ancestors of Homo Sapiens. 18 December 2009. Proceedings of the National Academy of Sciences. http://www.pnas.org/content/107/5/2147.full.pdf?sid=d523fbf4-43de-4dff-b8a4-66a59a1cd843
43 Despain, David. 2010. "Early Humans Used Brain Power, Innovation and Teamwork to Dominate the Planet." *Scientific American*. 27 February 2010. https://www.scientificamerican.com/article/humans-brain-power-origins/
44 Angier, Natalie. 2012. "Edward O. Wilson's New Take on Human Nature." *Smithsonian Magazine*. April 2012. http://www.smithsonianmag.com/science-nature/edward-o-wilsons-new-take-on-human-nature-160810520/
45 Wilson, Edward O. 2012. *On human nature*. Harvard University Press.
46 Penelope Spikens. 2015. How Compassion Made Us Human: The Evolutionary Origins of Tenderness, Trust and Morality. Pen and Sword Archaeology.
47 Chad D. Huff, et al. 2021. "Mobile elements reveal small population size in the ancient ancestors of Homo sapiens." PNAS. 19 January 2010. http://www.pnas.org/content/early/2010/01/06/0909000107%20
48 Wilson, Edward O. 2012. *The social conquest of earth*. WW Norton & Company.
49 Humanistic Management Network. http://www.humanetwork.org/
50 Peterson, Christopher. 2008. "What is Positive Psychology and What Is It Not. *Psychology Today*. 16 May 2008. https://www.psychologytoday.com/blog/the-good-life/200805/what-is-positive-psychology-and-what-is-it-not
51 Introductory video. Humanistic Management Network. http://www.humanetwork.org/
52 Seligman Martin. 2004. The New Era of Positive Psychology. TED talk. February 2004. https://www.ted.com/talks/martin_seligman_on_the_state_of_psychology
53 Benyus, Janine. 2016. Biomimicry Institute. http://ben.biomimicry.net/coolbio/2012/welcome-to-the-wood-wide-web/
54 OECD. 2016. Better Life Index. http://www.oecdbetterlifeindex.org/
55 Costanza, Robert, et al. 2014. "Development, time to Leave GDP Behind, *Nature*. 15 January 2014 http://www.nature.com/news/development-time-to-leave-gdp-behind-1.14499
56 New Economics Foundation collected surveys from around the world on what makes people happy. From this, it developed the Happy Planet Index (HPI), a combination of material sufficiency and expressed satisfaction with one's life. http://www.happyplanetindex.org/
57 Murray, Alan. 2017. "When Two Models of Capitalism Collide." *Fortune*. 21 February 2017. http://fortune.com/2017/02/21/kraft-heinz-unilever-culture-clash/
58 Walt, Vivienne. 2017. "Unilever CEO Paul Polman's Plan to Save the World" *Fortune*. 17 February 2017. http://fortune.com/2017/02/17/unilever-paul-polman-responsibility-growth/

59 "Planetary Emergency Plan." 2019, Club of Rome. Potsdam Institute. 23 September 2019. https://www.clubofrome.org/wp-content/uploads/2019/09/PlanetaryEmergencyPlan_CoR-4.pdf
60 William Rees. 2019. "Yes, the Climate Crisis May Wipe out Six Billion People." *The Tyee*. 18 September 2019. https://thetyee.ca/Analysis/2019/09/18/Climate-Crisis-Wipe-Out/
61 Richard Wilkinson. 2020. "How do we 'build back better' after coronavirus? Close the income gap." *The Guardian*. 26 August 2020. https://www.theguardian.com/commentisfree/2020/aug/26/build-back-better-coronavirus-income-gap-pandemic?CMP=Share_iOSApp_Other
62 IPBES Global Assessment on Biodiversity and Ecosystem Services. May 2019. https://www.ipbes.net/news/ipbes-global-assessment-summary-policymakers-pdf
63 Nafeez Ahmed. 2019. "The Collapse of Civilization May Have Already Begun." *Vice Magazine*. 22 November 2019. https://www.vice.com/en_us/article/8xwygg/the-collapse-of-civilization-may-have-already-begun
64 Smith, Kirk. 2014. "Human Health: Impacts, Adaptation, and Co-Benefits." Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap11_FINAL.pdf
65 Randall G. Holcombs. 2019. Inequality: Capitalism's Biggest Challenge. The Beacon. Independent Institute. 25 July 2019. https://blog.independent.org/2019/07/25/inequality-capitalisms-biggest-challenge/
66 "The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2". Coronaviridae Study Group of the International Committee on Taxonomy of Viruses. *Nature Microbiology*. 2 March 2020. https://www.nature.com/articles/s41564-020-0695-z
67 Hawken, Paul, Lovins, Amory, Lovins, Hunter. 1999. *Natural Capitalism: Creating the Next Industrial Revolution*. Chapter 13. Little Brown. http://www.naturalcapitalism.info/
68 Hazen, Don. 2017. "Google, Facebook, Amazon undermine democracy: They play a role in destroying privacy, producing inequality." Salon. 23 April 2017. https://www.salon.com/2017/04/23/google-facebook-amazon-undermine-democracy-they-play-a-role-in-destroying-privacy-producing-inequality_partner/
69 From personal correspondence with the author

10. Julia C. Kim

1 Poole, Robert. Earthrise: *How Man First Saw the Earth*. New Haven, Conneticut, : Yale University Press, 2008.
2 Kennedy, Robert F. John F. Kennedy Presidential Library and Museum. [Online] March 18, 1968. [Cited: April 26, 2020.] https://www.jfklibrary.org/learn/about-jfk/the-kennedy-family/robert-f-kennedy/robert-f-kennedy-speeches/remarks-at-the-university-of-kansas-march-18-1968.
3 Jackson, Tim. *Prosperity Without Growth: Foundations for the Economy of Tomorrow*. London : Routledge, 2017.
4 Stiglitz, Joseph, Sen, Amartya and Fitoussi, Jean-Paul. *Mismeasuring Our Lives: Why GDP Doesn't Measure Up*. s.l. : The New Press, 2010.
5 Meadows, Donella H., et al. *The Limits to Growth: A report for the Club of Rome's Project on the Predicament of Mankind*. New York : Universe Books, 1972.
6 Update to limits to growth: Comparing the World3 model with empirical data. Herrington, Gaya. 2020, *Journal of Industrial Ecology*.

7 Sachs, Jeffery. Introduction. [ed.] John Helliwell, Richard Layard and Jeffery Sachs. s.l. : Columbia Earth Institute, Columbia Earth Institute , 2012. *World Happiness Report*.
8 Ura, Karma, Alkire, Sabina and Zangmo, Tshoki. Case Study: Bhutan Gross National Happiness and the GNH Index. [ed.] John Helliwell, Jeffery Sachs and Richard Layard. s.l. : Columbia Earth Institute, 2012. *World Happiness Report*.
9 Reimann, Nicholas. *Forbes*. Leaving A Planet In Crisis: Here's Why Many Say The Billionaire Space Race Is A Terrible Idea. [Online] July 12, 2021. [Cited: Nov 29, 2021.] https://www.forbes.com/sites/nicholasreimann/2021/07/12/leaving-a-planet-in-crisis-heres-why-many-say-the-billionaire-space-race-is-a-terrible-idea/?sh=6da382ea77c9.
10 The Centre for Bhutan Studies and GNH Research. *A Short Guide to the Gross National Happiness Index*. Thimphu : s.n., 2012. p. 7.
11 University of Calcutta. Annual Convocation Address by His Majesty Jigme Khesar Namgyel Wangchuck, King of Bhutan. Calcutta : University of Calcutta, 2010.
12 Kim, Julia C., Richardson, Julie A. and Tenzin, Tsoki. Weaving Wellbeing into the Fabric of the Economy: Bhutan's Journey Towards Gross National Happiness. [book auth.] Elizabeth Rieger, Robert Costanza and Ida and Dugdale, Paul Kubiszewski. *Towards an Integrated Science of Wellbeing*. Oxford : Oxford University Press.
13 CBS. *A Compass Towards a Just and Harmonious Society: 2015 GNH Survey Report*. Thimphu : The Centre for Bhutan Studies and GNH Research, 2016. ISBN 978-99936-14-86-9.
14 World Bank. Bhutan Country Snapshot. Washington, DC : s.n., 2014.
15 UNDP Bhutan. *Bhutan National Human Development Report: Ten Years of Democracy in Bhutan*. s.l. : United Nations Development Programme Bhutan & Parliament of the Kingdom of Bhutan, 2019.
16 Climate Council. Bhutan is the World's Only Carbon Negative Country–So How Did They Do It? [Online] April 2, 2017. https://www.climatecouncil.org.au/bhutan-is-the-world-s-only-carbon-negative-country-so-how-did-they-do-it/.
17 Kim, Julia C. and MacKenzie, Amy. Beyond GDP, Beyond Numbers: Bhutan's Journey Towards Gross National Happiness. [book auth.] Anders Hayden, Céofride Gaudet and Jeffrey Wilson. *Towards Sustainable Wellbeing: Moving beyond GDP in Canada and the World*. Toronto : University of Toronto Press, in press.
18 Royal Government of Bhutan. *Defining a New Economic Paradigm: Report of the High Level Meeting on Wellbeing and Happiness*. UN Headquarters, New York : Royal Government of Bhutan, 2012.
19 Dorji, K. Why Bhutan? A GNH Perspective. *Kuensel*. December 29, 2012.
20 Dalziel, P, Saunders, C and Saunders, J. *Wellbeing Economics The Capabilities Approach to Prosperity*. s.l. : Cham Springer International Publishing, 2018.
21 Anielski, Mark. *The economics of happiness : Building genuine wealth*. Gabriola Island : New Society Publishers, 2015.
22 Raworth, Kate. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. London : Random House, 2017.
23 Happy Planet Index. The Happy Planet Index: A Global Index of Sustainable Wellbeing. [Online] February 2021. https://happyplanetindex.org.
24 OECD. *How's Life? 2020: Measuring Well-being*. Paris : OECD Publishing, 2020.
25 Wellbeing Economy Alliance. Wellbeing Economy Governments. [Online] [Cited: Feb 2, 2022.] https://wellbeingeconomy.org/wego.
26 *Advancing Well-being in an Inequitable World: Moving from Measurement to Action*. Summary of Insights from the Robert Wood Johnson Foundation;s Global Conference on Well-being. Robert Wood Johnson Foundation. Bellagio : Robert Wood Johnson Foundation, 2018.

27 *The Limits to Growth: The 30-Year Update*. Meadows, Donella, Randers, Jorgen and Meadows, Dennis. 2004.
28 Sachs, Jeffrey D. Prof Jeffrey Sachs Delivers the 2019 Hubert Curien Memorial Lecture, "Eudaimonia in the 21st Century: Looking to Aristotle for New Solutions". *The Cyprus Institute*. [Online] Feb 20, 2019. [Cited: Nov 28, 2021.] https://www.cyi.ac.cy/index.php/in-focus/prof-jeffrey-sachs-delivers-the-2019-hubert-curien-memorial-lecture-eudaimonia-in-the-21st-century-looking-to-aristotle-for-new-solutions.html.
29 Kasser, Tim. *The High Price of Materialism*. Cambridge : MIT Press, 2002.
30 Lerner, Adam. How Unequal Does It Feel? *The Understory*, Issue Eleven. [Online] Sept 26, 2020. [Cited: Feb 2, 2022.] https://theunderstory.substack.com/p/how-unequal-does-it-feel.
31 Putnam, Robert D. *Bowling Alone: The Collapse and Revival of American Community*. New York : Simon & Schuster, 2000.
32 Mull, Amanda. *The Atlantic*. Stop Shopping: America needs you to buy less junk. [Online] Oct 22, 2021. [Cited: Nov 29, 2021.] https://www.theatlantic.com/technology/archive/2021/10/stop-shopping-global-supply-chain-shipping-delays/620465/.
33 Meadows, D. "Leverage Points: Places to Intervene in a System." Hartland : Sustainability Institute, 1999. p. 18.
34 Nagler, J. We become what we think: the key role of mindsets in human development. *International Science Council*. [Online] February 8, 2020. https://council.science/current/blog/we-become-what-we-think-the-key-role-of-mindsets-in-human-development/.
35 Forum for the Future. *Moving Mountains: How Can Faith Shape Our Future*. London : Green Futures, 2011.
36 Capra, F. and Luisi, P. L. *The Systems View of Life: A Unifying Vision*. Cambridge : Cambridge University Press, 2014.
37 Scharmer, O. and Kaufer, K. *Leading from the Emerging Future: From Ego-System To Eco-System Economies*. San Francisco : Berrett-Koehler, 2013. pp. 18-19.
38 Shawoo, Z. and Thornton, T. F. The UN local communities and Indigenous peoples' platform: A traditional ecological knowledge-based evaluation. *WIRES Climate Change*. February 15, 2019.
39 The plasticity of well-being: A training-based framework for the cultivation of human flourishing. Dahl, Cortland J., Wilson-Mendenhall, Christine H. and Davidson, Richard J. 51, s.l. : National Academy of Sciences, 2020, *Proceedings of the National Academy of Sciences*, Vol. 117, pp. 32197-32206.
40 Center for Healthy Minds. University of Wisconsin–Madison. The Loka Initiative. [Online] [Cited: Feb 2, 2022.] https://centerhealthyminds.org/programs/loka-initiative.
41 Lipari, Lisbeth. *Listening, thinking, being: Toward an ethics of attunement*. University Park, Pennsylvania : The Pennsylvania State University Press., 2014.
42 Hayashi, Arawana and Scharmer, Otto. 2021. *Social presencing theater : The art of making a true move*. Cambridge. PI Press.
43 Moving from Transactional to Relational. Koenig, Oliver, et al. 2, 2021, *Journal of Awareness Based Systems Change*, Vol. 1, pp. 1-7.
44 Kumar, Satish and Cenkel, Pavel. *Transformative Learning: Reflections on 30 Years of Head, Heart, and Hands at Schumacher College*. London : New Society Publishers, 2021.
45 Capra, F. and Luisi, P. L. *The Systems View of Life: A Unifying Vision*. Cambridge : Cambridge University Press, 2014.
46 Relational Systems Thinking That's How Change is Going to Come, From Our Earth Mother. Goodchild, Melanie. 1, 2021, *Journal of Awareness Based Systems Change*, Vol. 1, pp. 75-103.

47 Bateson, Nora. Warm Data. [Online] Sept 19, 2018. [Cited: Feb 1, 2022.] https://batesoninstitute.org/announcement/warm-data/.
48 Richardson, J. A. *Forming Economies of Wellbeing*. Plymouth : Unpublished manuscript, 2021.
49 Journal of Awareness-Based Systems Change: The Birth of a Journal. Koenig, O., et al. 2021, *Journal of Awareness-Based Systems Change*.
50 Scolaro, Nathan. Service Space. Paying it forward: Interview with Nipun Mehta. [Online] Sept 2, 2019. http://nipun.servicespace.org/blog.php?src=cf&id=28450.
51 Connecting Inner and Outer Well-Being in Social Innovation Education. Chima, Aneel and Germano, David. s.l. : Stanford University, Nov 18, 2020, *Stanford Social Innovation Review*.
52 UNDP. Transforming Systems in the Decade of Action: Global Dialogue Series. *SparkBlue*. [Online] Jan 21, 2021. https://www.sparkblue.org/transformation-dialogue-1.
53 Inner Development Goals. The Inner Development Goals: Transformational Skills for Sustainable Development. [Online] [Cited: Feb 2, 2022.] https://www.innerdevelopmentgoals.org.
54 Connecting Individual and Societal Change. Grdina, Linda Bell, Johnson, Nora and Pereira, Aaron. s.l. : Stanford University, Mar 11, 2020, *Stanford Social Innovation Review*.
55 Kaufer, Katrin and Steponaitis, Lillian. *Just Money: Mission-Driven Banks and the Future of Finance*. Cambridge : MIT Press, 2021.
56 The Club of Rome. Rethinking Finance Impact Hub. [Online] [Cited: Feb 2, 2022.] https://www.clubofrome.org/impact-hubs/rethinking-finance/.
57 Akenji, Lewis, et al. 1.5-Degree Lifestyles: Towards A Fair Consumption Space for All. Berlin : *Hot or Cool Institute*, 2021.
58 Sen, Amartya. *The Human Develpment Report*. New York : UNDP, 2013.
59 Weber, A. *Enlivenment: Toward A Poetics For The Anthropocene*. London : MIT Press, 2019.

11. Sirkka Heinonen

1 Heinonen, Sirkka and Karjalainen, Joni. 2019. *Electrification in Peer-to-Peer Society – New Narrative for Sustainable Futures*. FFRC eBook 1/2019. http://urn.fi/URN:ISBN:978-952-249-537-2, print books from: https://utushop.utu.fi/p/2986-electrification-in-peer-to-peer-society-a-new-narrative-for-sustainable-futures/
2 Glenn, Jerome. 2021. Artificial Augmented Learning and some related issues. Third International Scientific Conference "Philosophy Nowadays: Traditions, Innovations, Education", organised by the Bulgarian Academy of Sciences, Institute of Philosophy and Sociology. 10th Sept 2021 Panel "Where Does the Digital Transformation of Education Lead to?"
3 Glenn, Jerome and the Millennium Project Team. 2019. Work/technology 2050 – scenarios and actions, The Millennium Project. Washington D.C. http://www.millennium-project.org/projects/workshops-on-future-of-worktechnology-2050-scenarios/
4 Kuusi, Osmo & Heinonen, Sirkka. 2022. Scenarios from artificial narrow intelligence (ANI) to artificial general intelligence (AGI) – Reviewing the results of the International Work/Technology 2050 study (under review, submitted to *World Futures Review*).
5 Glenn, Jerome and the Millennium Project Team. 2019. Work/technology 2050 – scenarios and actions, The Millennium Project.

Washington D.C. http://www.millennium-project.org/projects/workshops-on-future-of-worktechnology-2050-scenarios/
6 Farrow, Elissa. 2021. "Extending the Participant's Voice to Guide Artificial Intelligence Transformation Using Futures Methodology and Layered User Story Analysis." *World Futures Review* 13 (3-4): 214–36. doi:10.1177/19467567211030377.
7 Our Common Agenda. 2021. A Report of the Secretary-General. United Nations. https://www.un.org/en/content/common-agenda-report/
8 Bennis, Warren, and Burt Nanus. 1985. *Leaders: Strategies for Taking Charge*. Harper Business.
9 Kaivo-oja, Jari, and Lauraeus, Theresa. 2018. "The VUCA approach as a solution concept to corporate foresight challenges and global technological disruption." *Foresight* 20 (1): 27–49. doi:10.1108/FS-06-2017-0022.
10 Beck, Ulrich. 1992. *Risk Society: Towards a New Modernity*. London: Sage.
11 van Oldenborgh GJ, van der Wiel K, Kew S, Philip S, Otto F, et al. 2021. Pathways and pitfalls in extreme event attribution. *Climatic Change*. 166(1–2): 13
12 Karjalainen, Joni & Heinonen, Sirkka. 2022. Anticipatory hybrid governance for energy transition and futures resilience (under review, submitted to *Futures*).
13 Moynihan, Thomas. 2020. Existential risk and human extinction: An intellectual history. *Futures*, 116, 102495.
14 Heinonen, Sirkka. 2021. Continuous Learning Propelled by Multidimensional Creation of Futures Knowledge. https://ffrc.wordpress.com/2021/10/06/continuous-learning/
15 Sardar, Ziauddin. 2010. Welcome to Postnormal times. *Futures* 42 (5) 435–444.
16 Montuori, A. 2011. Beyond postnormal times: The future of creativity and the creativity of the future. *Futures*, 43, 221–227.
17 Rifkin, Jeremy. 1998. *The Biotech Century. Harnessing the Gene and Remaking the World*. New York
18 Beresford-Kroeger, Diana. 2019. *To Speak for the Trees. My Life's Journey from Ancient Celtic Wisdom to a Healing Vision of the Fores*t. Random House Canada.
19 Heinonen, Sirkka. 2020. Bioeconomy as Proponent of Digital Meanings Society. In: *Bio#Futures-Foreseeing and Exploring the Bioeconomy*, edited by Emmanuel Koukios and Anna Sacio-Szymanska. Springer. https://link.springer.com/book/10.1007/978-3-030-64969-2
20 Pouru, Laura, Wilenius, Markku, Holstius, Karin & Heinonen, Sirkka. 2018. Collection of poems written by Pentti Malaska. In: P*entti Malaska. A Visionary and Forerunner*. Futures Series 9. The Finnish Society for Futures Studies, Helsinki, p. 215. http://www.tutuseura.fi/wp-content/uploads/2018/04/Futures-Series_9_Pentti-Malaska.pdf
21 Bardi, Ugo. 2017. *The Seneca Effect. Why Growth is Slow, but Collapse is Rapid*. Springer.
22 Malaska, Pentti. 2010. A more innovative direction has been ignored. In Grönroos, Riitta (ed.) *Understanding Neo-Growth: An Invitation to Sustainable Productivity*. TeliaSonera Finland Plc, p. 200–210. http://www.sonera.fi/media/13069ab55806de22e8955bc2a3f1afeab17b28bd/Understanding_Neogrowth.pdf
23 Heinonen, Sirkka. 2013. Neo-Growth in Future Post-Carbon Cities. *Journal of Futures Studies*, 18(1): 13–40. Tamkwang University.
24 Botkin, Daniel B. 1990. *Discordant Harmonies. A New Ecology for the Twenty-First Century*. New York. 241 p.
25 Martin, James. 2007. *The Meaning of the 21st Century. A vital blueprint for ensuring our future*. London.
26 Heinonen, Sirkka. 2000. *Prometheus Revisited – Human Interaction with Nature through Technology in Seneca*. Doctoral dissertation. Helsinki University. Commentationes

Humanarum Litterarum Vol. 115, the *Finnish Society of Sciences and Letters*, Helsinki 2000, 232 p.
27 Heinonen, Sirkka. 2017. Pioneer analysis and international cultural changes. Application of positrend and negatrend analysis in the identification of cultural change. In: Heinonen, S., Kuusi, O & Salminen, H. (eds): *How do we explore futures?* ACTA FUTURA FENNICA nro 10, Helsinki, p. 241-251.

12. Yury Sayamov

1 *No Limits to Learning. Bridging the Human Gap*. 1979. Report to the Club of Rome. Oxford, Pergamon Press. 159 p. ISBN 0-08-024705-9. https://clubofrome.org/publications/no-limits-to-learning-1979/ Date of request 09.07.2021.
2 Guterres A. 2020. Remarks to the General Assembly on the Secretary General's priorities for 2020. https://www.un.org/sg/en/content/sg/speechts/2020-01-22/remarks-general- assembly-priorities-for-2020. Date of request 18.07.2021.
3 TVC 22.09.2020: The UN Secretary General warned about the coming Apocalypse due to pandemic Covid-19. https://www.tvc.ru/news/show/id/193101/ Date of request 30.06.2021
4 United Nations General Assembly. 21 October 2015. Resolution Transforming our world: the 2030 Agenda for Sustainable Development A/RES/70/1 A/RES/70/1 Transforming our world: the 2030 Agenda for Sustainable Development (un.org) https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalimpact/A_RES_70_1_E pdf / Date of request 02.08.2021
5 TASS, 18 July 2020. https://tass.ru/obschestvo/8999053 Date of request 17.06.2021
6 Lenta RU. 18 July 2020. https://lenta.ru/news/2020/07/18/bogatstvo/ Date of request 17.06.2021
7 Kefeli I. Asphatronics. 2020. *On the way to the global security theory*. St. Petersburg.

13. Sandrine Dixson-Decleve

1 ICRC, "No one is safe until everyone is safe -why we need a global response to COVID-19" 24 May 2021, available: https://www.icrc.org/en/document/no-one-safe-until-everyone-safe-why-we-need-global-response-covid-19.
2 Sandrine Dixson-Declève and Aileen McLeod, "Europe's 21st Century Insurance Plan for Recovery & Renewal" *The Solutions Journal*, 28 February 2021, available: https://thesolutionsjournal.com/2021/02/28/europes-21st-century-insurance-plan-for-recovery-renewal/
3 ESIR, "Transformation post-COVID: Mobilising Innovation for People, Planet and Prosperity" ESIR Policy Brief No. 2, March 2021.
4 Editor, "Economist Dennis Snower Says Economics Nears a New Paradigm" *Evonomics*, 28 December 2020, available: https://evonomics.com/why-behavioral-economics-cant-fix-a-broken-discipline/.
5 IRP embodies material data 2021
6 https://www.gov.scot/groups/wellbeing-economy-governments-wego/
7 https://www.clubofrome.org/publication/a-system-change-compass-implementing-the-european-green-deal-in-a-time-of-recovery/

14. Mamphela Ramphele

1 Peccei, A., and I. Daisaku. 1984. *Before it is Too Late*. NY: Kodansha International.
2 https://www.clubofrome.org/publications/towards-new-narratives-of-hope-for-fostering-transformative-african-futures/; https://www.clubofrome.org/blog-post/rebalancing-the-books-beyond-the-debt-cancellation-paradigm/

3 Meadows. 1982. "Whole Earth Models and Systems". *The CoEvolution Quarterly*, Summer, pp 98–108
4 Preisser, R., Swilling, M., et al. 2020. *New Narratives of Hope*.
5 James, G. M. 2020. *Stolen Legacy*. eBook.
6 Gorissen, L. 2020. *Building Innovation on Millions of Years of Nature's Intelligence*, Studio Transitio. eBook.
7 Bendell, J. 2020. Deep Adaptation: A Map for Navigating Climate Tragedy, an occasional paper quoted in Krznaric, R., *The Good Ancestor*, Penguin.
8 Lent, J. 2021. *The Web of Meaning*. Prospect Books.

15. Petra Kuenkel

1 Meadows, D., Meadows, D., Randers, J., & Behrens, W. 1972. *The Limits to Growth: A report for the Club of Rome's project on the predicament of mankind*. London: Earth Island Limited.
2 Meadows, D., Randers, J. & Meadows. D. 2004. *Limits to growth: the 30-year update*. White River Junction, Vermont, USA: Chelsea Green.
3 Lovelock, J. 1995. *The ages of Gaia: A biography of our living earth*. New York, USA: Oxford University Press.
4 Gimbutas, M. 1974. *The Gods and Goddesses of Old Europe, 7000 to 3500 BC: Myths, Legends and Cult Images*. Thames and Hudson, London 1974.
5 Alexander C. 2002a. *The nature of order. An essay on the art of building and the nature of the universe: Book I – The Phenomenon of Life*, Berkeley, CA: The Center for Environmental Structure.
6 Alexander C. 2002b. *The nature of order. An essay on the art of building and the nature of the universe: Book II – The Process of Creating Life*, Berkeley, CA: The Center for Environmental Structure.
7 Preiser, R.; Swilling, M., Nnoli-Edozien, N., Ramphele, M. 2020. Towards New Narratives of Hope for Fostering Transformative African Futures. Publication by the African Chapter of the Club of Rome. Retrieved from https://www.clubofrome.org/wp-content/uploads/2021/01/COR-ENCI_NewNarratives_Dec2020_A4-v1-1.pdf 7th May 2021.
8 Daly, M. 1978. *Gyn/Ecology. The metaethics of radical feminism*. Boston: Beacon Press.
9 Weber, A. 2016. *Biology of wonder: Aliveness, feeling and the metamorphosis of science*. Gabriola Island: New Society Publishers.
10 Macy, J. & Brown, Y. M. 2014. *Coming back to Life*. Gabriola Island: New Society Publishers.
11 Meadows, D. 1999. "Leverage points: Places to intervene into a system." VT, USA: Sustainability Institute.
12 Otto, I.M., Donges, J.M., Cremades, R., Bhowmik, A., Hewitt, R.J., Lucht, W., Rockström, J. Allerberger, F., McCaffrey, M., Doe, S.S.P., Lenferna, A., Morán, N., van Vuuren, D.P., Schellnhuber, H.J. 2020. Social tipping dynamics for stabilizing Earth's climate by 2050. *Proceedings of the National Academy of Sciences*, 117(5). 2354-2365. https://doi.org/10.1073/pnas.1900577117
13 Kuenkel, P. 2019. *Stewarding Sustainability Transformations – An Emerging Theory and Practice*. Report to the Club of Rome. New York: Springer Nature.
14 Kuenkel, P., Waddock, S. 2019. Stewarding Aliveness in a Troubled Earth System. *Cadmus*, 4(1), 14-38. http://cadmusjournal.org/article/volume-4/issue-1/stewarding-aliveness-troubled-earth-system
15 Sahtouris, E. and Lovelock, J.E. 2000. *Earthdance: Living systems in evolution*, San Jose, CA: iUniverse.
16 https://www.printfriendly.com/p/g/t44DEr

17 Mies,M. & Shiva, V. 1993. *Ecofeminism*. ZedBooks
18 Shiva, V. 2015. *Earth Democracy. Justice, Sustainability, Peace*. Berkeley: North Atlantic Books.
19 Griffin, S. 2016. *Women and Nature. The roaring inside her*. Counterpoint Press.
20 Kelly, Marjorie. 2012. *Owning Our Future: The Emerging Ownership Revolution*. Berrett-Koehler Publishers.
21 Raworth K. 2018. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Random House Business Books, London, UK.
22 Trebeck K. and Williams J. 2019. *The Economics of Arrival. Ideas for a Grown Up Economy*. Policy Press, Bristol, UK.
23 Lovins H. L., Wallis S., Wijkman A. & Fullerton J. 2018. *A Finer Future. Creating an economy in service to life*. New Society Publishers. Gabriola Island, British Colombia, Canada.
24 Mazzucato M. 2021. *Mission Economy: A moonshot guide to changing capitalism*. Allen Lane.
25 Zettel, C. 2017. Gott würfelt nicht. Mystik und Wissenschaft. Wien: Ibera-Verlag.
26 Macy, J. 1991. *World as lover, world as self*. Berkeley, California: Parallax Press.
27 Kuenkel, P., Kuehn, E., Stucker, D., Williamson, D.F. 2020. *Leading transformative change collectively: A practitioner's guide to realizing the SDGs*. Routledge.
28 Rockström, J., W. Steffen, K. Noone, Å., Persson, F. S., Chapin, III, Lambin, E. & Foley. J. 2009. Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society* 14(2): 32.
29 Andersen, Lene Rachel. 2019. *Metamodernity: Meaning and Hope in a Complex World*, Nordic Bildung.

17. Yi-Heng Cheng

1 Bio passed away unfortunately in 2019.
2 TimeWaver Pro is a machine with Software containing different Modules and descriptive data bank, distributed by TimeWaver Home GmbH, Schloss Kraenzlin, Darritzer Strasse 6, 16816 Kraenzlin, Germany; Energy Point is one of the modules with an open data bank, which users can add in by themselves. https://timewaver.com/en/

18. Gaya Herrington

1 Lomborg, B., and O. Rubin. 2009. "The dustbin of history: Limits to Growth." *Foreign Policy* 103:34–48. Retrieved from http://foreignpolicy.com/2009/11/09/the-dustbin-of-history-limits-togrowth
2 Herrington, G. 2021. "Update to limits to growth: Comparing the world3 model with empirical data." *Journal of Industrial Ecology* 25 (3): 614–26. doi:10.1111/jiec.13084.
3 Turner, G. 2014. Is global collapse imminent? Melbourne Sustainable Society Institute, The University of Melbourne. Retrieved from http://sustainable.unimelb.edu.au/sites/default/files/docs/MSSI-ResearchPaper-4_Turner_2014.pdf
4 Meadows, D. H., D. L. Meadows, and J. Randers. 2004. *The limits to growth: The 30-year update*. White River Junction, VT: Chelsea Green Publishing Co.
5 Intergovernmental Panel on Climate Change (IPCC). 2021. *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved from https://www.ipcc.ch/report/ar6/wg1/
6 Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, et.al. 2015. Planetary boundaries: Guiding human development on a changing planet. *Science* 347: 736, 1259855. DOI: 10.1126/science.1259855

7 Global Footprint Network. 2021. *Ecological Footprint*. Retrieved from https://www.footprintnetwork.org/our-work/ecological-footprint/
8 Morales-McDevitt, M. E., J. Becanova, A. Blum, T. A. Bruton, S. Vojta, M. Woodward, and R. Lohmann. 2021. "The air that we breathe: Neutral and volatile PFAS in indoor air." *Environmental Science & Technology Letters* 8 (10): 897–902. doi:10.1021/acs.estlett.1c00481.
9 Trasande, L. 2019. *Sicker, Fatter, Poorer: The Urgent Threat of Hormone-Disrupting Chemicals to Our Health and Future . . . and What We Can Do About It*. Boston, MA: Mariner Books.
10 Wright, Stephanie L, and Frank J Kelly. 20 June, 2017a. "Plastic and human health: A micro issue?" *Environmental Science & Technology* 51 (12): 6634–47. doi:10.1021/acs.est.7b00423. PMID:28531345.
11 Vargish, T. 1980. "Why the person sitting next to you hates limits to growth." *Technological Forecasting and Social Change* 16 (3): 179–89. doi:10.1016/0040-1625(80)90030-X.

20. Nora Bateson

1 Bateson, G. (2000). *Steps to an ecology of mind*. University of Chicago Press.
2 Blake, W. (2000). *The selected poems of William Blake*. Wordsworth Editions.
3 Bateson, G. (2002). *Mind and nature: A necessary unity*. Hampton Press, Inc.

21. Carlos Alvarez Pereira

1 Guterres A. 2017. Remarks during the Opening Ceremony of the Web Summit, Lisbon, 6 November 2017. https://www.youtube.com/watch?v=WiE17YsV1Bw
2 Guterres A. 2020. Address on "The State of the Planet" at Columbia University, New York, 2 December 2020. https://www.un.org/sg/en/content/sg/speeches/2020-12-02/address-columbia-university-the-state-of-the-planet
3 Brundtland, G. H., and P. Ehrlich, et al. 2012. E*nvironment and Development Challenges: The Imperative to Act*. University of Tokio Press.
4 Meadows, D. H. 2002. "Dancing with Systems." *Systems Thinker* 13
5 Valero, A. N., and A. Valero. 2015. *Thanatia. The Destiny of the Earth's Mineral Resources*. World Scientific.
6 Mineo L. 2017. "Good genes are nice, but joy is better". The Harvard Gazette, April 11, 207. On "Harvard Study of Adult Development": https://www.adultdevelopmentstudy.org/
7 Pistor K. 2019. *The Code of Capital. How the Law Creates Law and Inequality*. Princeton University Press.
8 Piketty T. 2013. "Le Capital au XXIe siècle". Éditions du Seuil.
9 Mostert M. 2021. "Value, values and valuations: Beyond the African debt cancellation paradigm. A recalculated global debt exchange". Discussion paper for the Club of Rome. Institute for Futures Research.
10 Amaro S. 2021. "Blackrock's former sustainable investing chief now thinks ESG is a 'dangerous placebo'". Sustainable Future, 24 August 2021.
11 Peccei A., Ikeda D. 1984. *Before It Is Too Late. A Dialogue*. I.B. Tauris for edition 2009.

More books from Exapt Press

Go to https://exapt.press to find more books on seeing the world differently.

Exapt Press specialises in complexity and systems thinking books. Books that see the world as a whole and bring a different viewpoint or new analysis to old problems and situation.

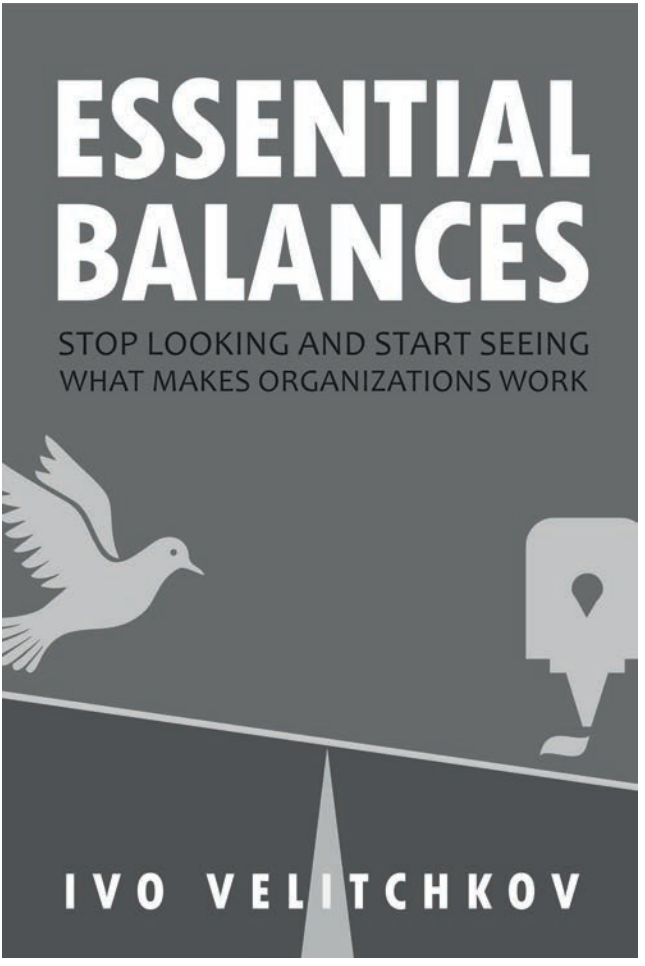
Sign up to our newsletter to receive regular book announcements, news, and book reviews.

Follow us on Twitter: @ExaptPress and @Rob_Worth (Editor-in-Chief).

https://exapt.press

Do you really understand your organization?

You won't until you understand
the Essential Balances.



Find out more about *Essential Balances* at
https://exapt.press/essential-balances