Risk, Responsibility, and Resilience

New Strategies in the Labyrinths of Uncertainty

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Highlights of the Third European Blue Sky Conference Proceedings

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Introduction

This volume is a compilation of some of the keynote speeches and lectures that were delivered at the Third European Blue Sky Conference, held in Budapest between 23-25 November 2018. The conference, entitled *Risk, Responsibility and Resilience: New Strategies in the Labyrinths of Uncertainty,* was part of a series that the Institute of Advanced Studies Kőszeg organizes biannually, in association with the Hungarian Academy of Sciences and the UNESCO Chair in Cultural Heritage Management and Sustainability. Started by the late Elemér Hankiss, and previously attended by such world-renowned scholars as Zygmunt Bauman, Benjamin Barber, Richard Falk and Tamás Szentes, the purpose was to debate the regional and local impacts of today's global and interconnected social, political, technological and cultural transformations. The basic premise is that the world is in a precarious state of deep crisis marked by several interdependent processes, whose complex functioning and possible outcomes are difficult to fully understand and explain. The traditional methods of disciplinary scientific inquiry provide us with limited and insufficient and conceptual tools. New methods, new ways of knowing and learning need to be developed that are socially relevant, responsible and problem-centered. Knowledge for its own sake is not enough, we need rather strong, courageous and open-minded visions and imaginations, i.e. a kind of future-oriented and socially-responsible blue-sky thinking, in order to navigate the changes on the level of communal existence.

Like earlier events, the organizers of the 2018 conference wanted to provide an open and safe platform for academics and activists, thinkers and practitioners, from a variety of disciplines, generations, cultural backgrounds and expertise, to discuss the complex nature of social, political and economic processes. This can lead to the formulation of alternatives, imagining new scenarios for a 'sustainable future' (see Chabay in this volume). The themes of the conference and the excellence of the individual contributions are reflected in the essays that follow: Norbert Kroó and Thomas Filk speak to the change in scientific paradigms and the necessity of transdisciplinary approaches and methodologies. Sean Cleary addresses possibilities for new governance and the need to create institutions that are fit for purpose. Ahmet Evin and Etelka Bogárdi ponder burning issues such as the rebirth of democracy and the metamorphosis of the state in a changing global economy. Daniel R. Brooks and András Gelencsér discuss the social repercussions of climate change and humanity's responsibility to cooperate in tackling the problems it causes. László Csernai approaches sustainable development through the lens of energy efficiency, its production consumption and entropy. With a discussion on the topic of vulnerable women and children, Mária Herczog addresses the larger issue of human security in today's migration flows and raises awareness to the inefficiency of supra-national or national institutions in meeting the challenges. Finally, the necessity of finding new cohesive narratives and collective identities through creative thinking and cooperative learning is emphasized by Ilan Chabay. While these essays cover large topics, time and again they address the responsibility that the state, the citizens, the power elites, the global intelligentsia and corporate capital have in tackling global risks in order to build resilient communities and sustainable societies. Although the lively discussions that followed these contributions cannot be adequately represented here, iASK is honored to release this selection of timely essays on hot issues with the conviction that together they will serve as grounds for further thought and debate on the complexities of global transformations.

Izabella Agardi

About the Authors

János Bogardi was an Assistant Professor at the Institute for Water Resources Management of the Technical University of Budapest, and later part of the scientific staff at the Federal Institute for Hydraulic Engineering at the University of Karlsruhe. His trajectory took him to UNESCO in Paris, as Senior Programme Specialist and then Chief of the Section on Sustainable Water Resources and Management. He was appointed Director of the United Nations Institute for Environment and Human Security (UNU-EHS) in Bonn,and became Vice-Rector at the United Nations University in Europe. He has authored, co-authored, and edited more than 170 publications including books, journal papers, research reports, lecture notes, as well as numerous articles for the media.

Sean Cleary is the chairman of Strategic Concepts (Pty) Ltd., Managing Director of the Centre for Advanced Governance, Founder and Executive Vice Chair of the FutureWorld Foundation and Chairman of Atlantic Holdings (Pty) Ltd. He studied social sciences and law at the University of South Africa, the University of Cape Town and Pahlavi University in Iran and holds an MBA from Henley Management College at Brunel University in the UK. He served in the South African Navy before beginning a diplomatic career in the Middle East, the US and Namibia. As Chief Director in Namibia in the mid-1980s, he initiated negotiations between all political parties for the release of political prisoners and the adoption of a Bill of Rights paving the way for independence. He lectures internationally on global corporate strategy, conflict resolution, and the challenges of globalization and development economics. He is the co-author, with Thierry Malleret, of two books on risk: *Resilience to Risk* (Human and Rousseau, 2006), and *Global Risks* (Palgrave Macmillan, 2007).

László P. Csernai is a theoretical physicist. He is a professor at the University of Bergen, and an external member of the Hungarian Academy of Sciences, as well as the Norwegian Academy of Sciences and the Academia Europaea. In the 1970s he took part in designing the Paks Nuclear Power Station. He worked with the Central Research Institute of Physics in Budapest, and at the universities in Frankfurt, Munich, Minnesota, and Michigan and at the nuclear research institutes in Dresden and Los Alamos. He is a member of the Energy Steering Panel of the European Academies Science Advisory Council (EASAC) and of the Energy Group of the European Physical Society (EPS). He is an adjunct professor at the Frankfurt Institute of Advanced Studies and the Wuhan University of Technology.

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Norbert Kroó was Vice President at the Hungarian Academy of Sciences, and member of the iASK International Advisory Board. His fields of interest are material sciences, optics, neutron physics, and science policy. He has published over 250 scientific papers and 7 books. He has 40 patents and numerous technical reports and serves on the editorial board of 4 scientific journals. He was President of the European Physics Society and the Hungarian Physical Society. He has served on many international, European and Hungarian committees and science advisory boards, including the Executive Committee of EPS, Freedom of Science Committee of ICSU, Physics Action Council of UNESCO, and Governing Council of ESF. He serves as scientific advisor to the EU and several EU countries (Germany, Finland, Ireland).

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Daniel Brooks is and Emeritus Professor at the University of Toronto, and a senior research fellow at iASK. He is a Fellow of the Royal Society of Canada and of the Linnaean Society of London. He has been awarded honorary doctorates from Stockholm University and the University of Nebraska and was a senior visiting fellow at the Collegium Budapest and Stellenbosch Institute of Advanced Study. He is an evolutionary biologist whose work ranges from field studies of the evolution of host-pathogen systems in tropical wildlands to foundational studies of evolutionary theory. His current focus is integrating evolutionary principles into understanding emerging disease and using those insights to develop proactive measures for coping with the emerging disease crisis. He is the author of more than 350 scientific publications, including half a dozen books. His forthcoming book from University of Chicago Press is *A Perfect Storm: Climate Change, Biodiversity and Emerging Disease*.

Ervin László is the founder and president of The Club of Budapest, the director and co-founder of the Ervin Laszlo Institute for Advanced Study (ELIAS), the Laszlo New-Paradigm Leadership Center (Italy), Chancellor of the Giordano Bruno New-Paradigm University, and editor of *World Futures: The Journal of New Paradigm Research*. He is recognized as the founder of systems philosophy and general evolution theory. His work in recent years has centered on the formulation and development of the "Akasha Paradigm," a new conception of the cosmos, life and conscious-

ness emerging at the forefront of the contemporary sciences. He is recipient of the highest degree in philosophy and human sciences from the Sorbonne, the University of Paris, as well as of the coveted Artist Diploma of the Liszt Ferenc Academy of Budapest. His appointments have included research grants and professorships at prominent American, European and Asian universities. His career also included guest professorships at various universities in Europe and the Far East. He is an advisor to the UNESCO Director General, ambassador of the International Delphic Council, member of the International Academy of Science, World Academy of Arts and Science, and the International Academy of Philosophy. He was twice nominated for the Nobel Peace Prize and received the Goi Peace Prize. He has authored more than 70 books, which have been translated into twenty languages, and has published more than 400articles and research papers, including six volumes of piano recordings.

Ahmet Evin was the founding dean of the Faculty of Arts and Social Sciences at Sabanci University in Istanbul. At Columbia University, he was named William Mitchell Fellow where he received his PhD in Middle East Studies and Cultural History. He is director of education at the Aga Khan Trust for Culture and coordinated the Aga Khan Program at Harvard University and MIT. He initiated, with European Commission support, a policy dialogue on the EU's eastward expansion, its Mediterranean policy, and the customs union agreement with Turkey. He established, with the EUI Schuman Center, the EU-Turkish Observatory, and programs and policy research with academic institutions and NGOs. He is the founding member of Turkish Economy and Social Studies Foundation and the Middle East Studies Association of North America.

Etelka Bogárdi is a financial services regulatory lawyer and Senior Counsel at the Hong Kong Monetary Authority, a member of the FinTech working group of the Asia Securities Industry & Financial Markets Association (ASIFMA). She advises international financial institutions, investment funds, intermediaries and insurance companies on compliance with regulatory laws, with financial services legislation, implementation, licensing and authorization issues, banking and intermediaries' supervision and conduct matters, and cross-border regulatory issues, as well as legal issues relating to the development of the financial infrastructure of Hong Kong. She currently sits on the FinTech working group of the Asia Securities Industry & Financial Markets Association (ASIFMA) and provides frequent commentary to the press on regulatory issues.

Mária Herczog does research and is a university lecturer lectures on children's rights at ELTE. She is President of Eurochild, and a member of UNCRC, UNICEF, and National Focal Point of WHO. She was trained as a sociologist whose main areas of research are child welfare and child protection with special focus on children deprived of family care, infanticide, child abuse and neglect, children's rights. She is a reader at Karoly Eszterhazy College. She was one of the authors of the first shadow report submitted to the Committee on the Rights of the Child in 2004. She has worked as an expert for the Council of Europe, UNICEF, and participated in many EU-funded projects. She was elected a member of the UNCRC.

Ilan Chabay studied chemical physics and biophysical chemistry and is the Head of Strategic Science Initiatives and Programs and the Knowledge, Learning, and Societal Change Research Alliance at IASS. He is an Adjunct Professor in the School of Sustainability of Arizona State University (ASU). Over the past decade, his focus has been on understanding and facilitating processes of societal change toward just and equitable sustainable futures, including understanding scientific, local, and cultural knowledge systems for decisionmaking on common resources

through affective narratives. He has co-led inter- and transdisciplinary research on decision making for ecological, social, and economic transformations in the Eurasian Arctic. He was elected an Honorary Member of the Swiss Academy of Humanities and Social Sciences, and appointed Hasselblad Professor in Sociology and Applied IT in Gothenburg and Chalmers Universities, Sweden. He founded the New Curiosity Shop, a workshop in Silicon Valley, where he led design and production of interactive learning exhibitions for more than 230 museums, science centres, and corporations worldwide, including Disney and NASA. He was Associate Director of the Exploratorium Science Museum in San Francisco, and consulting Professor of Chemistry at Stanford University.

I. The Challenges for Science

Science and Technologies (Rewards and Risks)

Norbert Kroó

Economists usually say that the strength of the economy is based on these resources: labor, material, energy, capital, and knowledge. From these five, knowledge is gaining in importance, and within this category scientific knowledge as well. Of course, we have to introduce newer approaches and put together our efforts in multidisciplinary activities. Working in groups and not alone, we have to find new priorities. You may remember that a few decades ago each country was very careful regarding its science, and the reason for this was that science was believed to be the basis of national security.

After the political changes in the late 80s and early 90s, this has become less important. It was more important to create jobs and to be more competitive and this of course changed the priorities also. One more thing, technologies are developed and after a while they die out. One of the most important technology groups is now semiconductors. Transistor chips are found in everything we use. We already know of course the limits, and a technology dies out in order for new technologies to be developed further. These new technologies have to be based on new ideas, and these new ideas again come mainly from research.

There is another trend. It is partly connected to saving materials, so things are getting miniaturized. "Miniaturized" means modern smaller scales, and this introduces again new technologies. The key technologies of the future, in my understanding, are coming from this field. They mainly come from nanotechnologies that will be the key technologies in a few decades in any field whether the economy drives them or not. Biotechnology, information technologies and materials technologies will also be of basic significance of course, but in addition to that, the quantum technologies are going to enter into the group of basic forces driving the future economic development. The next figure is the illustration of these statements.

We experience every day that things are getting complicated and therefore cooperation is a must. Even the biggest countries are now not big enough to realize all the ideas that are on the table. In addition, there is what I call the "time paradox". We need more and more knowledge to get around in life, and of course this means, that more time is needed to acquire it. At the same time, knowledge becomes obsolete faster and faster, and therefore time is one of the most important factors in our life. Change is continuous and I return to Heracleitos who said: "change is the only reality. Nothing exists, and nothing existed, everything happens". Let us look at what is going to happen in the future.

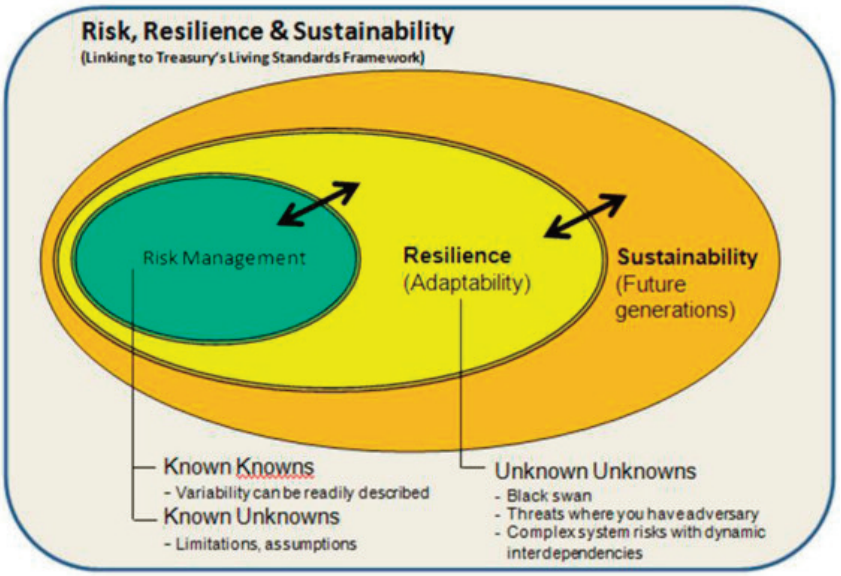
Here is one example: compare the transistor from fifty years ago, with a chip invented by IBM recently, called "True north". It imitates 1 million neurons and 256 million synapses from the human brain, and this chip uses ten thousand times less energy than the classical chip with the same power. Another example from 50 years ago was the IBM 7090 computer; now we are building quantum computers. When I started my career in the late 1950s in physics, we dealt with only three-dimensional systems. Now we go to two dimensions, one dimension, even zero dimension, and this opens the field for newer and newer global technical possibilities. At that time, we communicated by mail, now we have the Internet of Things, and everything can be found and reached on the internet. At that time, we already knew about DNA, but now we are mastering it. At that time, we had the first interactive TV; today we have artificial intelligence and everything is connected. These are just a few examples of what happened in the last 50 years, and this process is accelerating.

What are the driving forces behind this? First, it is global competition. Competition is an added value and it improves the quality of everything produced. Cooperation and networking are connected with the need to avoid parallel activities. "Support of excellence" was the slogan of the European Research Council when we started our work. If you want to develop fast, you need to support the best. You must also invest in infrastructure, because without it nothing works.

There is another paradigm that helps to accelerate development. In the last century, when we wanted to produce something new, we made experiments to test it. Nowadays we can compute it. Simulation takes over part of the experimental work. I am an experimental physicist, we will have enough work in spite of these changes, but the statement is true for robotics and many other things. I mentioned already these technologies: nanotechnology, biotechnology, information technologies, quantum technologies, and materials. The quantum world is very exciting, and I am happy to think about the first Hungarian, Elemér Hankiss, who turned our attention to the idea by introducing quantum science to the social sciences and humanities.

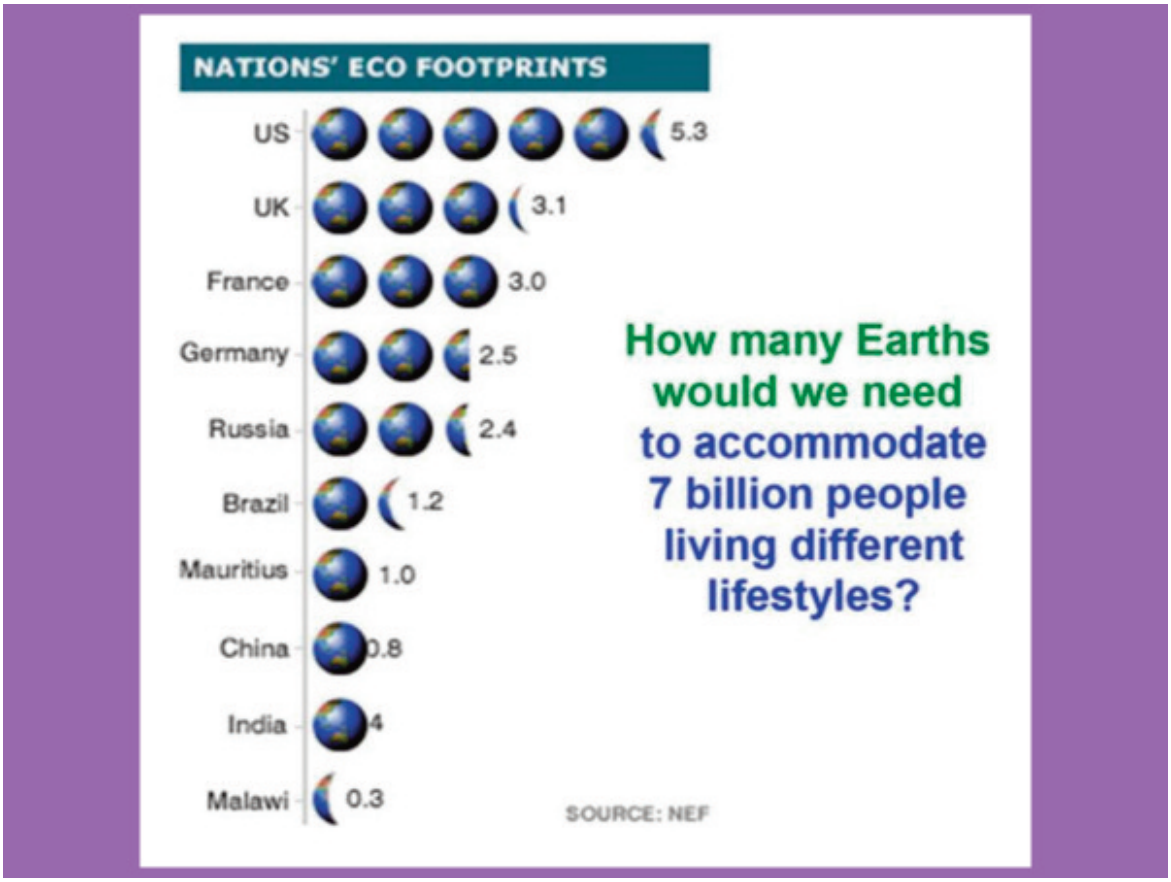
The other thing I want to mention is that whenever we develop and make new things, it is always combined with risk. Benefits and risks come together, but there is no benefit without risk and therefore we have to have a healthy balance between rewards and risks. This is a complicated issue, and I do not want to go into the details, but I want to mention that responding to risks is involved in many practical activities of everyday life.

Risks are of course always there, and we have to minimize or manage them. Risk is part of a larger activity that we call 'adaptability' or if you like is 'resilience' which is one of the topics of this conference. This is included in the field of sustainability, and now I want to share with you a few ideas on that. The figure is an illustration of this interdependence.

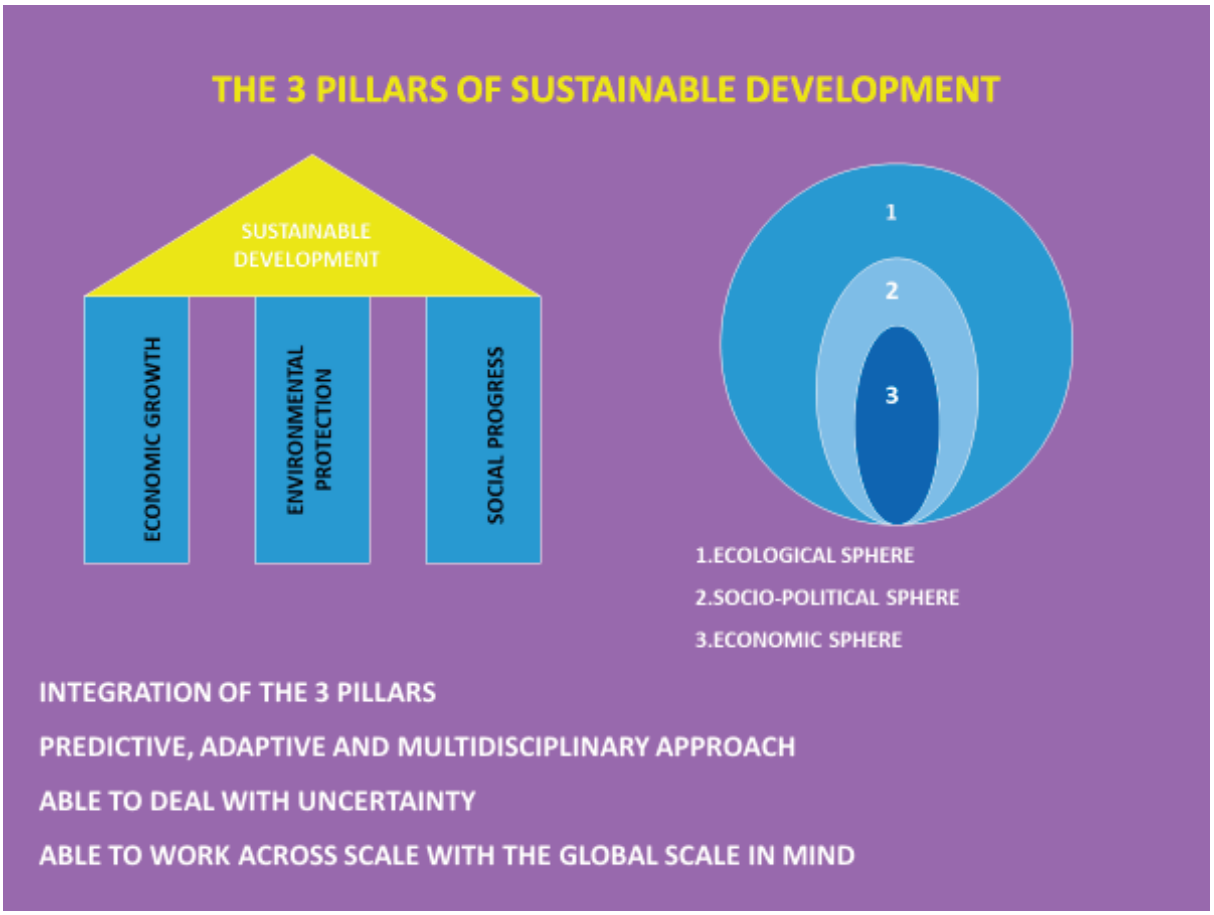


Sustainability is always complicated. When we speak about sustainability, the economist thinks of how to produce more and better products. But if we think of the environment and energy production, we use materials and produce waste. So, the economy and environment are topically correlated. The third element concerns what we do influences our lives, and so the social aspects need to be included.

The consumption of resources is distributed unevenly between different countries. This is shown in the next graph that I think clearly shows the main problem of the overuse of available resources. How many Earths are needed to sustain the current quality of life in each country?



The United States uses the resources of 5.3 worlds in one year; while the lowest consumption is in Malawi that uses only 0.3 worlds. Brazil is around the average at 1.2. This clearly shows that the World lives highly above sustainability. and that it is not maintainable in the future. Sustainability rests on 3 pillars, as illustrated in the next figure, and these pillars have to be integrated under one common roof of sustainable development.



We need to build a balanced integration of these three spheres, and this should involve everyone in what is called 'multidisciplinary' science. We know that there are a lot of uncertainties, so safety switches have to be built into the system, and we have to think globally, and act locally.

What have been the results of what we have been doing? Poisoned food, water, air, and soil, increasing energy consumption in transport, manufacturing, heating, and cooling, wasting non-renewable energy resources, oil, metals, and so on. Overuse of water in industry, agriculture, and at home; overuse of land for economic activity, and human lifestyle. A shocking list of negative developments are mainly the result of human activities.

Let me give you an example. We are very happy when new industrial parks are born, but where are they built? On land which could be used for food production. You may know that there are many Dutch farmers who are buying land in Hungary. I told my Dutch friends that they are coming here because they are afraid of the rising sea level in Holland. Of course, they strongly protested against this idea, but I think it is still true.

I have tried to summarize here the challenges that we are facing in the next 40-50 years.

SOME OF THE GRAND CHALLENGES FOR THE NEXT 50 YEARS

1. ENERGY AND RAW MATERIALS
2. WATER
3. FOOD
4. ENVIRONMENT PRESERVATION
5. POVERTY
6. TERRORISM & WARS
7. HEALTH PROBLEMS
8. EDUCATION
9. DEMOCRACY
10. POPULATION
11. MIGRATION & DEMOGRAPHY
12. INFORMATION (AND ITS SECURITY)
13. COMPETITIVENES AND EMPLOYMENT
14. SECURITY OF PEOPLE
15. TRANSPORT

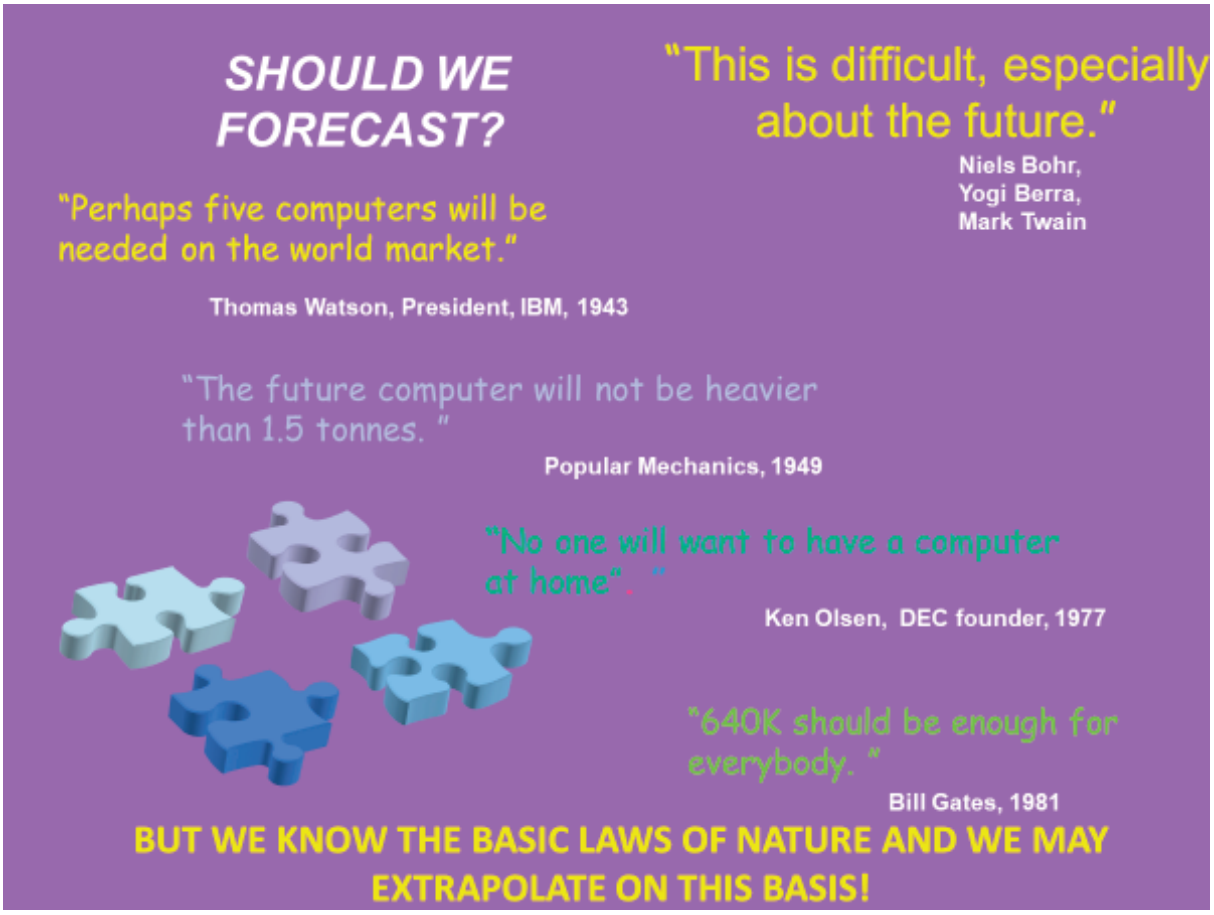
Each would require a lecture to explain what lies behind them, and there could be many others. I just wanted to illustrate that we have many problems to face in the coming decades. Now I want to speak about our hopes. With technological development, each big discovery has changed society completely. With Newton's physical laws came the first Industrial Revolution, the steam engine and many other things that changed human life, transport, production, and much more. Another was the discovery of electromagnetism and we made electric light in the world, electromagnetic waves which led to electric light, and radio communication. There is an anecdote about a German couple with a gifted son. They took him to a famous professor to ask whether they should send their son to school for science or music. The famous physics professor, Jolly by name, advised them that their son should study music because in science everything has been done. Of course, the son, Gustav Hertz, discovered electromagnetic radiations, changing also significantly our societies. The third groundbreaking discoveries are connected with the nuclear forces, which lead to nuclear fission and fusion. and opened the nuclear age, usually interpreted with the famous equation of Albert Einstein, $E = mc^2$. This science helped us to understand the universe and gave us new energy resources. This helped us also to understand the human body, and DNA was discovered.

At the same time, and parallel, quantum mechanics was discovered, completely changing our concepts of our world. We learned the rules of quantum mechanics in the previous century and we invented lasers and transistors, but this century is even more important because we learned how to manipulate the rules of quantum mechanics. This is a significant change, hopefully leading to the quantum computer, and we have already secret communication, and very sensitive

sensors. There are already sensors with which we can detect one single molecule. This method allows, for example, to detect cancer as early as possible. And this is just one possibility.

There is a global problem and that is while technological development is exponential, the human way of thinking is linear. Let me explain this with two examples. When computers were invented, I myself thought that we would no longer need paper because everything would be stored in computer memories or in the sky. We have, however, never used so much paper as we do today. Another example is that communication has developed for video conferencing, and so one would think that we would travel less, but we have never traveled as much as we do today.

And forecasting is dangerous. One example of how easily we may make mistakes is seen in the figure below that shows a set of forecasts in connection with computers.



As far as technologies are concerned, I want to mention a few things. Technologies only bring possibilities; how we use it is important, and strongly connected to the social context. Another issue deals with human nature. Speaking brutally, we have 21st century technologies in our hands, and we try to drive these technologies with 19th century attitudes. This gap needs to be overcome.

What are the technological challenges in the future? I already mentioned that the traditional technologies are dying out, and we have to find new ones to replace them. Research is gaining in importance, since new technologies are based mainly on ideas born in research. and, at the same time, these new technologies are more quickly becoming out-dated, therefore the application of research results must be made as fast as possible.

What type of technologies do we need? Of course, we need technologies that decrease risks, which are economic, efficient, and which use less raw materials. There must be harmony and balance between technology and nature. We must take a lifecycle approach, where industry has to think about the use of any material or resource lasting over a lifetime of the product. We have to integrate products into the environment and social conditions that exist.

I collected five paradoxical issues that we face.

1.The significance of science increases while the interest of the young generation in it decreases (**knowledge paradox**)

2.We need more knowledge to get along in the world. The time needed to acquire this knowledge increases but the obsolescence time of this knowledge is decreasing (**time paradox**). This means, that fast reaction is needed from all of us. The future belongs to those who learn. Those who learned only in the past belong to a world that does not exist.

3. There is good research in Europe, but it is loosing its competitiveness (**innovation paradox**).

4. The role of R&D in competitiveness increases, but decisionmakers are often tempted to forget about this (**competitiveness paradox**).

5. The share of governments in financing R&D activities is decreasing, but the role of the remaining contribution is increasing (**governance paradox**).

I want to remind you of one of the big Hungarian thinkers, Gábor Dénes, the inventor of holography and one of the founders of the Club of Rome. He said that the human race may die out for three reasons: one is nuclear war; the second is overpopulation; and the third is laziness. I think this last one is the biggest danger, and if you look around in Europe you might agree with me.

Finally, I want to quote two statements from the greatest scientist of the last century, Albert Einstein. The first is: "The problems we are facing today cannot be solved with the same way of thinking by which we created them".

I think his second statement is equally important: "I am afraid of the day when technology gets ahead of human connections, it will result in a generation of idiots".

I hope it is not going to happen.

The (Mis)use of Scientific Knowledge

Thomas Filk

A (very) Long Introduction

I will not talk much about the success of science in the past 100-150 years; I am more concerned about how we communicate science because I have a feeling that there is an increasing gap between what scientists do and what the people who eventually have the power (these are the voters, the media, and the political, economic and financial decision makers) know about science. Furthermore, when I was asked to give title to this presentation, I hadn't really made up my mind what to talk about. After I gave the title my ideas somehow were directed into different directions, but at least some parts of my talk will be related to this title.

I hope we can all agree that the world is facing several crises. On an everyday level we face the danger of a financial crisis, a political crisis between different countries - America, Europe, England, China, England and others – and we do have a crisis with the resources of our world and with climate change. And in particular, as has been mentioned many times before, we seem to have a crisis of democracy, at least with many of those leaders who have recently come to power. I would no longer consider some of the so-called democracies as the kind of liberal democracy in which I grew up and in which I would be happy to live in in the future.

Let me say a few words about one of the crises mentioned, even though it may be an example of what could be a misuse of scientific thinking. I am a physicist and physicists are always accused of oversimplifying things, so let me now oversimplify the first aspect – financial crises.

We all know Newton's first law of physics: An object either remains at rest or continues to move at a constant velocity, unless acted upon by external forces. It is a very simple law, and we use it successfully almost everywhere in physics. You may ask the question whether a similar law exists also for other sciences? Newton's law is about what happens if we do not intervene, if there is no force acting on things. So, the question is: what is the 'default' dynamics in other disciplines, the default behavior of systems if we do not intervene? Is there a kind of first law, like Newton's first law, for, say, economy? I would say yes, at least how it appears to be: our economy seems to be based on a law which I formulate, perhaps too simply, in analogy to the law of physics: "An open economy either continues to grow with a constant growth rate or with a constantly increasing growth rate, unless acted upon by external forces". I know that most economists are aware that a constantly increasing growth rate will be of harm in the long run, but somehow decision makers do not always act according to this insight.

So, according to my impression, most of our economic models are based on exponential growth. What happens if the resources are limited? Biology tells us what happens to exponential growth when resources are limited – the growth stops. Now, mankind came up with an ingenious idea to deal with this problem: We have invented "virtual resources". This may have started already more than 100 years ago, but the person who started it with respect to the present situation might have been Richard Nixon in 1971, when he essentially removed the balance between paper money and gold reserves. Later, banks and insurance companies introduced virtual money, which only exists as a number in some data base. This makes resources unlimited, well almost, only subject to the memory capacity of computers. Some years ago, I was told that before the 2008 crisis, the ratio of actual values to virtual values was 1 to 20. I do not know exactly what it is today, but I am afraid it could be even worse.[1] As an illustration of what this means I counted the chairs here in

1 John Cleary later remarked in his presentation at the Blue Sky conference that the situation is slightly better today due to regulations which put massive restrictions on financial instruments for 'ordinary people'.

the room, and there are approximately 100 chairs. This implies that only 5 people will get a seat when 'the music stops' and the crisis starts. And for about 10 years now we even have virtual currencies that can make the situation even worse. This idea of inventing virtual resources was kind of ingenious when you look at the first law of economics – maintaining exponential growth – because it is very easy to do to circumvent the problem of limited resources.

Of course, one may wonder, as we have found this ingenious solution, why didn't evolution come up with something similar? However, at present it seems that we cannot live on virtual food or mate with virtual partners. Maybe, in the future we will be able to, I do not know. The way we are dealing with the financial crises reminds me of Douglas Adams who once said: "Human beings who are almost unique in having the ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so". This is what happened after 2008 and this seems to happen again and again. As I said, this may be simplified physics thinking.

The following picture somehow reflects how I view the situation of the world today.[2] This is how we are dealing with these crises. I actually saw it first in a TED lecture of Juan Enriquez. Let me come to the point I actually wanted to talk about. In a certain sense, there is still an ivory tower of science and scientist often have the attitude: "We just write about the world, you guys have to go out and save the bloody thing". This is something we have to change.
What I want to talk about are two different subjects:

1. The communication of scientific insights: This is not about the communication to our peers, but how we can communicate our scientific results to political and economic decision-makers, to the media, and to the voters. We have to address all three groups, in particular the last one, because otherwise we will have almost no effect and this is a problem because this is where scientific knowledge has been misused a lot.

2. The second issue is slightly more positive. What we need is a kind of interacting network of global science; and by global I do not mean all over the world, but I mean a science over all disciplines so that different disciplines start to cooperate more and there is more communication between disciplines. This is where I think scientific knowledge can be most useful.

Misusing Science

Let me start with the first point and with what is called Simpson's Paradox. I believe many of you know this. It seems to be widely known in the social sciences. I learned about this just two years ago. In physics we do not learn about Simpson's Paradox, which I find strange. In the following example, I do not want to be politically incorrect, but I will talk about white and black people and criminals and non-criminals, and I use this terminology to make the result more shocking. All the numbers are made up for illustrational purposes, they are not real data.

	White	Black
Total	250.000	250.000
Criminals	100.000 (40%)	150.000 (60%)

Let us suppose there is a city with 500,000 inhabitants, half of which are white and half of which are black. Let us further assume that we have a clear criterion when to call somebody a criminal and when not. According to statistics, 100,000 white persons (40%) are considered as criminals and 150,000 black persons (60%) are considered as criminals. What does this prove? Black people have a higher tendency to be criminals? No!

2 https://www.twielectric.com/safety-and-energy-saving-tips/dont-swim-shocks/

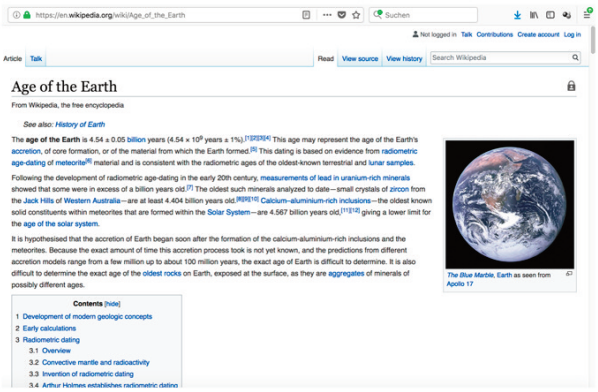
We now take the same data set but we distinguish between 'poor' and 'rich' persons (again we assume that we have a clear criterion). Now we get the following numbers: Among the group of poor people we have 50,000 white persons and 200,000 black persons, among the white persons we have 40,000 criminals (i.e. 80%) and among the black persons we have 140,000 criminals (70%). Similarly, among the group of rich people we have 200,000 white persons of which 60,000 (30%) are criminals and we have 50,000 black persons of which 10,000 (20%) are criminals.

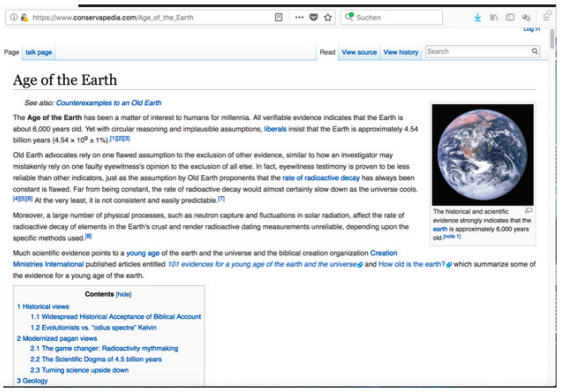
poor	White	Black
Total	50.000	200.000
Criminals	40.000 (80%)	140.000 (70%)

rich	White	Black
Total	200.000	50.000
Criminals	60.000 (30%)	10.000 (20%)

In both groups the number of criminals his higher among the white people as compared to the black people. These are the same data (you can add up the numbers in the two tables above and you will get the numbers in the first table), there is no cheating with data.
So one doesn't even need 'fake data' in order to prove essentially whatever one wants. One only has to split a data set into proper subgroups of data. I think that many people are not aware of this but, in my opinion, it should even be taught in schools.

The second thing I would like to talk about refers to a phrase we all heard before: "Science has proven that …" or "science can prove that …". When I prepared this talk I accidentally found two pages on the internet, which on first sight look very much alike and in particular I think from a distance you would not notice much difference between these two. In particular, both give the respectable impression which we nowadays attribute to most Wikipedia articles.





When you start reading the first lines you immediately recognize the difference. The page on the left-hand side is the actual Wikipedia page on `Age of the Earth', the other is called *Conservapedia*, and it starts with the statement that "All verifiable evidence indicates that the Earth is about 6,000 years old." This page, very much like Wikipedia, claims to give scientific proof to this statement. What is wrong? Whom to believe? There are scientists on both sides!
This is just one example. Again, by searching the internet, I came upon a book which essentially is about refuting evolution. It is printed in 500,000 copies, and it is intended to be a handbook for students, parents, and teachers. I guess in the standard sciences you have to be Stephen Hawking to get this number of books sold. And this book sells very well. Essentially this is just one ex-

ample and there are hundreds of others. In most cases the authors are really scientists. In this case the author has a PhD in chemistry, he has published articles in *Nature*, he has been the chess master of New Zealand – so in a way he is very respectable. How then does he argue in favor of a young Earth?

"Science has proven that…". Essentially, the arguments can be categorized into three different groups: (1) "Science has proven that" the earth is indeed about 6000 years old, (2) "Science can prove that" the earth has to be younger than 4,5 billion years (which is the claim of 'standard' science), and (3) "Science can prove that" the methods used in favor of an old Earth (amongst others radioactive age-dating) are wrong. The first group of arguments is mainly based on written records (apart from citations from the bible) and, therefore, is rather a proof that writing systems are not older than about 6,000 years, which I don't deny. The third group essentially rejects radioactive age-dating by giving examples where the true age of objects is known and where the radioactive age-dating methods yield a different result. Indeed, such examples exist, but in all cases, we know why the radioactive methods give wrong results. I admit that such counter-examples should make us more cautious in our argumentation, but we should make clear that it is not only radioactive age-dating of a few samples which leads us to the conclusion but that almost the whole network of scientific insights supports an old earth and that, if indeed the earth were 6,000 years old, almost all of our scientific insights must be wrong, including those which are used for the second group.

The most interesting group – in particular from a scientific point of view – is the second group of arguments: Proofs that the earth has to be younger than 4,5 billion years. There are many examples, and I only list some from the realm of physics: the magnetic field of the earth, the helium concentration in the atmosphere, old supernovae remnants, the receding moon from the earth, the salt concentration in the oceans. Even recent discoveries like the rotation velocities of galaxies (which in standard physics is attributed to a hitherto unknown form of so-called 'dark matter'), and the acceleration of the expansion of the universe are used for this strategy.

In almost all cases, one finds that the explanations sound (and mostly are) very scientific. It is very difficult to put your finger onto something and say, "here is the mistake". For someone who is not an expert, and here I mean a real expert in this special field, not simply a physicist, this is almost impossible. The arguments are often based on exactly the same equations and they use exactly the same numbers as the equations and numbers you will find in standard textbooks. The mathematical argumentation is often surprisingly sophisticated and usually correct. So, what is wrong? The point where the standard arguments start to differ from the 'alternative' arguments is often hidden. In many cases either the standard scientific argumentation becomes really complicated while the 'alternative' argumentation is much simpler (and the reason why the alternative argumentation is wrong is not so obvious at all), and sometimes the standard argument has to use 'reasonable numbers' or reasonable assumptions which can easily be replaced by other numbers or assumptions.

Let me illustrate this on the example of the receding moon based on tidal forces. The physics behind this phenomenon is fascinating: Due to tidal effects the rotation of the earth is decelerating; days become longer (the order of magnitude is 2 milliseconds per century). The energy is transferred to the velocity of the moon (because due to the coastlines on earth, the tidal bulks are slightly ahead of the earth-moon axis and, thereby, transfer energy to the moon due to gravitational forces). Because of this effect the moon recedes from the earth at present by about 3,8 cm every year. This were not a problem, but for at least two reasons the effect was stronger in the past: the moon was nearer to the earth and the rotation of the earth was faster. Taking these effects into account leads to a number of 1,4 billion years when the moon essentially must have

touched the earth, showing that radioactive age-dating must be wrong and the earth must be younger. However, the essential assumption (amongst many other details) is about the above-mentioned number 3,8 cm, which can be transformed into a 'coupling strength' independent of the earth-moon distance and the rotation rate of the earth. The statement in the 'alternative' literature is that this coupling was 'very likely much larger in the past' while the statement in the 'standard' literature is rather that is was smaller in the past, because this number essentially depends on the shape and distribution of coastlines over the world and this has changed due to continental drifts and was presumably much smaller during periods of 'supercontinents'.

This paragraph was not meant to convince you of an old Earth – it cannot. Rather my intention was to show how difficult and complicated the argumentation often gets. Sometimes the exact numbers and/or physics is not really known and understood. I mentioned the decaying magnetic field of the earth: this happened many times before and, in most cases, the magnetic poles switched. We do not know the exact mechanisms in the center of the Earth which give rise to this effect, but does that mean that the 'standard' arguments are as weak as the 'alternative' arguments? In my opinion 'no'! But often the main reasons in favor of the standard arguments are not the single arguments by themselves, but the general consistency of a whole network of arguments, theories and models – and this is very difficult to communicate.
The essential question for me is, why are 'alternative' arguments often easier to communicate than 'standard' arguments?

One reason is that some people hate science. They hate science for many reasons: scientists receive a lot of money for something nobody understands and, in addition, science produced a lot of bad things. For those, who don't understand science, science can be threatening. And when humans feel threatened they start to 'hate'. And these people embrace any argument which seems to prove that 'standard scientists' are wrong. I receive many emails where people claim that the theory of relativity must be wrong, that quantum theory must be wrong, that the theory of elementary particles must be wrong, etc. There are even people who believe that the earth is flat. Many of the addressors claim to be scientists (and some of them are). This would not be a problem, but many non-scientists tend to believe these claims more than the explanations of standard scientists.

A second reason is that the 'alternative' scientists know much better than the standard scientists how to communicate their ideas. One of the reasons is again the "Science has proven that …". Most standard scientists avoid this phrase because they know that science cannot prove anything, at least not in the mathematical sense of this word. Science has plausible models and theories, and in lucky circumstances these models are falsifiable or we can find their range of applicability. Statements like "Dr. X Y has proven that …" seem to sound much more convincing (apart from the observation that scientists seldom use academic titles in scientific writings). Another reason is that 'alternative' scientists are often better in communicating their science. And this point is often neglected by 'standard' scientists; they don't care about 'elementarization' ('Elementarisierung' in German) or, even worse, they reject it. But this is needed in order to make science communicable to non-scientists.

These are just two reasons, but I am convinced there are many more. This is one field where the natural sciences can learn a lot from the social sciences: What do we have to do in order to communicate our science to the people, the media, and the decision-makers?

Using Science

Let me come to the second part of what I wanted to talk about. How can we use science beyond simply inventing new gadgets or getting deeper insights?

I like the metaphor of Aikido. Aikido is a Japanese word, and in its modern form as a martial art it was invented in Japan slightly more than a hundred years ago, so it is quite young. The three Chinese characters for Aikido, ? ? ? , have an interesting meaning: The first character ? "Ai" means 'to come together', 'to meet', but it can also have the connotation of 'to harmonize', 'to synchronize'. The second character ? "Ki" referred originally simply to 'a gas', 'a gaseous substance', but it became also a character for 'mind', 'spiritual strength', 'spiritual power', and 'spiritual energy'. The last one is the famous ? "Do", or in Chinese "Dao", and its meaning is "path", "way". In compounds like here it often means 'the art (way) of how to do things'. So, in this case it refers to the way to bring together or to harmonize the spiritual forces. This is the idea behind Aikido. For me this is a metaphor for 'how to utilize the thrust in an opponent', not working against it. This can also refer to nature: throughout history we tried to utilize nature by working against it - cutting trees, rectifying rivers, using natures resources and returning pollution, etc. This has to change. We must start to utilize things in harmony with nature.

How can this be done? And how can we as individuals contribute? Well, it seems that many projects in this direction were initiated by individuals. Big companies enter when they see that they can make money, and politicians start to act when they see that they can get votes. Some of the most successful models I know of were initiated by individuals and only later economic and political decision makers followed. This is one of the reasons why scientists have to learn how to talk to the public, e.g. about climate change.

I wonder how many people know about Ursula Brunner (1925-2017). She became famous for what has been called the "Banana Women of Frauenfeld" (a community in northern Switzerland). In the 1970s, she saw a movie about the production conditions in banana plantations in Nicaragua and she started asking the question: why are bananas so cheap in Switzerland despite the fact that people in the countries of production live in miserable conditions? Isn't it possible to sell bananas for a slightly higher price and give the surplus to the really poor people in the producing countries? Today this is called fair trade. She talked to big companies (like Chiquita and Migros, in Switzerland the biggest importers and distributers of bananas) without success. She talked to politicians, but in most cases the reaction was that a woman should be at home with her kids (women were just allowed to vote in Switzerland). She started to make this a public issue and informed people about the conditions in the producing countries. And she learned the trade. More and more people got to know about these things and some of them started to by their bananas in third world shops, where there was a certain guarantee of fair trade. That was the point where also Migros and Chiquita recognized that one can make money with fair trade (and there is nothing to say against that – forcing companies to give up on profit is 'against their nature', this is not Aikido). In 1992, the Max Havelaar Foundation, dedicated to fair trade, was founded in Switzerland and nowadays fair trade means also good business. A few years later, also bananas became part of the Max Havelaar fair trade. Ursula Brunner was not really satisfied with the result, people in developing countries still suffered, but it was a start. And as she was convinced that there should be no competition amongst those who have the same goals, she stopped her 'trade' (but two organizations, first gebana and later terrafair, followed).

I read somewhere that the banana women wanted to follow through with their project without men and I always wondered why. The only reason I can think of is that they wanted to get things done and not just to talk about it. This proves that a single person can do something, but it needs a lot of commitment.

I want to mention another person. Two months ago I met Hillary Brown (from the City College in New York) in Kőszeg. She gave a presentation at the KRAFT Conference and talked about circular economy. Circular economy is not her invention, but together with students from the US as well as from Hungary she conducted a project with the goal to apply circular economy to the town of Kőszeg. If you look at their plans you will find amazing interrelationships between Kőszeg forest, the Kőszeg environment, the Kőszeg tourism industry, the Kőszeg community, and so on. This is really tailored to the special conditions in Kőszeg. She and her group of students wanted to give an example that at least in a small community you can start to do things which are 'circular' and 'sustainable'. Essentially, the idea of a circular economy is that one has the densely connected network of units – private and public business, municipal activities, companies, shops, etc. – and the waste of one unit becomes the input for another.

There are similar projects throughout the world. Some of you may have heard about the 'blue economy', which has very similar goals. Closely related is the ZERI initiative (zero-emission research initiative). There are roughly 200 projects all around the world (maps of the locations of these projects can be found on their website). If you look at the eastern part of Europe, however, there seem to be remarkably few projects, two or three in Serbia, but nothing in Austria, Hungary, or Poland. I was quite disappointed that there are only few projects in Germany. But on the other hand, this is just one example for such projects.

Cradle-to-Cradle is based on similar ides: no waste products as far as possible. We must be more careful about being able to recycle or to reuse things which up to now have been considered as waste. This is in the spirit of Aikido: make the problem your partner, make it work for you.

I can imagine that Kőszeg is an ideal place to implement a Master's program in circular economy. You start, e.g., by making a BSc in physics, biology, chemistry, or a BA in economics, and then the MA specializes on methods to make processes more sustainable and circular, e.g. how the waste from one economical unit becomes the input for others, or how to organize 'sustainable festivals' or 'sustainable conferences', etc. If one thinks about it, there are many ways to develop a curriculum for such an MA program and there are many possible applications: The absolvents can become advisors for companies, cities, organizers of events, etc. They have to work in groups because, as I said, you need in principle all sciences working together in order to accomplish this. This is what I meant by 'global science'.

Confronting the Challenges of Global Complexity

Sean Cleary

Norbert Kroó has set an historical context and defined the issues that we have to address; Thomas Filk, has spoken on the misuse of scientific research to frustrate our ability to address the challenges we face. That is a wonderful backdrop for the modest contribution that I shall try to make in weaving this together in the context of policy.

Why does science not translate into better policy outcomes? We are seeing societal fracture both in efforts at *collective action* at the level of the *Global Commons*, and now even, *collective action* at the level of the nation-state. These fractures are apparent everywhere for different reasons: Why is that? Perhaps that is what we ought to discuss, because unless we solve that problem, science, research, and technology will not solve anything. As Norbert Kroó very correctly said: "they are means to ends". It is the purpose to which we put them, that matters. The fact that science and technology enable solutions that we could not have imagined 10 years ago, or 30 years ago, or 50 years ago, is of no use if we cannot find ways to deploy them based firstly on individual scientific excellence, and secondly to translate that into collective action at appropriate scales.

Let me start with something that Ferenc Miszlivetz said right at the beginning, but I'll use a non-Hungarian reference to illustrate that the thought is widespread. When Antonio Gramsci was in prison in 1930, he wrote extraordinary prison diaries (*Quaderni del carcere*) between 1929 and 1935, that are well worth reading. In the diary for 1930 he made an interesting and lyrical observation: "The past is not yet dead, the new is not yet born, and in the interregnum awful monsters appear", and if you recognize elements of that thought in the present, I am not surprised.

I'll give you one other quote on that topic before I get to the slides. Gramsci's diaries come from the middle of the interwar period, reflecting the rise of national socialism and fascism. William Butler Yeats, wrote "The Second Coming in 1919, reflecting the angst of the privileged classes of Europe after WW I. The first stanza of" is evocative:

"Turning and turning in the widening gyre
The falcon cannot hear the falconer.
Things fall apart
The center cannot hold
Mere anarchy is loosed upon the earth
The blood-dimmed tide is loosed and everywhere
The ceremony of innocence is drowned"

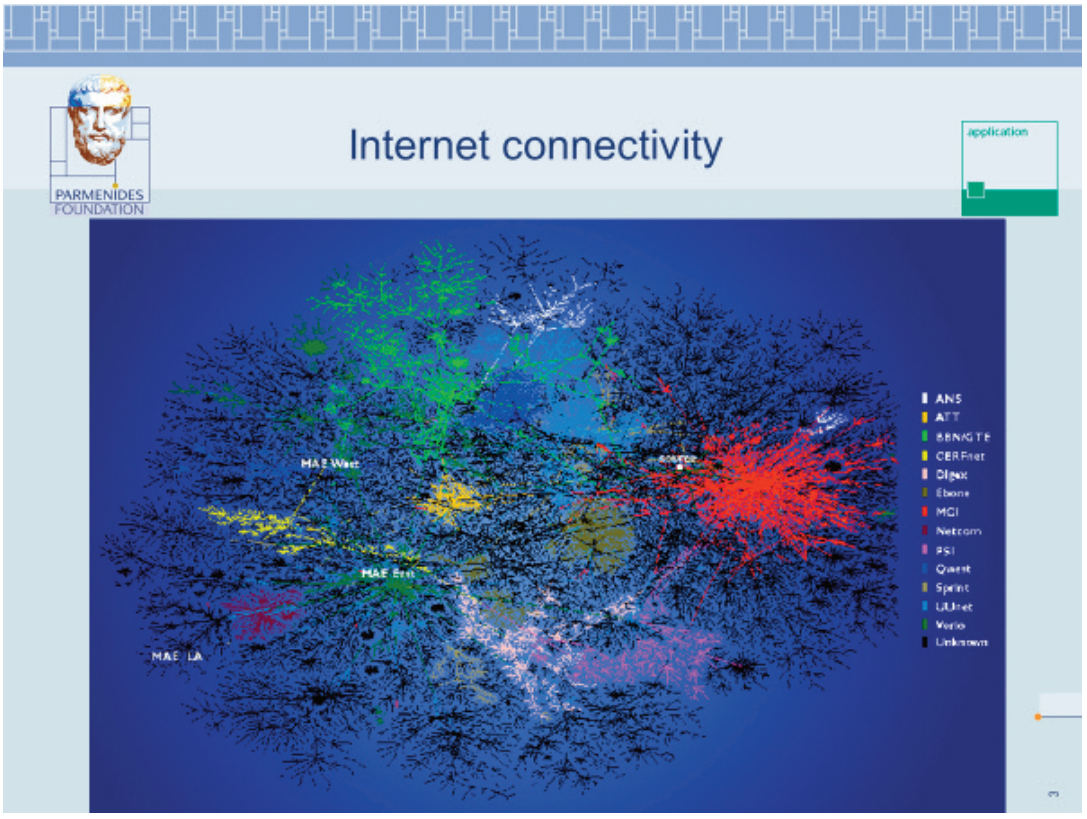
and then the last two lines of the first stanza explain why this is:

"The best lack all conviction, while the worst
Are full of passionate intensity".

Now, again, if that imagery echoes in the present, this is not surprising. At this conference we have an obligation to prevent "mere anarchy" being "loosed upon the earth" and "the blood-dimmed tide" sweeping over us. So, let's have a look at the problem, because if we understand it, perhaps we can do something about solving it.

Look at the level of air connectivity, forget the carbon emissions produced by the flights for a moment and just think about the level of connectivity that potentially enables collective action.

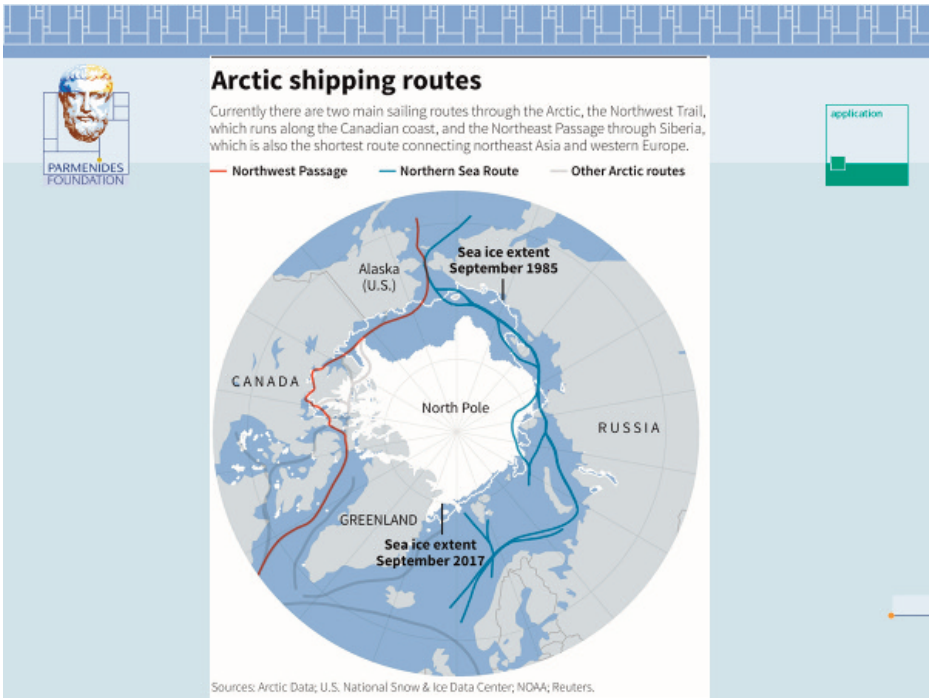
Look at the level of internet connectivity.



In both the real and the virtual worlds, the level of connectivity we have today is completely unprecedented. That has implications, as Dan Brooks will tell you, in respect to the spread of pathogens, but that is a different problem for the moment.

We are also seeing a gigantic shift of the center of economic gravity, sharpened by the aspiration of the Chinese to be able to reach out into their hinterland and beyond through a remarkable Belt and Road initiative, potentially impacting 172 countries.

Here is another form of connectivity. As a result of greenhouse gas emissions hastening the melting of Arctic ice, shipping lanes are opening around the Arctic.



If we look at this as a series of expanding opportunities, through the lens of *Aikido*, "the way of combining forces", this connectivity is remarkable. We must understand what it offers in collective benefit if we get it right, and for disaster if we get it wrong.

Let us now try to define concepts that would enable us to address the challenges we face on a global scale. I am offering deep analysis right now, but simply an account of where we have got to in our efforts to define an agenda.

Firstly, we need to make economic growth – and I'm not convinced it must be increased appreciably in aggregate – both environmentally and socially sustainable. [Parenthetically, the reason why the ratio of financial assets to real assets have not worsened since the financial crisis is because of rising inequality. Unconventional monetary policy since 2008 has confined the ability to leverage financial assets for wealth creation to a smaller class of people – those who already had significant assets, and access to exceptionally-low-interest bank loans.]

Secondly, we need to rethink poverty and inequality through a lens of equity. It is not that inequality is simply a phenomenon of distribution. The present distribution of income and wealth is the product of intrinsically *inequitable* social and economic circumstances, and these must be seriously and urgently addressed.

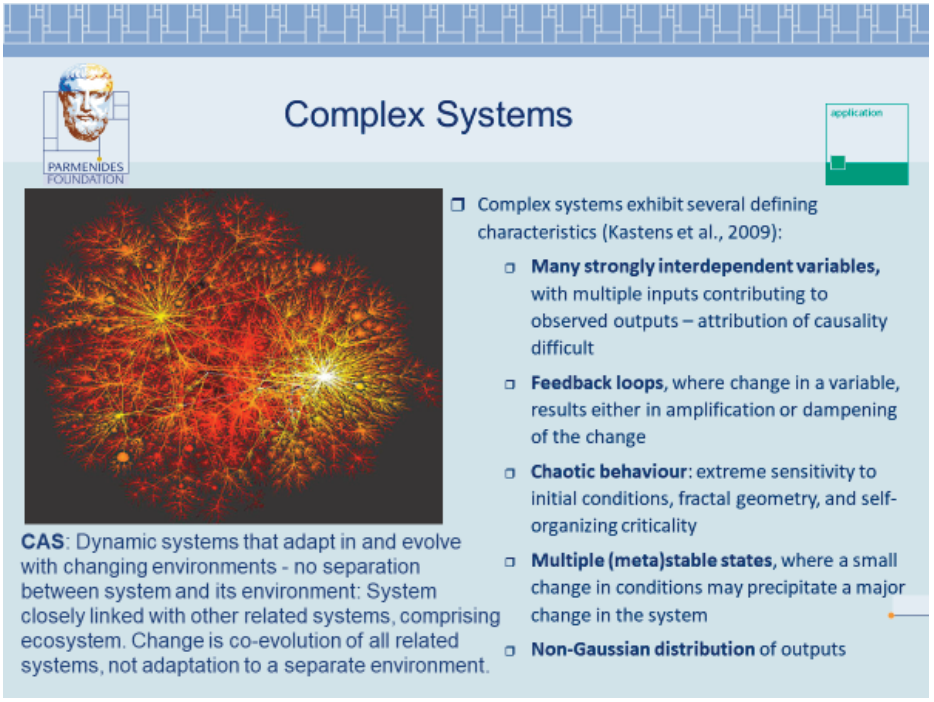
Thirdly we must start thinking about security in completely different ways. It makes no sense in this highly connected world to ring-fence national security, allocating a fixed percentage of budgets and GDP to the provision of *national* security while ignoring *regional*, *global*, and *human* security. If *security is the reduction of vulnerability and the creation of resilience*, we need to get our heads around all aspects of security in sensible ways and apply resources cost-effectively to achieve that.

Fourthly, we need universally-accepted normative frameworks that will allow us to address these three issues – sustainability, equity and security – because our current normative frameworks prioritize the nation-state and the individual and constrain our capacity for collective action at scale.

Finally, if – and only if – we can agree on appropriate normative frames, we can make our global and regional institutions truly effective: Brussels in the context of the EU, and the United Nations, the Bretton Woods institutions, and the WTO on a global scale. Only if we can change the normative frameworks, can we change the institutional paradigm.

So why are we not doing this? It is not really all that complicated; it is common sense on several levels. So, why can't we do it?

The first reason is the problem of complexity. I am not going to lecture you on the nature of *complex systems*, but one must understand that humanity is a complex system incapable of direction from a single point. Humanity, embedded in a *bio geosphere*, or an *earth system*, is a *complex adaptive system* in which coevolution for good or for ill, is a continuous phenomenon.



A complex system is characterized by many strongly interdependent variables, significant feedback loops, and chaotic behavior, because of the complexity of the system. Thus, multiple metastable states emerge, where temporary equilibria exist in conditions of instability, and the system generates a completely non-Gaussian distribution of outputs.

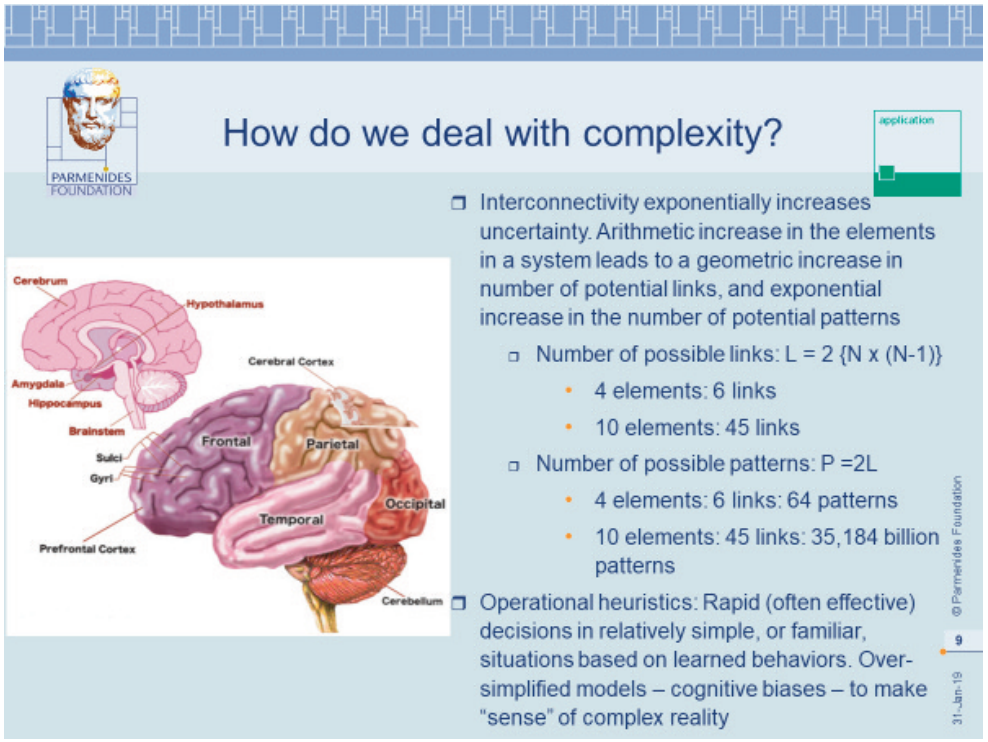
If you think about human behavior, the way in which human societies function, and our interaction with the biosphere, then again this is obvious. But that is not how we usually think about it, within individual academic disciplines – economics, sociology, political science, or law - and certainly not at policy levels.

Why is that? Firstly, human thought is linear, and we rarely encourage conceptual breadth; we do not think, or plan, or develop policy in the context of complex systems. Western education since the Renaissance has been premised on academic specialization, and specialization – although it has made an enormous contribution to the development of knowledge - hinders an adequate appreciation of the complexity of the system. When one discusses something through the lens of political science, or that of economics, or the lens of law, or that of sociology, one is describing the same complex reality from different intellectual perspectives. Each discipline is a paradigmatic lens, through which one visualizes a facet of the same complex reality. We do not have the time to discuss these processes this morning through the lenses of evolutionary biology

or cognitive neuroscience; suffice it to say that scientists also have difficulty making their insights comprehensible to one another.

This restricted ability of people from different disciplines to engage in meaningful debate about these critically important issues has destructive effects: misinterpretation of data, misunderstanding of paradigms, misinterpretation of scientific hypotheses and research. The resulting confusion afflicts debates among policymakers. Part of the problem is that interconnectivity exponentially increases uncertainty. The higher the level of connectivity the more difficult it is to come up with a policy appropriate to a highly interconnected, dynamic system with a propensity to chaos and a non-Gaussian distribution of outcomes.

So how do we cope?

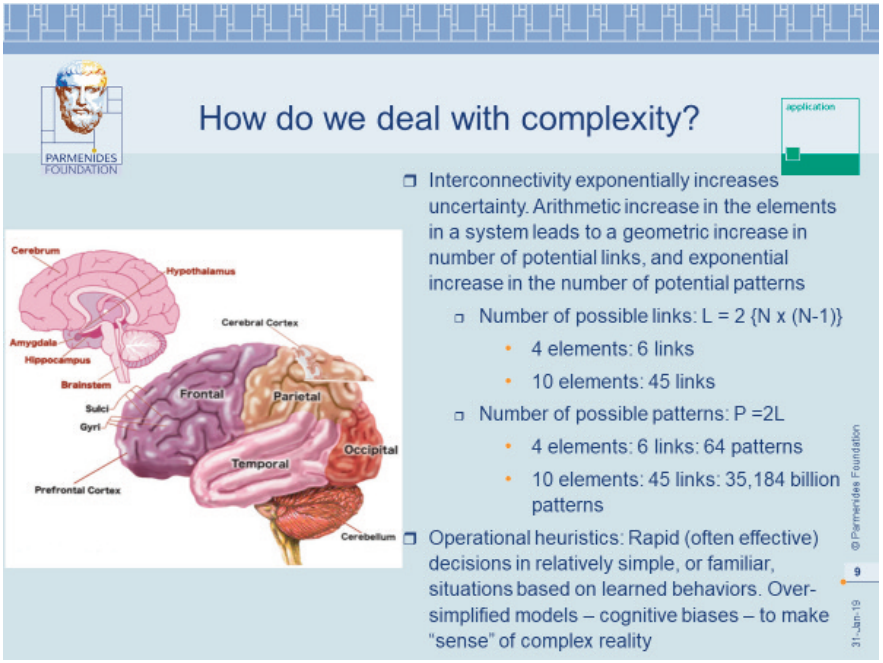


We cope by relying on heuristics. What is a heuristic? It is a learned behavior, premised on something that we have done before. When any of us walks into a room like this and finds a laptop there with a projector next to it, and a screen over there, a microphone, and a group of people sitting in chairs, you know what is expected of you. You do not have to calculate carefully because you've been in this sort of situation a thousand times and know that you are supposed to say something sensible and amuse the audience.

That is how policymakers operate; they apply learned rules derived from prior behaviors. They walk into situations that are largely unfamiliar, but which contain enough familiar elements to allow them to adapt, and they adapt. They do what they know how to do. Do they comprehend, grasp, analyze, and get a significant grip on the current reality? Of course not. It takes so long to learn, and the rate of obsolescence of new knowledge is astronomically high.

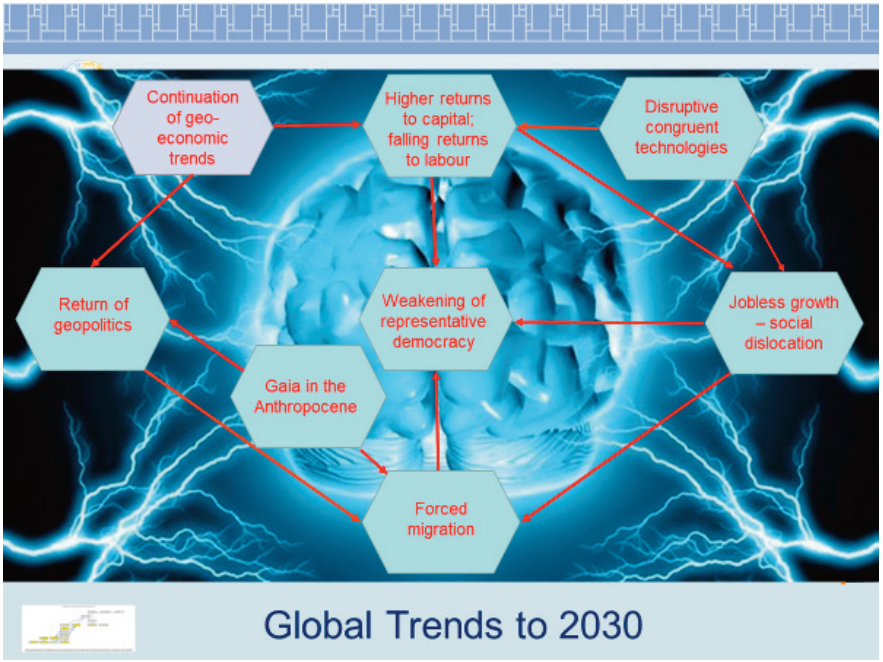
For the policymaker, who is not a specialist in any discipline, this is a nightmare. Making do until the next election is often the best one can do. Take Teresa May's management of the Brexit decision, I am not being disrespectful; in fact, I think she has displayed phenomenal courage. But she is just making do; she has no clue what would constitute an optimal outcome; she is just trying to survive. Mt Macron is not doing anything else by the way, nor is Mr. Juncker; each just keeps on going.

So, what do we know about the challenges of the future?



The population is around about 7.7 billion at present and it is heading for something like 9.3-9.7 billion by 2050. There is accelerating urbanization, 90% of which is taking place in Africa and Asia, not in Europe or the US, with urban populations estimated to reach 67 percent of the total human population by 2050. The population is also aging in all developed economies, and in China. Only sub-Saharan Africa and the MENA region will have a majority of their populations in the 18-65 bracket by the middle of the century. This will pose new challenges: four generations will be seeking economic returns for work at the same time. We are also experiencing the conflation of remarkable transformative technologies emerging in parallel and cross-fertilizing one another. Information technologies, bio-technologies, Nano-technologies, neuro-technologies and cogno-technologies are challenging our assumptions about epistemology, and even human ontology.

What trends can we see?



The first is a geo-economic trend that is causing chaos on a geopolitical level: The U. S. and Europe are declining as units of economic output in relative terms, while China, India, and certain other parts of Asia are rising. The center of economic gravity has shifted from the Atlantic to the Pacific. This is a secular trend; it will be with us for the next 20 years or so, but on many levels, there is great unease about it, particularly in the US. Think about the references to the so-called Thucydides Trap, which those of you who remember your Greek history, will know was about the rise of Athens relative to Sparta, that generated fear and tension within the antique world and, in the words of Thucydides "…. made war inevitable".

The second trend is in a completely different realm. For the last 30 years we have seen increasing returns to capital and declining returns to labor. As a result, there has been widening inequality in society, leading to tensions and pressures on many levels.

That problem will be exacerbated over the next 20 or 30 years by disruptive, congruent digital technologies, biotechnologies, nanotechnologies and neuro-technologies. The only people who will be able to derive significant benefits from these new technologies are those who have ownership of the technologies, and those who are young, smart and educated enough to be able to capitalize on the opportunities they present. Huge numbers of people will be stranded as a result of this bio-digital transformation. Look at events between 1780 and 1860 - the period of the first Industrial Revolution – and reflect on the level of social and political disruption that it occasioned across the European landscape.

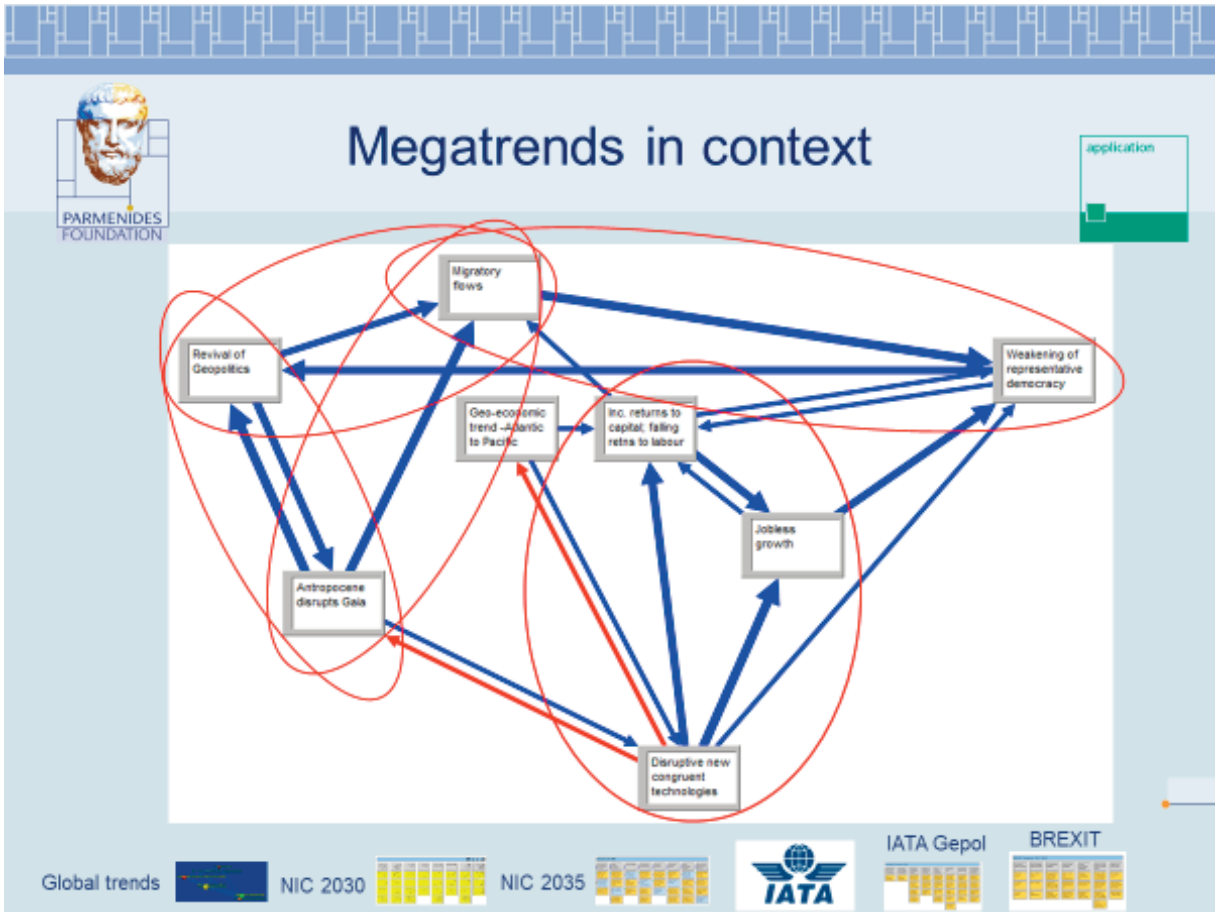
One of the consequences is jobless growth and increasing social dislocation that unsurprisingly is leading to a weakening of representative democracy. Firstly, governments cannot meet the expectations of their electorates; they cannot provide protection in economic downturns and cannot take credit for surges in economic opportunity because both upswings and downswings are now largely the product of the global economy, not any national economy. So, the appeal of representative democracy and the governments it produces, has declined. Every political system is the product of its age and the emergence of representative democracy was the product of the late 18th century and the Industrial Revolution in the 19th, which saw a shift from *sovereignty of the sovereign*, to *sovereignty of the people*. Direct democracy was not possible, however; you could not get all the people into the Agora in the way you could in Periclean Athens, not even in the thirteen states of the United States after the adoption of the Constitution in Philadelphia. So, we came to elect people to represent us. But that is not necessarily the best form of government, and it is not necessarily the form that will define the next 50 years.

Meanwhile, gaps in the security architecture established after WW II have seen the resurgence of geopolitical tensions on a significant scale. We have seen this in the area from the Mediterranean through Central Asia over the last ten years or so. We have seen it in Russian revanchism and Mr. Putin's desire to control Russia's "near abroad" which is creating tensions in Eurasia; and we are seeing it, though it has not yet caused a crisis, in the South China Sea and the East China Sea where Russia, China, the Koreas, and Japan all intersect without a regional security arrangement in place. So, geopolitics is back on the map and we do not have instruments available to deal with it sensibly.

All these factors together have led to the problem of forced migration. Most people are in favor of migration – you want access to skills in a global economy and not all those skills are available among your own citizens. What you do not want is 600,000 people arriving at the border tomorrow when you don't have the means to accommodate them within national economic or social structures. Forced migration, which is the product of rising inequality, inability to provide for national citizens, and geopolitical tensions, is thus a threat to the entire system.

Finally, we have 7.7 billion people pushing up against planetary boundaries on every level, because we are producing more, consuming more, and wasting more today than humanity has ever done. Before 1930 there had never been 2 billion people on the planet; we now number 7.7 billion. Between today and 2050, more people will move into cities then existed on the planet before 1930. We are pushing up against planetary boundaries in an integrated Earth system, with unintended, and potentially perverse, consequences.

Let me show you the problem:

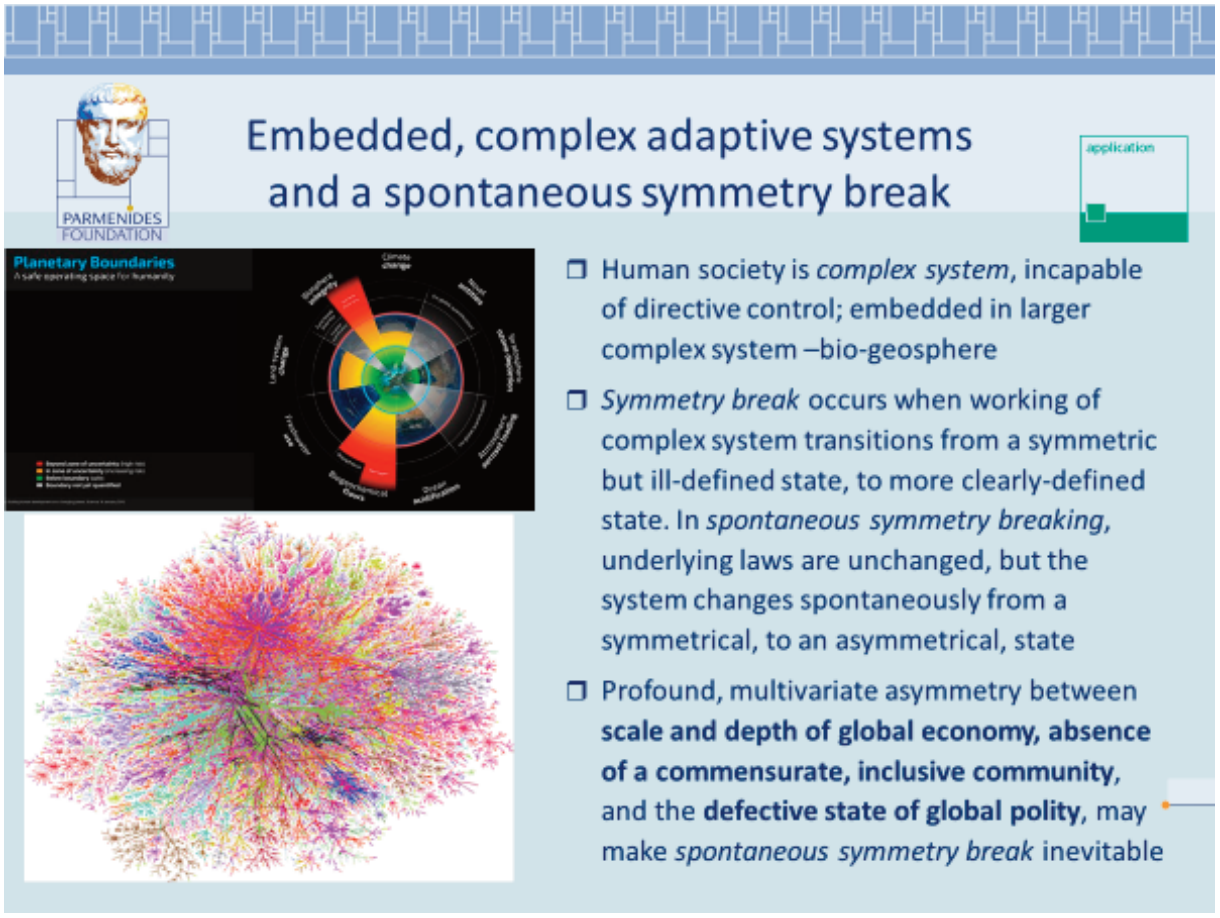


These are not isolated phenomena, geopolitical clashes and migratory flows are closely related, and each exacerbates the other. The increasing returns to capital and falling returns to labor, jobless growth, and disruptive technologies reinforce one another. Any one of them drives the migratory flows and the weakening of representative democracy that one can see all over Europe at present, and arguably in the US as well. Geopolitical clashes, leading to forced migration, clearly exacerbate the pressure that humans bring to bear on the bio-geosphere, or earth system.

It is likely that climate change will lead to significantly greater migratory flows in future impacting on all parts of the system. All elements affect all other parts of it; that is the challenge.

Now think about how difficult it is for a policy maker to devise policies that address the whole system. When you look at it analytically, the social impact of the new congruent technologies and the fact that we are pushing up against global earth system boundaries while geopolitical stresses are increasing, quite naturally leads to increasing returns to capital and falling returns to labor, jobless growth, greater migratory flows, and a weakening of representative democracy. Unless one understands the whole, one cannot deal with any significant part of it. Most policymakers deal only with fragments of this complex reality; they do not deal with the whole; they do not

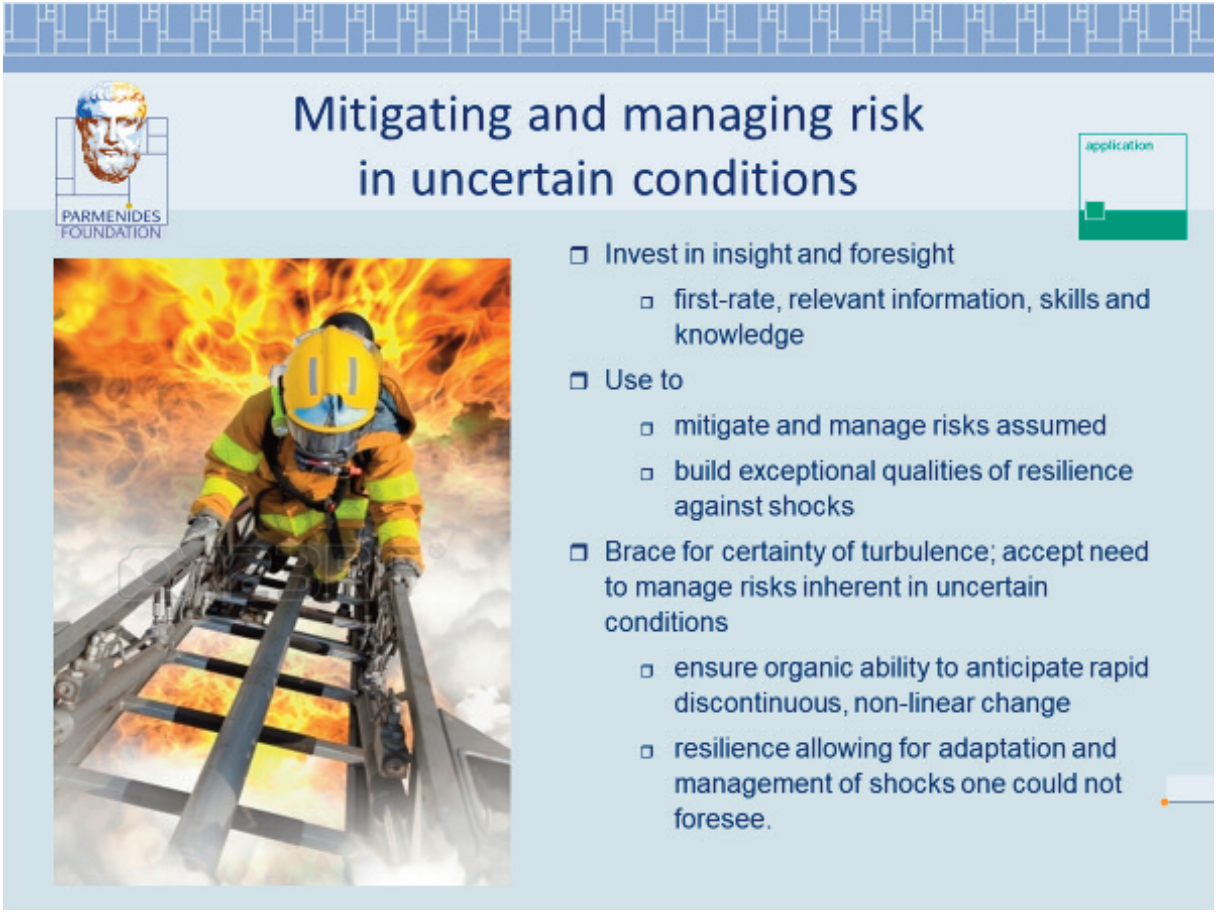
have the resources to do so; too few people understand the whole and can advise them comprehensively. Because of the time paradox – the depth and complexity of knowledge and its increasingly rapid obsolescence – few can learn enough to develop policies which will satisfy citizens who increasingly, due to social media, have come to expect instant gratification. If I crowdsource ideas for the solution of a problem, I can get 15,000 ideas very fast. I might even be able to crowdsource the funding to implement them. But that is not how political systems work. Therefore, translating the expectations of millennial and even younger generations into policies that can address the complexity of these challenges is a bit of a nightmare.



We must grapple with the fact that we have become hubristic. *Hubris* leads to *nemesis*, and we have been guilty of *hubris*. We have created a highly connected global economy with global financial institutions and global value chains. The levels of connectivity through air travel and internet traffic show that we did it without understanding the implications. The easiest way to think about this is to take Tom Friedman's metaphor of the "global village". Those of you who know something about villages know that in a village the economy and the society are commensurate: the economy works for the benefit of the society on the scale of the village. The polity needs only to intervene at the margins to avoid, manage and resolve conflict. This works rather well, but on a global scale, and even on a European scale, things are rather different: The global economy is highly integrated, but the global "society" is fractured. The same is true at the level of Europe. The polity must thus intervene continuously to address challenges, and often does not have effective or appropriate instruments to deal with the challenges.

I hope we will be able to discuss solutions while we are here. There are no silver bullets, but engineering for sustainability, circularity and inclusivity is clearly necessary.

Meanwhile, the only way to mitigate and manage risk in conditions of extreme uncertainty is firstly, to invest in insight and foresight, by learning as much as possible about the challenges we face, whether one is a concerned citizen, a specialist, or a policymaker. One must try to understand the workings of the system and apply that knowledge to mitigate and manage the risks that one assumes. Secondly, one must build in as much resilience as possible against shocks, because turbulence is endemic in the situation we face at present.



Organic entities are evolutionarily adapted for resilience in the context of their environments. Humans are quite resilient – you can knock me down three times, and the odds are that I will get back up. I will almost certainly survive a fall from two stories; I may break a few bones, and I will certainly hurt for a few days, but I will probably survive.

Evolutionary biology indicates that species become progressively more resilient over time under boundary conditions. The challenge we face in developing social and political institutions that are fit for purpose, is thus to design and implement them to exhibit as much organic resilience as possible in the conditions of uncertainty endemic in our environment. Revolutions occur because institutions are unable to adapt to rapid economic and social changes. Extinctions occur because species cannot adapt to rapid to rapid and highly significant changes in the environments in which they flourished. We need to plan for, and develop, appropriate and organically flexible institutions that suit our present and emerging reality.

Climate Change: Dying Canary in the Coal Mine

András Gelencsér

I would like to talk about one aspect of global climate change because in the past I had several talks with a more general approach to this issue. Let us begin with some basic facts regarding the state of the atmosphere – in particular its composition. This is a rather peculiar representation of atmospheric composition, because students normally learn about the percentage composition of the atmosphere, but this table shows the absolute amounts of the major and minor atmospheric constituents.

State of the atmospheric composition

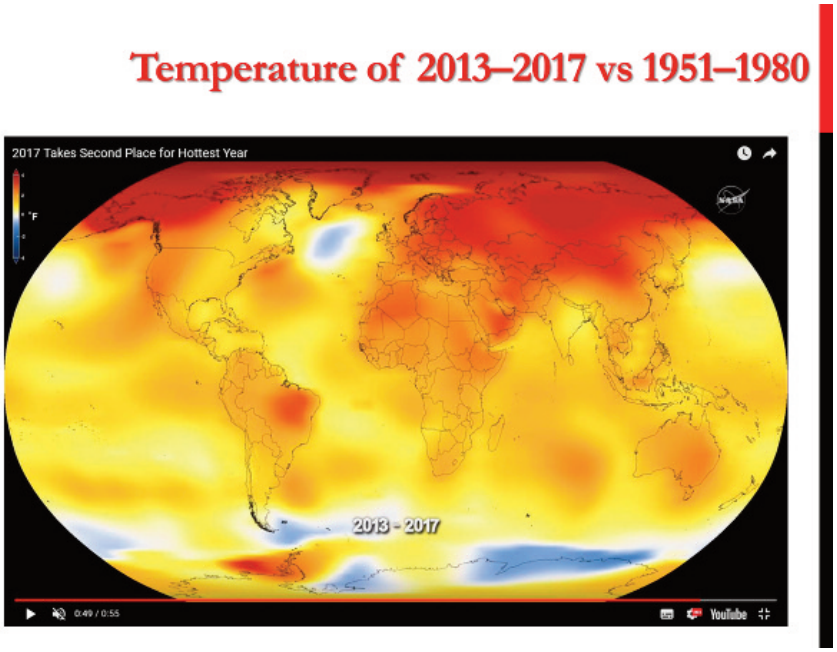
Component	Global amount (billion metric tons)	Change since 1750 (%)
Nitrogen	4 020 300	0
Oxygen	1 233 700	−0,05
Water	13 800	0
Carbon dioxide	3 240	+43
Methane	5	+250
Sulphur dioxide	12	+300
Dinitrogen oxide	2,6	+14
Ozone	2,7	−4

This shows an immense atmospheric mass of course, but what is more important is that it has suffered tremendous change since the Industrial Revolution. If we look at the third column of this table, we see that even the amount of oxygen has been reduced by a measurable amount, and also the considerably reduced amount of ozone, which is a crucial component in the Earth's life. In the context of climate change, we most often quote the considerable increase in the concentration of carbon dioxide and other greenhouse gases and these atmospheric changes are the primary causes of the changes that we observe in the atmosphere. The concept that underlines climate change was established at the first World Conference on Global Climate in Geneva, Switzerland in 1979 when, in that year, satellite measurements of most of these phenomena began. At that time, scientists did not know as much about the changes that we know today.

The 1979 conference articulated a simple approach to make people aware of the potential changes that would likely happen, and this was the introduction of the greenhouse concept which turned out to be not very useful for understanding the basic processes of climate change. This greenhouse concept was accompanied by a key derived parameter, that is the global mean temperature which does not mean anything. It does not exist. You cannot measure directly global mean temperature and from that follow that global warming becomes a kind of expectation, like in a greenhouse or in a car left in the sun. If this concept were that simple, we would expect quite

a uniform increase since greenhouse gases, when mixed in the atmosphere, are homogeneously distributed and would affect similarly at different locations around the world.

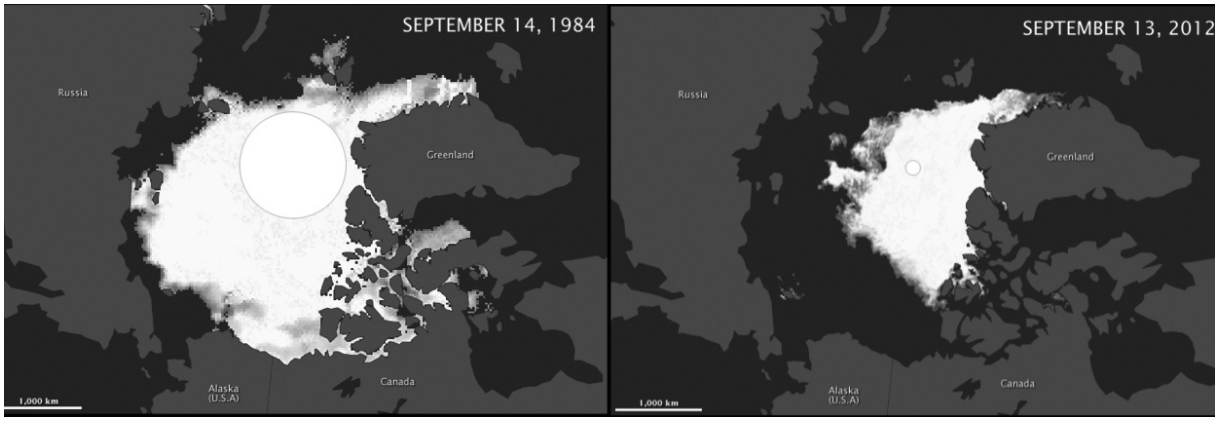
If we just rely on greenhouse effects and greenhouse gases, then we would expect a kind of uniform warming all around the globe, but what we observe instead is a rather non-uniform pattern of warming which is shown here in a representation showing most recent temperatures versus the average temperature of the middle of the second part of the 20th century.



The red color represents an increase of 4 degrees, yellow is about 2 degrees, and white is no increase, blue registers some cooling We can see from this map that there is no uniform warming of the globe. There is very pronounced warming at high latitudes in the north and relatively less in the southern hemisphere.

The reason for such a non-uniform warming pattern is that the greenhouse concept is an imperfect representation of the processes that are taking place on Earth. A more realistic model of how the world is affected can be pictured as a cocktail containing ice cubes and this model is more realistic because liquid water covers 2/3rds of the Earth's surface in oceans, and ice at the poles and at a high altitudes. If I present this model to schoolchildren and I ask them what changes they would expect if we expose this system to heat, they all say that the first and most spectacular phenomenon of what the change will be the melting of ice. They did not mention that the air temperature above the glass would increase. They just said that the ice would melt.

We focus on ice because it is a kind of indicator of the changes that are happening on earth. Regarding the changes in the cryosphere, ice on the pole, especially on the North Pole, we are witnessing a very significant reduction in the volume and the areal extent of the ice. We could state that sea ice is the most vulnerable part of the cryosphere in the Arctic Ocean and it is actually collapsing.

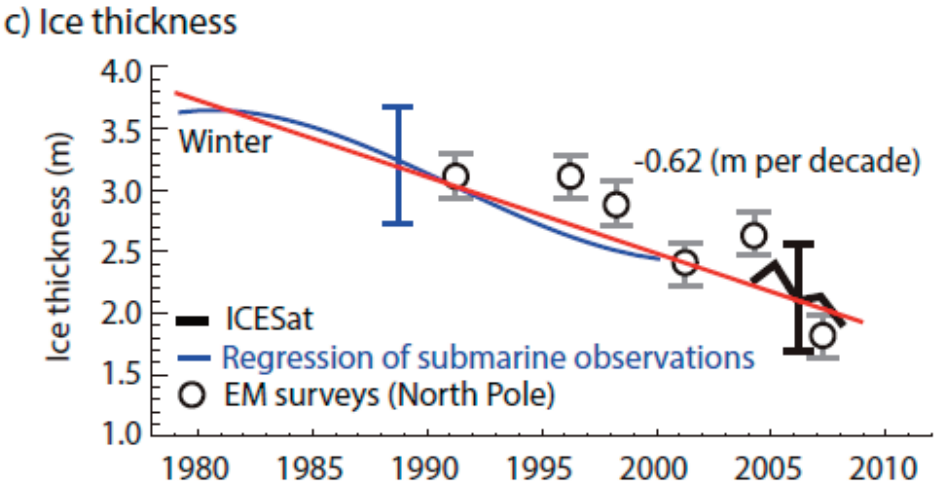


If you look at the two figures, the first one was taken in 1984, just 30 years ago. It shows the late summer areal extent of the sea ice over the Arctic Ocean. The left figure was taken in 2012, less than 30 years later and there is a reduction of 40% between the two. So, the late summer ice was reduced by 40% in 30 years.

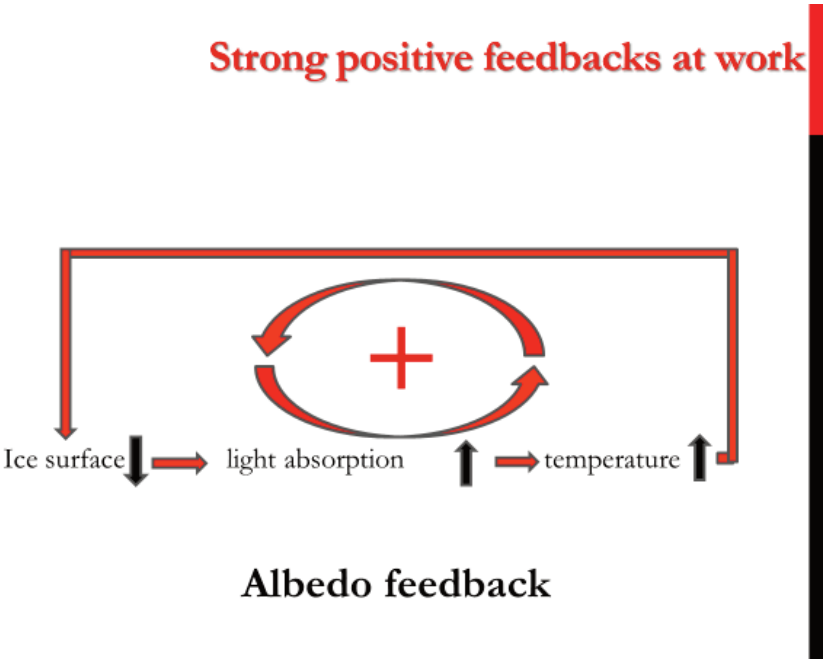
These are geological changes over a very short time scale. This rate of decrease is unprecedented in the history of the earth, so this is really a very pronounced change that we are witnessing. This is easy to observe because there are satellites that look at the state of the ice from a geostationary orbit and we can monitor the changes that are happening in the cryosphere and the state of the ice daily. If we put these changes in the context of a time span of 1,500 years, then we see that these changes in the cryosphere are really abrupt and unprecedented. Of course, the data from the past are proxies, and are just reconstructions from geochemical and other observations but they are quite reliable. There is a range of uncertainties which is shown in the gray shaded area, but apart from this we see a pronounced drop in the volume of the area of the sea ice over the Arctic.

There is another process that is not seen from the space. This is the thickness of sea ice over the past 40 years. These observations are relatively recent because nobody in the past dared to go under the ice sea in the Arctic. Today there are many possibilities to make these measurements either from satellites, geophysical measurements or by drones. Nobody has to risk their life to go under the ice and they can make the measurements. These measurements show the average thickness of sea ice over the Arctic within the last 40 years. Starting from 4 meters on average, it is now about 2 meters thick. If we combine the area reduction with the thickness re-

duction then we just come to the conclusion that 70% of the volume of ice or mass of sea ice has disappeared within 40 years. This is a tremendous change given that there are tens of thousands of cubic kilometers of ice sea ice over the Arctic, and ice covers more than 10 million square kilometers of the Arctic. We are talking about tens of thousands of cubic kilometers of ice – so it is an immense volume of ice that has disappeared recently.

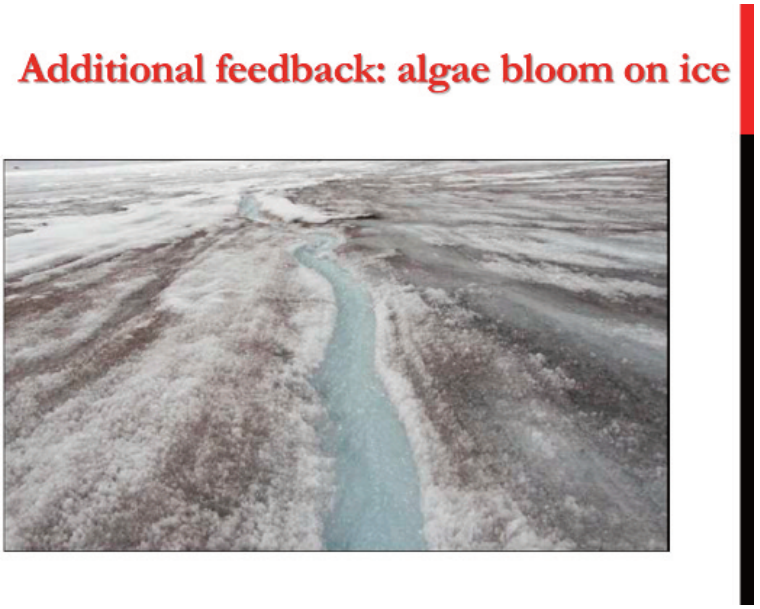


How can such a large and robust environment lose so much within a few decades? The reason for this is not just in the triggering effect of increase in greenhouse gases, but also a positive feedback that is linked to the physical behavior of ice. These 'positive feedbacks' are a kind of reinforcing mechanism that help accelerate processes that are initiated by other external factors. The most well-known feedback is the albedo feedback when the ice surface starts to shrink and exposes more dark surface water and the absorption of solar radiation is increased when ice is replaced with water, which means that more solar energy is absorbed.



This means that the temperature increasing which also feedbacks to further reduction of ice surface. This is a kind of accelerating and reinforcing mechanism that is very effective. It was the underlying mechanism in the Pleistocene, in the variations of the inter-glacial and glacial periods, that was the main factor behind these variations, but these were much slower than the processes that we observe today.

There are additional feedbacks which are less known but also important. This is how the ice looks in the middle of Greenland. In the middle of nowhere when it is expected to be bright, white, pure, and very clear, it looks like some dirty snow in the city. This is not only atmospheric pollution that is deposited on the surface of the snow which also happens and contributes to the darkening of snow (and has an albedo effect the same way as the disappearance of ice), but these are atmospheric deposits. For example, smoke plumes from forest fires provide nutrients for algae growth which make the snow surface darker. Cryo-algae have a color that reduces the reflectivity of ice and adds extra solar energy to surfaces. This is the kind of process that can be observed in recent years and looks to be accelerating.



Another feedback is the increasing temperature and changing conditions over the Arctic Circle caused by boreal forest fires. This year there were vast boreal forest fires in far in the north over the Arctic Circle. These forest fires contribute to pollution, dark deposits, and contribute to a kind of feedback mechanism that accelerates these processes. Actually, the frequency and the area exposed to forest fires or consumed by forest fires has quadrupled during the last two decades in Canada, Siberia, and Scandinavia.

There are additional mechanisms which are just starting to show up, and these are: a potential greenhouse emission from the thawing permafrost layer. Permafrost means frozen ground. Frozen soil covers a pretty large area over and around the Arctic Circle and it is melting. The permafrost boundary has already moved 80 kilometers north, exposing large areas to thawing. The permafrost contains a lot of carbon that was isolated from the atmosphere because the soil was frozen, but when it heats up, the carbon that is stored in the permafrost is liberated and it directly enters the atmosphere. This contributes to the greenhouse effect by emitting methane and carbon dioxide. This also liberates viruses and microbiology that was just frozen for thousands of years in the permafrost, and there are other examples of the sort of dangers that arise from this process.

Finally, just have a look at why Arctic ice is so important, in fact I would say it is globally important. One might think that this is just a local phenomenon and it just influences people living there, or polar bears, or some species far in the north. Actually, Arctic ice is more important than it may seem to be at the first sight because this large volume of ice is a key parameter in atmospheric dynamics in the Northern Hemisphere. Atmospheric circulation in the Northern Hemisphere relies on the stages of ice because much of atmospheric circulation starts from far in the north, and then moves southward or eastward. It is a kind of air conditioning for most part of the Northern Hemisphere, and the volume of ice up in the far north changes the situation in lower latitudes, having a global impact. As we have seen, this area in the North is very close to the area where the engine of the global oceanic circulation operates. This is the driving force for the whole conveyor belt, the great oceanic conveyor belt that carries heat and nutrients all through the worlds' oceans. Therefore, this is really a critical point. This is one of the main drivers or engines of the global oceanic system and it is located close to the Arctic Ocean where the ice is located. What we can state, based on the importance of Arctic ice in the global climate, is that we are exposing ourselves to the danger of a potentially disruptive climate change. If something happens, for example, with oceanic circulation and it stops, this would just cause a very abrupt transformation of the global climate as we currently know it.

According to physical models, this disruption can happen within a few months, so the whole oceanic conveyor belt can stop within a few months and it takes thousands of years to regenerate. It is really a danger that the loss of ice at this high rate will cause disruptive climate change in the future. This is not a prophecy, because I think our understanding is limited to predict when and how these changes will occur, but this is a physically feasible process that can happen any time in the future. I think that we have risked a lot by changing the conditions that we have gotten used to over the world, and this will have profound social and economic consequences.

Energy and Sustainable Development

Laszlo P. Csernai

The term *Sustainable Development* is used frequently for rather different goals. Here we recall the fundamental, natural science definition based on the laws of physics. I show how one can apply this definition quantitatively for natural, technological, economic and social processes with a few examples. In the last century, the population of the world quadrupled, and the use of fossil energy increased by more than an order of magnitude and the economic production of goods increased by a factor of twenty. In view of this, the question is how we can satisfy the needs of an increasing population at a given or improving living standard, while we are constrained by limited territory and limited material reserves.

Sustainable Development

The challenge confronting us is how to ensure continued sustainable development in the future. A frequently quoted definition of sustainable development is given in the Brundtland report "Our Common Future" (1987). This definition states, "Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Technology and social organization should conform to the environment in meeting present and future needs. Some people and some organizations argue that this can be reached only by placing serious limitations on technology and living standards. The definition does not specify what the needs of future generations are. These cannot be the same as that of earlier generations because then we could not speak of development. Some prefer to use the term 'sustainability' that hides the goal of development. We should emphasize that we aim for development and not for sustainable stagnation or sustainable degradation.

A particular concern relates to energy resources that are very dominant as an essential input in all kinds of economic activity and in life in general. Energy is the seventh of the UN Sustainable Development Goals (SDG), with the objective to "ensure access to affordable, reliable, sustainable and modern energy for all". At the outset, we clearly seem to have sufficient energy available by using, directly and indirectly, the energy derived from the Sun (such as solar radiation, wind, water and fossil materials), gravitational energy in tides, and nuclear energy in fission and fusion. Taking proper advantage of these sources, societies would not necessarily have to change their values and goals. We are confident that development can be made sustainable the same way as in previous centuries and millenia with finite material resources and on finite territory.

We have had limited resources and territory for a long time on Earth. About 3.8 billion years ago, life appeared first in the form of single-celled prokaryotic cells, such as bacteria. Since then the matter on the surface of the Earth has undergone a continuous development in the direction of increasingly complex biological, technological and social organisation. This development continues even today, although from time to time worries surface that there are limits to our growth. History then regularly falsifies these worrisome prophecies. Interestingly enough, not all of our resources are limited, even on a scale of many billions of years.

We discussed the subject of sustainable development already at the 2nd European Blue Sky Conference in 2015, so this is not a new problem. Erwin Schrödinger, who invented quantum mechanics, in his book, "What is Life" (1944)[3] already, discussed this problem of development, with finite

3 Erwin Schrödinger: What is life? - The Physical Aspect of the Living Cell, (The Cambridge University Press, 1944) Based on the Lectures delivered under the auspices of the Trinity College, Dublin, in February 1943.

material resources and finite space. He concluded that development is only possible in the direction of increasing Complexity (he used the term "orderliness"), that is, with decreasing entropy. Furthermore, he pointed out that development is only possible if it is based on already complex material ingredients, which are then converted to even more complex ones. These development processes are frequently connected to others, which induce an increase in entropy. The materials, which represent this entropy increase, should be removed from more complex systems. In his time, Schrödinger could not show or calculate how these processes work, but we now have sufficient knowledge. In a recent article, it is quantitatively shown how this development takes place with special attention to the chemical and biological development.[4]

Material or tissue	**Entropy, S, for 1 kg [J/K°]**
H_2 – ideal gas hydrogen	$58.3 \cdot 10^3$
H_2O – water vapor, ideal gas	$8.24 \cdot 10^3$
H_2O – liquid water, T = 100 C°	$4.43 \cdot 10^3$
H_2O – liquid water, T = 0 C°	$3.12 \cdot 10^3$
H_2O – water ice, T = 0 C°	1900.2
UF_6 – Uranium-hexa-fluoride, ideal gas	513.2
C_{60} – Fullerene, ideal gas	263.2
DNA molecule* of Candidatus Carsonella ruddii (CCr)	$1.79 \cdot 10^{-96105}$
Human DNA	$3.96 \cdot 10^{-1\,974\,000\,000}$
One state of the Human brain tissue	$\sim 10^{-301\,000\,000\,000\,000}$

*DNA molecule of the smallest bacteria, with only N = 159 662 base pairs.

Table 1. Based on ref. [2]. The development of the complexity of materials quantitatively presented by the decreasing entropy of 1 kg matter or tissue. In case of the DNA, there are different possible, non-lethal, sequences, (Polymorphisms) that should be added up. Furthermore, the spatial configuration of the DNA changes at different stages of cell development: the DNA can be curled up into the 23 unique shaped compact chromosomes, or it can be stretched out for replication. In this second state, the entropy of the same molecule is significantly larger. For the Human nervous system, the unique determination of a single physiological state is also uncertain, and to count the possible brain microstate corresponding to a given well-determined macro-state is highly problematic, especially if we are including the vegetative nervous system. Just as for the DNA, the status of the brain permanently changes including also the change of the entropy of the system. This entropy change requires of course energy, which causes the approximately 50W energy consumption of the brain. The same methodology can be applied for technological development, and even for the development of economic or societal structures.

As Schrödinger showed, sustainable development should be based on the highest level of development thus far, and that should not be constrained (such a constraint, usually leads to extra entropy production). Although, there are attempts aiming to constrain our needs and demands in the name of sustainable development,[5] but these are erroneous, as they point to the direction of a previous lower stage of development. This attitude is usually coupled with a mistrust in technological development, which is generally harmful and counterproductive. In history less developed countries often surpassed neighboring societies that constrained their own development for a longer period. This in most cases led to the disappearance of these societies. The ancient Roman Empire is an example.

The next fundamental question arises when we observe the increasing complexity and decreasing entropy in the world. Is this a new phenomenon, or does it follow the laws of physics?

4 L.P. Csernai, S.F. Spinnangr, S. Velle, Quantitative assessment of increasing complexity, *Physica* A 473 (2017) 363–376, arXiv: 1609.04637.

5 H. Verstappen, Planet Earth and Humanity, *European Review*, 25, 688-697 (2017).

According to our everyday experience, closed systems deteriorate with time which means that their entropy, i.e. disorder, increases.

Do we need new laws of nature to explain development? Schrödinger also observed and discussed this problem. He concluded that mechanical systems exist that do avoid entropy increase for very long periods. He used the example of mechanical clocks. He concluded that new physical laws are not needed to describe development in the direction of increasing complexity or decreasing entropy.

The fundamental concept of entropy is tightly connected to energy, E, and temperature, T, which are also widely and intensively discussed subjects today. The physical definition of entropy change, ΔS, is yielded by the amount of absorbed energy by the system, ΔE, divided by the temperature: $\Delta S = \Delta E / T$. This formula explains that the development on Earth is caused and governed by external conditions.

The energy arriving from the Sun and the energy radiated out by the Earth are nearly equal, but the temperature of the incoming solar radiation is high, $T_{in} \approx 6000$ K, while the Earth's radiation is at much lower, $T_{out} \approx 300$ K. Thus, the change of the entropy of the Earth is, $\Delta S = \Delta E / T_{in} - \Delta E / T_{out} < 0$, i.e. negative. Entropy is decreasing. In other words, the complexity of the matter on the surface of the Earth is increasing. This arises from the external conditions of our planet, and due to the fact that the Earth has an atmosphere, with water on its surface in three phases: ice, water and vapor. This acts as a thermostat keeping the temperature on Earth stable, and the reflected radiation at a lower temperature can take away more entropy than the radiation arriving from the Sun.[6]

These external (boundary) conditions make it possible to decrease the entropy of the Earth; in fact, this boundary condition enforces a decrease in entropy and increasing complexity. Thus, new laws are not necessary. Nevertheless, the largest massive development on the Earth is connected to energy production, or more precisely, to the conversion of energy to a form, which is usable for our purposes. We use the word *conversion* (instead of transformation) to indicate that losses are included in the process.

Energy

Most of the energy we use originates from the Sun, the so-called renewable energies (RES), like solar panels, wind turbines, water power, as well as the fossil fuels arising from historical solar radiation and biofuels from more recent solar radiation. In addition, tidal power plants exploit gravitational energy, but their role is modest. Finally, the potentially most important source is nuclear energy. This can be in the form of fission power plants, fusion power plants and in natural form in geothermal energy. Most of these energy conversion processes are entropy-increasing processes, with very few exceptions, like the *photosynthesis* and the *nuclear fusion*.

In the case of *energy conversion* processes, the *efficiency* of the process is the decisive aspect and not necessarily the increase of complexity. Still, if we do a quantitative analysis, we have to avoid the destruction of highly complex materials for energy production. *Consequently, biofuels cannot be considered as a sustainable way of energy production*. This is a process, which very strongly violates the rules observed by Schrödinger: that complex material should be the basis of further development toward even more complex products. Burning such materials does not serve sustainable development. One should not use biological materials as fuel, but rather, as food or fertilizer.

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6 L.P. Csernai, I. Papp, S.F. Spinnangr and Yilong Xie, Physical Basis of Sustainable Development, *Journal of Central European Green Innovation*, 4, 39-50 (2016), arXiv: 1612.06439.

Another energy-related fundamental issue is the difference between *heat* (thermal energy) and *mechanical energy*. Mechanical energy can be converted to heat with *100% efficiency*, while heat cannot be converted to mechanical energy without loss. Thus, mechanical energy is more valuable for us. The word 'mechanical' of course covers several forms of energy, like electric energy, water energy, kinetic energy of motion, etc. For historical reasons, the dominant energy production or energy transfer process uses fossil fuels and can have an *efficiency* of as little as 30%. When we convert heat energy to mechanical energy, we take heat from a higher temperature *heat reservoir*, a *heat engine* converts part of it to mechanical energy and the rest is released to a lower temperature *heat reservoir*. Next, we will review different common energy conversion processes from the point of view of entropy production, which is the same as the efficiency of the conversion. If the conversion efficiency is less than 100%, the loss directly or indirectly leads to heat released to the atmosphere or to the water of lakes, rivers or seas. Sometimes, part of this waste heat is used for heating in colder climates, which is practical, but leads to entropy and heat production anyway.

Heat Engines

The heat produced by fuels can be converted to mechanical energy in "*heat engines*". The efficiency of this process is determined by so-called Carnot efficiency, which is rather low: about 30-40% for most heat engines. The coal, oil, gas, and other power stations, diesel, gasoline, LNG, and hydrogen burning engines, in cars, trains, ships, etc. belong to this category. This efficiency even applies to the heat engines (usually steam turbines) in nuclear fission or fusion power stations (although the fusion process is entropy decreasing itself, contrary to oxidation).

From the point of view of physics, burning bio-fuels belongs to this category, and it is even worse than other fuels, as bio-fuels are more complex and their burning leads to an additional very high entropy increase because of their initial low entropy. Whether bio-fuels can be reproduced by agriculture at shorter or longer periods is irrelevant as the whole life cycle of this energy production is negative.[7]

Renewable Energies - Natural forms of mechanical energy

Unfortunately, the term 'Renewable Energy' is highly misleading as energy is conserved. It is available continuously on our timescales usually due to solar radiation as source. (The exception is geothermal and tidal energy.) Solar energy on Earth leads to many natural forms of mechanical energy, river flow, waves, wind, water from precipitation to high altitude reservoirs, monochromatic electromagnetic radiation from solar radiation, etc. These can be converted to usable forms of mechanical energy with nearly 100% efficiency, if we have the adequate technology. Unfortunately, not all currently used technologies are optimal.

We have seen earlier that entropy has a specific role in sustainable development, as it requires entropy decrease, while excess entropy is radiated out from the Earth to the universe. Energy conversion processes are all producing some waste heat, which should be radiated away to maintain sustainable development. As a consequence, we should minimize waste heat production, which is the same as entropy production. In energy conversion processes most of the entropy production appears in form of heat, which can be radiated away. Still some part of extra entropy resides in the material of exhaust, dust, smoke, waste materials of low complexity and high en-

7 Laszlo P. Csernai, Science, Energy and Sustainability-2018 (The role of Water), Keynote Talk at the 25th International Energy and Innovation Forum (NEIF), Aqua World Resort Hotel, Budapest; organized by the SUNWO Zrt, Budapest, Hungary.

tropy. These cannot be radiated away; these remain on the Earth and are harmful for the environment.

In order to compare quantitatively different energy conversion processes, we take a typical amount of the initial energy of E = 1 TWh = 3600 TJ. (The average household electricity use in the US is about 11,700 kWh each year, so 1 TWh is about the consumption of a settlement of 100 000 family houses in the US, and this is the one-month production of a modern nuclear power station.) If this energy is directly converted into heat at T = 300 K ambient temperature, the resulting entropy production is $S_{Th} \approx$ 12000 GJ/K (Giga Joule / Kelvin)[8]. As discussed above the direct heating by traditional fuels produces this amount of entropy. When 1 TWh initial heat energy is converted to mechanical energy with heat engines, we have the Carnot efficiency, which is in the range of 20-40%. Consequently, their waste heat production is ΔS = 7000-9000 GJ/K. and the resulting mechanical energy is 0.2-0.4 TWh. There are only moderate differences among the different realizations of this type of energy conversion.

Conversion of Natural Mechanical Energy

Let us start with the best example, the use of kinetic energy of water in rivers, lakes, reservoirs, etc. Water turbines have been developed for centuries and they can now reach a very high efficiency of η = 90-97%. The waste heat is minimal, just as the produced entropy, which is few percent of S_{Th}.

Water Energy

From rain, water is led to reservoirs on rivers or mountains and one can have substantial adjustable energy and energy storage. With enclosed turbines in different water power stations (WPSt) we have a continuous production of energy. A few examples are: the Three Gorges Dam 22.5 GW (103 TWh/yr) 2014 China (largest existing WPSt), the Itaipú Dam 17 GW (90 TWh/yr) 2016 Brazil & Paraguay, the Grand Inga Dam 39 GW, and the DR Congo (planned).
From ocean tidal currents (wave of 54cm in height), regularly changing energy production is in enclosed turbines: Rance Tidal Power Station 0.24 GW (0.5 TWh/yr) 1966 France, Sihwa Lake Tidal P.St. 0.254 GW (0.55 TWh/yr 1way) 2011 S.Korea, and Penzhin Tidal Power Plant 87 GW Russia (planned).

The water turbines are rather compact with very high-power production and efficiency. For different heights, different turbine configurations are used, like the Francis, Kaplan and Pelton turbines. The largest hydropower turbines (Enclosed turbines) are: A P= 767 MW Francis turbine at the Three Gorges dam, China, diameter: 10m, efficiency: η~94%. Loss ~ 6%, consequently the waste heat is $\Delta S = (1- \eta)\, P\, \Delta t\, /\, T$, small, (with T~300 K, ambient temperature); A compact P= 423 MW Pelton turbine in the Bieudron P.St. Switzerland, diameter: 4.63 m, efficiency: η =90-95%, loss ~ 5-10%, thus the waste heat is small. Large power and small size characterize these turbines.

Another way to convert water flow energy is via open underwater propellers and tidal sails (TS). Furthermore, for TS, in low viscosity water the flow remains largely laminar, and maintains its kinetic energy. This moderates entropy production. Thus, for 1 TWh the entropy production is ΔS = 100-1000 GJ/K.

8 We use the unit qualifiers kilo, Mega, Giga, Tera and Peta. Each is 1000 times larger than the previous one.

A big advantage of water energy is that it can be regulated in a wide range and in reservoirs one can store large amounts of energy for a very long time, even for seasonal storage, with negligible loss. This is needed to balance intermittent energies (iRES) (wind and solar) as well as constant energy production (e.g. nuclear) to varying load (varying consumption). In the case of rivers, this feature can be used also to manage floods and low water in droughts. These additional features of water power stations can be more important and more valuable than the produced electric energy. Thus, in countries where unexploited waters (rivers and lakes) exist, the installation of water power stations are highly beneficial (e.g. Norway or Hungary).

Wind Power

While water power stations have very high efficiency, negligible entropy production and their output can be adjusted to the demand perfectly, wind turbines and wind farms are much less optimal. Wind is intermittent, iRES, and can be utilized for wind-speeds in the range of v = 5 to 25 m/s only. A typical offshore floating windfarm the HyWind pilot park of Statoil, 25 km out of Peterhead in Aberdeenshire, Scotland has 5 floating wind-turbines with 6 MW of installed power each. The height of each turbine is 253m above sea level, their draft is 78m and the rotor diameter is d = 154m. (Compare this to the diameter of water turbines!) The tower of each turbine is made of 2200 tons of steel, and its ballast is 8100 tons of concrete. This material cost for 6 MW installed power is extremely high.

The nominal, 6 MW, installed production power is reached around 14 m/s wind-speed and it remains constant. At this wind-speed the kinetic energy of the wind crossing the rotor is 32.6 MW. At 25 m/s the turbine must be stopped to avoid its destruction. Up to this wind-speed, the rotor blade pitch is adjusted so that the rotation speed remains constant and the produced power remains at a maximum. At 14 m/s wind-speed the efficiency, compared to the kinetic energy of the wind crossing the turbine, is about 18%, but when the wind speed increases to the maximal 25 m/s, its energy increases tremendously (with the 3-rd power of the wind-speed, $\boldsymbol{v}^3$) to 185.6 MW. Its efficiency drops to 3%. This is much less than the Carnot efficiency for any fossil fuel or any kind of fuel. The rest energy in this case leads to turbulence, to large entropy production and to the heating of the atmosphere.

The question arises what part of this 97% loss leads to this heating and entropy production. Does it not remain in the kinetic energy of the wind? Pictures in humid air show a condensation cloud formation of a tremendous size. This condensation releases the large latent heat of water vapor condensation (opposite of cooking the same amount of water). Furthermore, the production of turbines in the second and third row of turbines is strongly reduced. This indicates that most of the loss is heating the atmosphere. This leads to ΔS = 9790 GJ/K entropy production at v = 14 m/s wind speed and to ΔS = 11600 GJ/K at v = 25 m/s for 1 TWh incoming wind energy. In this last case, almost all of the energy of the wind crossing the rotor will heat the atmosphere. The large entropy production, according to Schrödinger's definition, makes this energy production method the least sustainable at extreme cost.

Figure: Cloud formation in a wind farm in high humidity air. The turbulence behind the turbines leads to the nucleation of water droplets. The condensation releases the large latent heat of the vapor to fluid phase transition to the atmosphere. The size of the formed cloud indicates the level of atmospheric heating by the wind turbines.

Some other uses of wind power can be much more optimal, e.g. a large 45', America's Cup sailing boats with hydrofoil can reach 100 km/s speeds. These sails can be well adjusted to the wind-speed and lead to minimal thermal loss. Furthermore, the kinetic energy of the wind is directly converted to the kinetic energy of the boat, without additional losses of other conversion steps.

The intermittency is an additional reduction of the produced power compared to the installed power because when the wind-speed is not in the production range, the turbine does not supply any electric power. Thus, the produced power for a longer period is only 20-30% of the installed power. This is typical for iRES. In addition to intermittency, the usable production of iRES is even less due to the mismatch with consumption. According to a recent study in Germany, the used iRES power is only around 15% of the installed power.[9]

Due to the above reductions for 1.2 GW average production (average of a modern Nuclear Power Station) one needs about 1000 wind turbines. To avoid additional reduction of produced power these cannot be close to each other so the needed areal is ~ 1000 km^2. This indicates that the possibility of installation of wind energy is limited.

Photovoltaic (PV) Solar Energy: Solar panels are also intermittent, iRES, but the most recent ones can reach 25% efficiency, which makes them competitive, especially if they are installed on roofs or parking places. PV panels convert solar radiation to electricity. On the other hand, monochromatic EM radiation is a form of mechanical energy that can be transferred in wave

9 Laszlo P. Csernai og Jan S. Vaagen, Bærekraftig utvikling og energi (in Norwegian, Sustainable Development and Energy), *NATUREN* 2, 68 (2018).

conductors or coaxial cables with some loss, and it can be converted to electric energy also with a little loss. Specific, high gain antennas have high efficiency, with the most modern nano-technology, the solar radiation can be split up to frequency bands, amplified with moderate losses and an efficiency up to ~ 40% can be reached. These types of PV panels on the other hand are still very expensive today. In this best case, for 1 TWh incoming solar energy the extra entropy production is about ΔS = 7200 GJ/K, which is quite competitive.

Ocean, tidal energy: The same principles as water energy hold. Open and enclosed versions of turbines or sails exist. Enclosed turbines have better efficiency, while in open waters underwater sails in slower currents have an advantage. It is important to mention that water has 800 times higher density than air, thus the energy converting devices can be more compact.

Heat pump: To heat with electric energy. This reduces electric energy consumption about 3-4 times, for the same heat production. This is done with an inverse heat engine that heat from a lower temperature heat reservoir (outside air or water) is converted to heat in the heated room. The installation is more expensive than direct heating but profitable even without any subsidies. The waste heat and entropy production of the inverse heat engine is minimal. The overall entropy change is negative, as this is not a closed system and external (electric) energy is used.

Electric cars: Advantageous only if electricity is taken from water, nuclear and renewable energy sources with high efficiency. In a cold climate, heating with electricity is a waste. It may have sporadic advantages in large, dense, polluted cities. Otherwise, if electricity is from fuel burning, then energy conversions impair its efficiency and the transport of batteries requires additional energy. If the required energy is coming from fossil fuel burning power stations, the overall pollution and energy consumption will actually increase due to several energy conversions and the larger weight of the vehicle.

Energy Policies

The EU has recently been trying to form an *Energy Union*, but at the moment this procedure is politically dominated, and it is dominated by the interest of the largest countries in the EU. A more fundamental and science-based analysis of sustainable configuration and sustainable development would be highly beneficial for the whole EU, as well as to the strongly connected surrounding countries like Norway.

An example for this problem is Germany, where the installed wind turbine capacity is 41 GW (2015) and the installed Photovoltaic solar panel capacity is 39 GW (2015).[10] The total demand (or load) is around 97 GW. This was installed with large subsidies, which led to a doubling of the electricity price for costumers. This intermittent energy supply, iRES is a very large fraction (~80%) of the demand, and if it unexpectedly drops out, one should have sufficient backup energy. Even if foreign countries are used for balancing, Germany needs about 30 GW backup power. At this moment, this is provided the cheapest way by lignite fueled power stations, where the fire is kept on even without production to be there when this backup is suddenly needed. At the same time, emission free nuclear power stations are turned off, increasing the need for balance power. This is clearly not a stable and sustainable organization, neither economically, nor environmentally friendly. Thus, the recent installations, dominated by preferences of political parties, led to a highly non-optimal configuration.

It would be significant and demanding work to estimate the level of sustainability quantitatively, but it is possible based on the fundamental principles of Schrödinger introduced in the

10 GW is the power of one present nuclear power station or the average production capacity of ~1000 wind turbines, considering that there is no optimal wind all the time.

beginning. Economic relations and arrangements complicate the problem further. One can find a better example in the system of the Nordic countries. Norway with 96% waterpower, which can be regulated in a wide range and Sweden with 10 nuclear reactors providing the base-load, seems to be a much better functioning system, with lower electricity prices and a better functioning *NordPool Spot* economic market organization. This leads to varying prices in time and region-by-region. Of course, the geographical conditions are largely responsible to this advantageous situation.

Nuclear Energy

Nuclear energy is the most advanced and most modern form of energy conversion. This is clearly the energy source of the future as it can provide for increasing energy needs, when other (mainly fossil) energy resources are exhausted. Natural forms of it are known as the source of geothermal energy and the natural fusion of large uranium concentration in craters where, due to rainwater, chain reaction may occur, e.g. in South Africa.

Nuclear energy can be gained from fission of heavy radioactive nuclei (nuclear fusion reactors) and fusion of light nuclei. This latter is the way, in which the energy of the Sun's radiation is gained. This does not produce heavy radioactive nuclei, which would lead to radioactive waste. On the Earth, the peaceful human use of fusion energy is under technological development. It is done in two forms: Magnetic Confinement Fusion (MCF in several Tokamaks like ITER and in a Stellarator) or Inertial Confinement Fusion (ICF). Research with MCF technology development is pursued in several laboratories. ICF technological research is pursued in three US facilities. The most advanced is the National Ignition Facility (NIF) at the Lawrence Livermore National Laboratory (LLNL). Here 192 of the highest energy lasers from all sides irradiate a ~ 2 mm size spherical Deuterium-Tritium (DT) pellet. So far, one succeeded to ignite a smaller part of the DT pellet, but with very low energy efficiency. Recent advances in ultra-relativistic heavy ion research and in nanotechnology combined in a special way, may lead to a much more affordable configuration for ignition with only two laser beams. This can be done with existing lasers in Hungary also.[11] We are planning this type of test in the near future, with the support of iASK.

Global Energy Future

Global energy use is increasing. In 2018, the total use was 14.5 Gtoe (Giga ton oil equivalent) including oil, coal, natural gas, nuclear, hydro, etc. This is 168 PWh. (1 Mtoe = 11.6 TWh) and doubling every 50 years. With an increasing population and increasing living standards, energy use will continue to grow. Electricity use is also increasing. In 2018, the World electricity generation was 26 PWh. This is 15% of the total energy use, but it is doubling every 36 years, so the fraction of electricity generation will increase further.[12]

How does this human activity compare to the natural astrophysical energy balance and entropy conditions of the Earth? From the data above, it can be seen that the total human energy production power is 19.2 TW (168 PWh/yr.). 15% of this 2.97 TW (26 PWh/yr.) is electric power. Most of this energy is released by heat engines, so the efficiency and the waste heat is ~ 30 – 40 %. This leads to entropy production and heating. That is 6.7 TW.

The average power of solar radiation is 31 TW (274 PWh/yr.). This is given by an average irradiation of 175 W/m2 and 1000 maximum. Thus, not counting the atmospheric reflection or greenhouse effect by GHGs, direct human heating is already 20% of the solar radiation. Most of

11 L. P. Csernai, N. Kroo, and I. Papp, Radiation dominated implosion with nano-plasmonics, Laser *and Particle Beams*, 36 (2), 171-178 (2018); arXiv: 1710.10954 (2017).

12 Data are from the IEA (International Energy Agency).

this 20% is just converting the present and past solar energy to other energy forms for human use. This type of human use already leads to additional heating, which originates from natural kinetic energy forms from solar radiation, and from non-solar energies such as gravitational, tidal, and nuclear energy. The rest leads to heating anyway even if it is not used for human purposes. This is only a smaller part of the total human use, which, at this time, can be estimated to be of the order of 1 TW. Still, with a rapid increase of human energy use, this part may become more significant. The message of these studies is that we have to attempt to increase the efficiency of the energy conversion processes as much as possible. At the same time, we have to abandon the ones with low efficiency and excessively large entropy production.

Room to Move: Climate and Migration in Human History

Daniel R. Brooks

Climate change unites humanity like it has never been united before. There are two reasons for thinking this is true. First, climate change is literally beyond belief. No matter what religion you believe in, no matter what political system you believe in, no matter what economic system you believe in, you are being treated the same by climate change. Mother Nature does not care what you believe. Second, climate change is a national security issue for every country, and if it is a national security issue for every country it is a global security issue. So, whether we like it or not, this puts us all in the same boat. Climate change is not simply occurring, it is accelerating. We cannot stop or reverse it, and it is becoming more apparent that we probably cannot even slow it down. But there is reason to hope.

There are some good things happening in the world of climate change: global fertility rates are declining faster than anticipated. The use of renewable energy sources is increasing (though aspects, especially storage batteries, threaten to create new forms of pollution). Generally, health is improving around the world. Fresh water is abundant globally. There are more reasons for us to worry about the state of the world. Population is still increasing (because enhanced health means low infant mortality); The atmosphere is warming. Accelerated melting at both poles is raising sea levels. Agricultural soils are depleted. Droughts and floods occur the wrong places (affecting the distribution of fresh water). Emerging Diseases are everywhere. Socio-economic inequality is rising. Political instability leading to conflict and migration is a global problem.

Discussions of sustainability have had one thing in common – they are discussions of how we would like to improve the world we have. We must reframe this discussion. We do not have the luxury of worrying about the quality of anything at this point; our fundamental interest has to be basic survival. Any questions about sustainability going forward have to start from the standpoint of not what we want but what we need and the first thing we need is to survive. We do not have a lot of time. It turns out that the *Limits to Growth* which has been incredibly criticized and misrepresented for being apocalyptic (i.e., everything is going to go to hell) turns out to be the most optimistic analysis that is still floating around. Even the IPCC has finally realized that the year 2100 is not a realistic point for us to start worrying. At the moment the consensus seems to be that 2050 is what we would call the LD50 for Humanity (LD50 is a term from toxicology studies referring to the dose at which your toxin will kill 50% of experimental animals or plants).

In 1958 Charles Elton warned that humanity has never faced climate change of the magnitude that is happening now and is coming at us, and he predicted that the two major outcomes of that climate change going forward would be conflict and migration (Elton, 1958). This has certainly proven to be true. In making that prediction, Elton drew on substantial knowledge of the evolutionary history of humans and their interactions with their environments. In the 60 years subsequent to Elton's landmark contribution, our understanding of human evolution has increased dramatically, and everything we have learned reinforces Elton's concerns for our future.

What does evolutionary theory "promise?" First, evolution is brutally short-sighted and relentless. There are severe limits to growth with great penalties for overshooting that growth that may be postponed, for example, by the development of technology but never completely avoided. The bills will come due eventually. Second, if you survive long enough you may come up with a better way of doing things, but even if you do the next time the environment changes

that solution will be obsolete. Third, biological systems are complex systems and thus sensitive to initial conditions. Inheritance re-sets the initial conditions each generation, and this is the way in which the ability to cope with changes in the surroundings is maintained. But that also means there is never a permanent optimal solution. And finally, there are always unanticipated consequences, so any solution that resolves a current conflict may set the stage for new conflict, requiring yet additional conflict resolution. Evolutionary changes are thus the result of conflict resolution, and conflict resolution requires cooperation (Maynard Smith and Szathmary 1995; Szathmary 2005).

Human Evolutionary History: A Precis

In the Beginning

About 3 million years ago, our ancestors moved from forests to savannahs. Other early humans seemed to have stayed in the forest, persisting at least until 2 million years ago, but none of their descendants are alive today (Desilva, et al. 2018). It is possible that the ancestral humans who found themselves on the savannahs were in some way pushed out by those who remained in the forest and who, ironically, no longer exist. Our ancestors brought with them a substantial amount of historical baggage inherited from their ancestors. Like all anthropoids, they were social primates, living in extended family groups. Their social structure likely comprised one group of females and youngsters and another of sub-adult and adult males. Within each group there was some hierarchical structure, headed by an alpha female and an alpha male. They foraged, eating primarily plant material but opportunistically eating animals (bird eggs, mammal and bird nestlings, rodents and lizards). Each such group moved about, motivated by the need for water, food, shelter and safety. Groups would tend to avoid each other, except in cases where the needs could be satisfied in abundance (such as seasonally fruiting trees), in which case more than one group might coexist, at least for a time. In those cases, it would not be uncommon for some unmated females from each group to move to another group and leave with them when they moved on. This reduced the threat of inbreeding problems within each group and was the primary source of cultural transmission, facilitating the spread of knowledge such as tool-making. We also inherited much of our reproductive biology from those remote ancestors. This means females are capable of having a single child, rarely twins, once a year. Females invest a lot of time and energy in their youngsters, and often are not capable of becoming pregnant while nursing. Being pregnant, delivering a baby, taking care of a child is physically demanding for an adult female, and life for most of human history was extremely dangerous for children, so the lifetime reproductive output of women was fairly limited. This was what we brought with us onto the grasslands.

We need water, food, shelter and security. As a result, we fear flood, drought, famine, conflict, and disease. Climate change produces – directly and indirectly – all of those fears. And the paleontological record shows that whenever the climate changed in ways that increased the threats, our ancestors migrated. Necessity, it seems, is not the mother of invention, but the mother of running away hoping to find your needs with decreased fears somewhere else. And in a complementary form, "invention" only occurs when the conditions of life are stable.

Let's look at what modern human beings have done in the past 150,000 years or so. From 150,000-90,000 years ago human beings lived in a period of relative climate stability. During that time of stability, we moved into new places and new habitats and started doing new things. Among other things we changed our diet, eating a lot of meat, and we started making tools that allowed us to stop being scavengers and actually start killing our own meat. This marked our

transition to true hunter-gatherer societies. The division of labor between male hunters and female gatherers emerged naturally from the pre-existing social structure. This also marked the beginnings of a recurring theme in human evolution. We acquired a number of interesting new diseases as a result of eating meat, such as tapeworms in the genus *Taenia* whose closest relatives live in felid, hyaenid and canid predators with which we competed for prey.

Another major outcome of this change in diet was that human beings started to get bigger, and women got bigger faster than men. Women benefited more than men from adding meat to the diet, but this created a potential problem. The bigger, stronger, better fed a woman is, the bigger and stronger and healthier her babies are. She is not going to start having babies every five months and she is not going to begin having twins or triplets, but she is going to have higher quality, babies, and babies are going to survive more often.

From about 90,000-12,000 years ago, human beings lived through a period of climate instability. During warm and wet periods, we expanded geographically in response to abundant food and water. Every time we moved, we added something to our dietary repertoire; we got bigger; our women got disproportionately even bigger; and we added more diseases. Humans were becoming widely distributed but because we were still extended family hunter-gatherer groups, overall population density was low. We maintained an evolutionary trajectory of hunter-gatherers whose primary innovations were improved hunting weapons.

The Holocene: We Change Our Evolutionary Trajectory

At the beginning of the Holocene, about 12,000 years ago, human beings experienced an almost unparalleled period of climate stability. This was a time of plenty for humans. Human groups were able to find places that satisfied their needs in abundance, with minimal fears. And as I noted previously, innovations occur during periods of safety and security, and this is the time when domestication and agriculture exploded onto the scene. This was the evolutionary transition from hunter-gatherers to agro-pastoralists.

There are a lot of benefits to a lifestyle of livestock and crops. We got bigger and healthier and could provide for larger groups of people. Our women and children were safer because they did not have to forage in areas where predators might lurk. Men did not have to engage in life-threatening hunting practices. But this is evolution, so we have to ask what this wave of innovations cost. First and foremost, we became less mobile. As the social groups became larger and more sedentary, the potential for conflict increased, and the potential for conflict resolution through one group leaving decreased. As well, we acquired more diseases, both due to crowding resulting from increased population density, from the migration of animal species, from insects and ticks to rodents and birds to human habitations; and even from the companion animals and livestock. By about 9,500 years ago, human beings were building permanent living spaces, even if they were not staying in them constantly all the time. This marked the transition from agro-pastoralism to urbanization.

One underappreciated consequence of the evolution of urban humanity is that cities reduce our ability to run away from climate change. This represented a major transition in our evolutionary trajectory. And there were benefits, costs, and unanticipated consequences.

The earliest cities were permanent living settlements where proportionately fewer and fewer people were involved directly in producing food. This freed people to specialize and as the complexity of goods and services provided by those specialists increased. Initially, population size was limited by local food production; cities that had an abundance of water and food could afford the specialists. If food and water became scarce, people who were not directly involved in food production could not afford to live in the city and moved on to cities that could afford their

services. Within a relatively short period of time, cities began to value their specialists who were not directly involved in food production. There is evidence of Trans-Eurasian trading routes as early as the Paleolithic, long before there were cities. Urbanization led to a new view of trading, increasing food supplies by trading specialized goods for food. And it seems that the more humans invested in trading for food to maintain specialized services, the less likely they were to abandon the site in the face of climate change or other natural disasters. And yet, most urbanized civilizations affected by major climate change events in the last 9,000 years were destroyed forever. The Angkor civilization in Cambodia, the Mayans in Central America, the Tamil in Sri Lanka (Fletcher 2019).

Finally, it soon became known that cities were immobile sites where lots of food and specialized goods were stored, so by about 7,000 years ago we have the first archaeological evidence of organized warfare against settlements, because it is easier to come and take somebody else's stuff than to make it yourself. Technical specialists displaced from one city as a result of such conflicts would migrate to another city, potentially making each city a richer target for attack. Cities thus seemed to catalyze conflict and migration.

The Anthropocene: We Intensify the Trajectory

The Anthropocene is arbitrarily considered to have begun in 1758 with the first commercial use of a steam engine. In many ways, the Anthropocene represents the logical outcome of the new evolutionary trajectory established when humans became sedentary and decided to fight against climate change rather than running away from it. When we decided to locate our industry in pre-existing urban centers, we created a situation in which the human population increased so rapidly that neither local food production nor existing trade routes could keep up. Increased population density not outran food supplies, so trading for food became vital, but the trade routes had to become longer, because people began leaving local the agricultural lands for the cities, responding to the hope for a better life in the emerging industrial revolution.

This represented the most recent transition in the evolutionary trajectory of humans. First, we stopped migrating away from trouble. Now we migrate toward the very urban centers that create the problems. In 1950, 30% of human beings lived in cities, by 2050, and this is a very conservative estimate and it is probably going to be higher, but at least 70% of the world will live in cities. Between 1950 and 2050, what we have done in the last two generations, is that we have produced two generations of people who are almost entirely urbanized children and that turns out to be important going forward. Modern cities are the ultimate density and connectivity traps. They are places where human beings are crowded together, that only exist because they are connected with external sources of food and essential supplies, and as a result are full of humans that cannot survive outside a highly technological urban environment. Meanwhile, non-urban sources of food and essential resources are being depleted in part by hyper-consumption in the urban areas and in part due to the migration of people from the non-urban to urban areas. As a result, they are extremely susceptible to a number of things, including emerging diseases. If urban centers are devastated by climate change, disease, natural disaster, massive migration to other such centers will be their only means of survival, exacerbating pre-existing problems of high density and hyper-connectivity. They will not be welcome.

What We Can Do?

Human beings have always made decisions coping with immediate problems of the day in the way that seemed appropriate at the time. This is evolutionary in the sense that it is brutally short-sighted, but relentless, because we kept doing this and as long as we were not dead, we kept

solving one problem after another on a contingency basis. Until Darwin (1859) we had no scientific framework for thinking about unanticipated consequences of actions. This is why technological humanity in its highly urbanized form is at risk. The change in our evolutionary trajectory created technical infrastructure that has put us at risk. We have been living beyond our means in this technological niche we have constructed, and the bill is now due.

There is hope. Evolutionary history is not destiny. Think of climate change threats as the things that came out of Pandora's Box. Left crushed at the bottom of the box, was Hope. You cannot cope with all the fears of the world if you do not have hope, but hope is not a plan, hope is only a reason to have a plan. Crisis response is too expensive and time-consuming. If we do not anticipate what is coming at us and try to mitigate its impacts, we are not going to be able to afford to survive. We need a sense of urgency, but not panic. The time is short, the danger is great, and we are largely unprepared. But we can change that. Our policies have to be based on the idea that in order to survive we have to buy time to figure things out at a time when the rate of climate change is accelerating, and the only way to accomplish that is by cooperating. Human beings are capable of great amounts of cooperation, but it has to be with somebody we feel warm and fuzzy about and overcoming that piece of our evolution because for many years it was not necessarily a good thing to automatically feel warm and fuzzy about the next stranger that came around the bend in the forest. We will not survive if we do not cooperate with people we do not like. We cannot defeat a common foe if we are at war with ourselves.

We are now a technological urbanized species. Despite the fact that there are more abandoned than occupied cities on this planet, humans have never thought that cities might be the problem – cities are the solution. Because with our technology, especially our internet technology, it is potentially possible to link together a group of cooperating small cities each of which is sustained by a circular economy, to emulate the benefits of a big city while mitigating the problems, the vulnerabilities associated with a big city like population density. This is the strategic perspective that drives proposals such as the one for the Pannonian region of Hungary (Brown 2018).

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Deeper Dimensions of Human Experience

Ervin László

I am addressing the issue as to whether we are a viable species, a viable culture. We need to know what the term "unsustainability" means – that you cannot continue the way you are, that you need to change, and the question is how do we change? Actually, I think it is no longer a question whether we have to change because it is very clear.

This is a process, we are not in the situation of crisis that leads to what sciences call a bifurcation. The evolutionary trajectory that we have followed in recent years is changing, and this gives rise to something else because the status quo is now not an option. The change driver is the catastrophic lack of sustainability to the point where it leads to catastrophe.

The first perceived driver is climate change and global migration. One relates to nature and the other to human society. We know the situation in nature and can provide a lot of data about it. We are destroying the balances, leading to the extinction of large numbers of species, and we are basically destroying the integrity of the natural systems that are the basis of life. On the human level, we are taking apart the integrity of societies; on the political level we are polarizing societies. The US is a very clear example today where there are total divisions and the loss of systemic integrity; but these conflicts and divisions, although perhaps less striking, occur elsewhere in the world too. We are destroying the integrity that is required for a viable system to maintain itself. This means that the policy at the political level, of putting oneself first and never mind the rest, and in business of winning and out competing, all of these are destroying the kind of necessary balance and coherence that you need to maintain a viable system.

These are drivers that are pushing us beyond the status quo. The responses could be various. Two alternative responses are: we try to continue going on the way we have and this has reached increasing levels of intolerance, increasing opposition that we see in the polity and in politics with increasing levels of fear and frustration. If we continue the way we are, we just create more levels of unsustainability.

The alternative seems to be utopian, but really what I want to devote this short talk to is to say that the alternative is realistic even though it does not seem so. There is a possibility of moving to another way of conceiving our situation, another way of surviving, another way of acting. I will just highlight this other way in spiritual terms, by a concentration centered on healing, using feelings of empathy and sympathy, and the whole idea of consciousness. What are we? What is consciousness? More and more people are saying today that what we need is a fundamental change and a fundamental change means an alternation and evolution and change of consciousness. Here are the two scenarios for moving forward.

The very visible scenario from intolerance to frustration and resulting breakdown is probable. There are elements that support this assessment of the situation today, and you know them all regarding biological natural sustainability, social sustainability. We are in a situation where the change, the necessity for change is becoming more and more evident, and I want to go on to basically show what I consider the more important question and that is: Where do we go from here? Can we change in a positive way or will we only change when our sustainability becomes catastrophic, brings catastrophic conditions? I am proposing to you the hypothesis that I have investigated with my colleagues and collaborators that we can indeed find a better way. This better way is already there, is already appearing but it is not very visible, and it is not yet powerful. But to the extent that the mainstream way doing things as we always have done becomes less and

less possible, less and less productive, less and less viable, alternative ways are becoming more realistic, moving from utopianism to realism, because there is no other good way. Of course, it is possible that we will not change, that we will not wake up, and then we will have major catastrophes, major population declines, major climate problems, major energy problems. This is entirely possible. I am not saying that this is the probable future, that we change, but I think it is a possible future. There are indications on the edges, on the margins of society, and they could move to the mainstream. There is an awakening there, an increasing valuation of collaboration, of coming together instead of competition or in place of competition. There is a shift toward empathy, toward moving in the same direction and all this is very strongly supported by new technologies – technologies of sharing, technologies of information, collaboration based on information, and these new developments are occurring in many spheres.

The conservative elements always stop and hinder the advance of these developments. For example, in education, we know that you could use the new technology to eliminate the classical classroom. This is just one example, and we could bring in people from all parts of the world. We could create collaborative teams, collaborative research programs, on which we can draw on the new technologies of information and communication, to create groups who would discuss what we are doing, where we are, and possibly change. It is possible.

The conservative elements are of course the classical structures of the universities, the elite universities, the academies, and so on, which want to keep on doing things the way they always have been doing, to keep control. In business, for example, the classical way is hierarchical as well. This means central governance structures, presidents and vice presidents, and the heads of various divisions that maintain the system so that it operates in a way which they consider is good, and which means serving the interests of the shareholders and being out to win, to out compete in the marketplace, creating larger market share for themselves.

In politics, the mainstream of course is gathering as much power and influence in the world as possible for the nation, for the government of the given nation, and in the government, of course, the key individuals who run the government, are conservative and if they remain powerful the situation will become untenable. The alternative to this comes from the margins, from the periphery, if they are movements powerful enough to move toward the center, so that they can take over. For example, that we can recognize that in business, which is already a trend, that the purpose is not the maximum gathering of profit and hence financial power quickly for themselves, but to create a positive contribution to society, serving the stakeholder rather than just the shareholder. The stakeholder in business, and in particular big businesses, is of course a very large segment of society. I am very much involved in some of these new trends in business, and just came home from China last week where we held a major meeting on these issues. This is a powerful movement that is beginning to show among business and political leaders. I have collected a set of these positive developments and they are all based on sharing and participation. These developments empower people with the new technologies of communication where we can all join in. This gives a voice to people so that they may be heard.

I will just give you one more thought. Is there something, in the system of human society and human mind, which favors the alternative approach? As a system theorist and system philosopher, I think the risk, as it appears now in the complexity of the natural biological world (although it can also be applied to stars in the solar system), is such that random processes could not have given rise to the social ecological systems that we find today in the world, and this includes the human body. Chance interactions could not have produced the complexity and the coherence that we find in the world, not within the evolutionary time frame of 50 million years of biological evolution, or 13.8 billion years for the physical evolution in the universe. Therefore,

there is something in nature, there is something in the universe, which favors the creation of coherent entities as opposed to chaos and disintegration. There is something underlying the evolution of the universe other than pure chance. It seems the chance is not an answer; randomness could not have produced what you have, therefore there is something which I call a 'Holotropic Attractor'.

I do not have time now to develop this idea, but just want to say that the minimum first presupposition is that there is a tendency built into the laws of nature which favors intelligent cooperation, which favors integration and creating systemic units opposed to chaos, disintegration and conflict. This particular *Holotropism* is likely to be in us, as well as in my new book which is not yet finished but should be published next fall. I look at what I call 'Spontaneous Transformative Experiences'. People have a spontaneous experience that is not rationally figured out, it just comes. These spontaneous transformative experiences are occurring more and more frequently now, and they all end up, somehow, being based on an element which calls for collaboration, which calls for union. They all indicate basically one thing: there is an inborn tendency toward creating integration, integrity, coherence and complexity of the world. Evolution builds in that direction. It is nonlinear of course, but, on the whole, it moves in this direction.

Currently, it seems that these trends may be breaking down due to stupidity, due to the short-sightedness of the leading powers, and misuses of technology for individual power and interest; but there is perhaps something surfacing in the heart, in the mind, in the spirit of people which is tending in the opposite direction, pulling in the direction of empathy. It is not accidental that young people respond to this more and more.

Let me end by saying this: we are facing a bifurcation, we are facing a situation where change has become necessary. Whether we change or keep to the same principles that we have kept in the last couple of centuries or not is a risk that is still open. It may or may not be the case. If we do not change positively, we will face a very serious breakdown. We will even face the possible extinction of higher forms of life including human life, but we have a unique resource: we are conscious, we can discuss these problems, we can become aware of the problems and of the opportunities and therefore we can use alternative means for moving ahead. The alternative means are given by technologies. Communication is possible, and with our intelligence we can perceive the problems and pull together. We do not know if we will wake up in time, but technology makes it possible for us to discuss these issues positively. More and more people are questioning whether we can go on the way we have or look for alternative paths. More and more people are looking inside themselves to find the answers.

My conclusion is: the solution will not come from above or from the outside; if it comes, it comes from the inside and from below, it comes from the periphery moving toward the mainstream, it comes from people looking into themselves and finding that there is a major element in their psyche, in their intellect that says we must cooperate, with empathy even love, rather than just dominate and placing oneself in the first position with no concern for the rest. We live in exciting times, but we should not disregard the fact that we are social beings: As Aristotle said, we have something *holotropic* in us, as there is in the universe as well. We have a chance to survive on this planet. It is not assured, it is not guaranteed, but there is a chance. The big question is whether or not we can recover this insight.

The Challenges to Societies and Economies

Plato's Cynicism or Premonition? The Meaning of Democracy in the Post-Truth Era

Ahmet Evin

When I was asked to make a contribution to this panel on the 'future of democracy', I thought of the gloomy early winter evenings under the clouds in Central Europe. I thought, therefore, that this time of year was quite appropriate with regard to a consideration of the future of democracy. What I am going to say has very little to do with the future of democracy, but rather I will take in fact not even a political scientist's perspective but more of a historian's perspective to share with you some of my thoughts as to how we have come to this state of affairs?

I will begin with a story from Plato's *Republic*: There is a ship owner larger and stronger than everyone on the ship, but somewhat deaf and rather short-sighted with the knowledge of sailing. The sailors are quarreling among themselves over the captaincy of the ship, each one thinking that he ought to be the captain, though none have ever learned that skill and in fact insist they cannot be taught; in fact, the sailors are prepared to cut to pieces anyone who says they can be. They try everything to make the ship owner give over the direction of the ship to them. If they cannot persuade others who disagree with them, they kill them.all and throw them overboard; then they immobilize the worthless ship owner with drugs and drinks or by some other means and take control of the ship. Helping themselves to what the ship is carrying, drinking and feasting they sail away just as you would imagine how people like that would sail.

This passage from the *Republic* vividly conveys one of Plato's most venomous attacks on democracy. Plato seasoned democracy with the makings of chaos. He perceived it as a form of rules that set the polity in an inevitable path towards disintegration leading to anarchy. Plato's cynical view was informed to a significant degree by a fear of mediocrity overtaking the apparatus of rule and crowding out values. A prominent classicist, John Ferrari, has identified no less than 10 categories of criticism that Plato levels in this passage at democracy, but essentially, I should like to point to others that I find relevant to the questions raised in this discussion.

The lack of recognition of political expertise goes hand-in-hand with the opposition to recognition of intellectual superiority as an asset for leadership. Too much emphasis on participation at the expense of hierarchy and institutions makes for a rudderless vessel. Plato saw this as an imminent danger for the Athenian freedoms, and it turned out that he was right. He gave us a vivid picture of the consequences of unrestrained "rule by the people, not even rule by the representatives of the people. This is not so different from what we are facing today in an increasing number of countries, states, and regions. This reversal, this departure from the rules-based international order that brought on continuous improvements to my generation's quality of life has been a disorienting experience for me and for most of us. What went wrong? Why would the very country that championed the liberal order abandon its self-appointed mission and suddenly adopt a protectionist stance and in doing so begin to show not merely disregard, but even contempt for the very values that the liberal order was supposed to embrace and universally promote? In other words, how did the political environment in some of the leading Western countries resemble the dynamics of Plato's ship of state? I do not wish to ignore the far-reaching geopolitical changes of our time and the corresponding changes in threat perceptions that form the background of the current political changes we have been witnessing.

Let me say now a few words about the global challenges that profoundly affected the perceptions of self-interest or national interests in large parts of the world. The most important change is the gradual but steadily accelerating movement of the world's economic center of gravity. The rise of China though expected has nevertheless set in motion a surprising set of transformations in terms of competition for resources and changing patterns of global trade and investments. China's total primary energy consumption, for example, surpassed that of the United States nearly nine years ago. With its planned economy, but with an economic regime opened to capitalism, China has emerged as a major power in a very short span of time. Two characteristics, apart from the rise of its economy, are worth noting: 1) it is emerging as a major energy producer in the world, because of centrally planned and well implemented economic growth objectives; 2) because it has raised its GDP per capita to similar levels as that of the developed world, its consumption patterns are resembling those of OSED countries. These two factors, among others, serve to reinforce China's trajectory of economic growth. The Trump administration has responded to China's phenomenal growth by raising strategic trade barriers with a view to putting an end to China's economic benefits at the expense of increasing U. S. trade deficits. The rude and abrupt way the U.S. has pursued international economic policies has attracted a great deal of attention. Trump's policy of 'America First' has been viewed as part of the new trend to draw popular support for nationalist policies at the expense of breaking the liberal order.

There are a series of paradoxes that accompany such major global shifts as we are witnessing today. It could be asked whether the Trump administration is weakening America's global leverage by increasingly isolating the United States from its longtime allies and trade partners as a result of its unilateral actions. With China's GDP surpassing that of the U. S. in the near future, America's economic power is bound to diminish relatively. It may be asked whether the Trump administration's confrontational approach to economic competitors is maintained because of Washington's reliance on its military power? If so, with the new containment policy the world is brought perilously close to the geopolitical background preceding the two world wars. China's rise boasts equally immediate challenges and possible opportunities for Europe. Beijing appears to be interested in promoting some of the key objectives originally adopted by the Western Alliance. One of them is the Paris Accords which is not surprising because of the costs and damages associated with China's pollution levels. The second is China's interest in promoting trade liberalization, again not surprising, since Beijing has been the main beneficiary of World Trade Organization rules. The One Belt One Road initiative is a gigantic project that will expand dramatically China's arena of economic activity and is designed to reach the European market spanning practically the entire area of Eurasia. Whether this will be taken by Europe as an exercise in adversarial economic competition or as an opportunity for the world's largest trading bloc remains to be seen. In promoting trade liberalization, however, China has in no way supported what had been considered to be the key values that sustained the liberal order. These were essentially democratic values and the rule of law, considered to be essential for that. Given the hints of creeping authoritarianism in unlikely quarters, one is tempted to ask whether there is a spreading doubt about the effectiveness of democratic values for achieving political stability today; or is the West developing amnesia about how it reached an understanding of democratic values as a result of an extended search over centuries?

With these questions let me now turn to the question I posed early on: What went wrong? We have in the West, and particularly in Europe, emphasized participation at the expense of institutions; we have chosen to follow relativism as a fashionable post-modern way of uncritically accepting all arguments without bothering to look and see if they had any merit because they were a fashion instead of reassessing and reaffirming common values. This has been going on

for decades now. It is the institutions that are positive values and values are modified and transmitted from one generation to the next by means of institutions. We have substituted a technical term which is essentially a form of rule. We have substituted the term 'democracy' for 'freedom' which is a key value that refers to human autonomy and dignity and we have forgotten the essential role of institutions to protect freedom by, in Kant's formulation, to prevent hindrances to freedom. Individual liberties are also protected by institutions which are given the authority by society to enforce contracts ranging from petty commercial ones to all-encompassing social contracts from which our modern democracy evolves. It is as Burke passionately argues: societal institutions that provide the foundations for political institutions, educational institutions, and others of instrumental importance. *Society,* said Burke*, is indeed a contract, and contracts need to be looked on with reverence. … It is a partnership in all science, it is a partnership in all art, partnership in every virtue, and in all perfection as the ends of such a partnership cannot be obtained in many generations it becomes a partnership not only between those who are living but between those who are living, and those who are dead, and those who are to be born . Each contract of each particular state is but a clause in the general primeval contract of eternal society linking the lower with the higher nature, connecting the visible and the invisible worlds according to a fixed compact sanctioned by inviolable oath which holds all physical and all moral natures each in their appointed place.* This is the penultimate paragraph of his reflections on the revolution in France. I chose to bring up Burke in this context not merely because of his impassioned eloquence in conveying the crucial importance of social life, in the shaping of human experience, but the more so because of his profoundly informed and sensitive way in which he was able to hold up a mirror to the organization of society that was a particular strength of 18th century observers of people and manners. His considerations thus provide, I would argue, an effective prism through which one is able to spot and identify what we are lacking today in terms of providing the space for freedom in our societies and political communities. It is true that our post-industrial society is far more complex than the European society of the pre-industrial revolution era which admittedly provided a very limited participation in the political community. But given Burke's clarity of vision, his perspective provides a helpful means for us to see the bigger picture of how a politics ought to function and whether we can identify some of the misconceptions that detract from our own ability to imagine how the concept of social compact might translate into a functioning relationship of exchange between institutions and people.

I have in mind not only the increased visibility of authoritarian tendencies on this continent and beyond, but also the opposite, namely, the complaints about democratic deficit, which ironically have reinforced nationalist or even particularistic demands. Burke's view that institutions are not artificially made, but they grow organically over time is a case in point. Institutions, he proposes, have a life of their own but they also respond to new demands of changing social and political environments and thus grow and mature over time. Burke has long been identified as a conservative – a word that brings to mind diametrically opposite characteristics to those of Burke especially as a person who pointed to the importance of change. In an age of rising empiricism that put proof before belief, he would argue that it is custom, tradition, and membership in society far more than reason that provides the moral quality of human nature. He did not, however, reject or refute the crucial importance of reason in the very heyday of the Age of Reason. Only a reasonable man, exemplified by some of his Augustine predecessors like Swift, Pope and Samuel Johnson, could clearly discern the limits of reason. Burke as the political scientist was not so much interested in celebrating the rational individual against repressive authority, but to relating individual refinement to his or her membership in organized society. Civility, as macrosociologists discovered more than a century later, was essentially the sharing of cosmopolitan

space with others and recognizing a common civic sense of belonging to the same social space with others. Membership of organized society that would follow would be the only way for individuals to embrace an internalized civilization. Like many of his contemporaries and predecessors Burke focused on the contrast between the state of nature and civil society, but his interest lay in stressing the vast and unbridgeable gap between what he said "this beautiful order," this array of true nature, on one hand and, on the other hand, the disbanded race of deserters and vagabonds.

Here I draw attention to the word 'nature' that is associated with the notions of both 'order' and 'truth'. As one of Burke's distinguished contemporaries, Sir Joshua Reynolds, said in one of his discussions on art: *nature is and must be the fountain which alone is inexhaustible and from which all excellencies must originally flow*". Nature, for Reynolds as well as Burke, is the source for education and improvement of human beings to enable them to develop their faculty of discernment. This association of nature with order and proportion that is with aesthetic and ethical concerns points to the way in which a moral worldview can be achieved by individuals. This kind of moral outlook informed by aesthetics and ethics, at one and the same time, is precisely what is lacking in our contemporary societies. As a result, we are unable to judge the workings and failures of democratic regimes, what we call 'democratic regimes' or of those that are supposed to be democratic, and even of those which claim to be democratic. We are only able to judge them on the basis of electoral and legal technicalities. Precisely because of such constraints, our political actors have become incapable of bringing communities to converge around common values, which have been emphasized as normative values. What can be done about this in terms of education, in terms of proposals for new perspectives, is something that we should address collectively.

Regulating Global Finance – The Rise of Virtual Currencies

Etelka Bogardi

Unlike most of the other speakers at this conference, I am not from academia or the public sector. In fact, you probably could not get more private sector than me. I used to work at the Hong Kong Monetary Authority, which is the de facto Central Bank of Hong Kong as well as the bank regulator, but I have now returned to private practice. I am a financial services regulatory lawyer, so as you can imagine I have been very busy over the last 10 years. I am a partner at Norton Rose Fulbright, which is one of the biggest global law firms. I represent, at its most basic, banks and other players in the financial services industry. This is a conference about Blue Sky thinking and issues affecting the world today. I must confess that I am not, due to the nature of my job, prone to introspection. I am in the trenches, not in the ivory tower, dealing with practical problems and helping clients solve them. However, what I can bring to the table is an understanding of what is happening, particularly in the financial services industry today; what is happening on the ground and specifically what we are seeing in Asia.

The second confession I have to make is that I envisaged the talk to be about regulation, regulating global finance and the trends we are seeing, but on reflection, what this talk is really about is data and technology. We are moving into a world where data is king, and banks and payment providers are calling themselves, first and foremost, technology companies. Today, the new banks are on our smartphones. We exchange information, services, and money – peer to peer, person to person, person to business and business to business, and we do so instantly. If you go to China, you cannot actually pay with cash anymore. You can only pay with your smartphone. So, this is coming, and this is coming to stay.

I will begin the presentation by talking about these new types of digital assets called 'cryptocurrencies' and a new method of capital raising called 'initial coin offerings', and then put them into context. I will talk a bit about the industry trends. We are seeing the regulation of these new trends and I will finish off by discussing the role of central banks and the state in all of this. This is where it does tie into what we have been talking about today. The last point, and this is more of a philosophical discussion then, is the discussion of how these new digital assets are changing the way the state and central banks are acting as trusted intermediaries in the payments process.

But let's first look at what the press are saying about cryptocurrencies, and I suspect that is what most of you in this room are thinking as well. Particularly 2017, and the early part of 2018, were the years of the token fundraising events. There has been a great deal of enthusiasm shown by investors or people providing the funds for these events, but there have been many words of caution as well. The most famous is probably the statement by Jamie Dimon, the chairman of JP Morgan, who basically said that "bitcoin is a big fraud and is only suitable for money launderers". Regulators have also expressed words of caution, both the SEC in the US, and the FCA in the UK.

You probably all know what bitcoin is. It is probably the most well-known cryptocurrency. In reality, I should be on a beach somewhere in Bermuda. I was approached in 2013 by the first bitcoin exchange that came to Hong Kong. They asked me to advise them on their regulatory position. I thought, what is this? This is rubbish. This is never going to take off. This was when Bitcoin was about 20 US dollars. At some point it was over 19,000 US dollars. I did not invest. I am not at all bitter about this. There have been cryptocurrencies and artificial currencies before bitcoin and there have been many since. There are probably thousands now in circulation. They

were actually developed in 2008. We still do not know who developed them. The persons did so under a pseudonym, Satoshi Nakamoto, but we do not know who is behind that name.

What is interesting is that the technology behind bitcoin, which is called 'blockchain', is not new. What is new about it is the combination of the existing technologies. One aspect of it, and I am not a technical expert, is that it involves cryptography, but also involves what is called 'consensus protocols'. Having transactions of a currency witnessed by a community in a way that enables no one person or group of persons to be in charge. That is where the word 'decentralized' comes from. The result of this blockchain technology is that the transaction records are effectively immutable and this is a game changer. They cannot be altered and they cannot be repudiated. In addition, the blockchain technology, and the way it was put together for bitcoin, means that there is no possibility of double spending of currency.

Normally, when you want to buy something using a bank card, this is what happens. I give my card details to the shop; the shop asks the bank if I am good for the money; the bank checks its records to see if I have got enough in my account. If I do, it lets the shop know. It updates its records to show the movement of money from my account to the shops and it takes a little for the trouble. Now, if you wanted to remove the bank from that system, who else would you trust to keep those records and not alter them or cheat in any way? Well, I would not trust you. In fact, I would not trust any single person. But I might trust everyone. The idea is that you do not have a central record of transactions. Instead, you distribute many, many copies of this ledger around the world. Each owner of each copy records every transaction; so to buy something using cryptocurrency I give the shop my details. The shop asks all the bookkeepers if I am good for the money; the bookkeepers all check their records to see if I have enough. If I do, they tell the shop, and then they all update their records to show the movement of money. There is no way that a forced transaction can make it If I try to alter a ledger, it will not match all of the other copies, and it gets rejected. In addition, one of bookkeepers chosen at random will be given a reward of some newly created cryptocurrency.

This is how cryptocurrencies work. Remember all of these bookkeepers, all of these ledgers, they are not actually people, they are computers, lots of computers.

Another point I would like to make is that the blockchain technology has other potential applications and this is going to really change the world. I started at Norton Rose Fulbright a year ago, and now over 30% of my practice is just in this world, from a standing start of 12 months ago. We are seeing this blockchain technology being applied in shipping, in trade finance, in the administration of insurance claims, in the authentication of diamonds. The possibilities are endless.

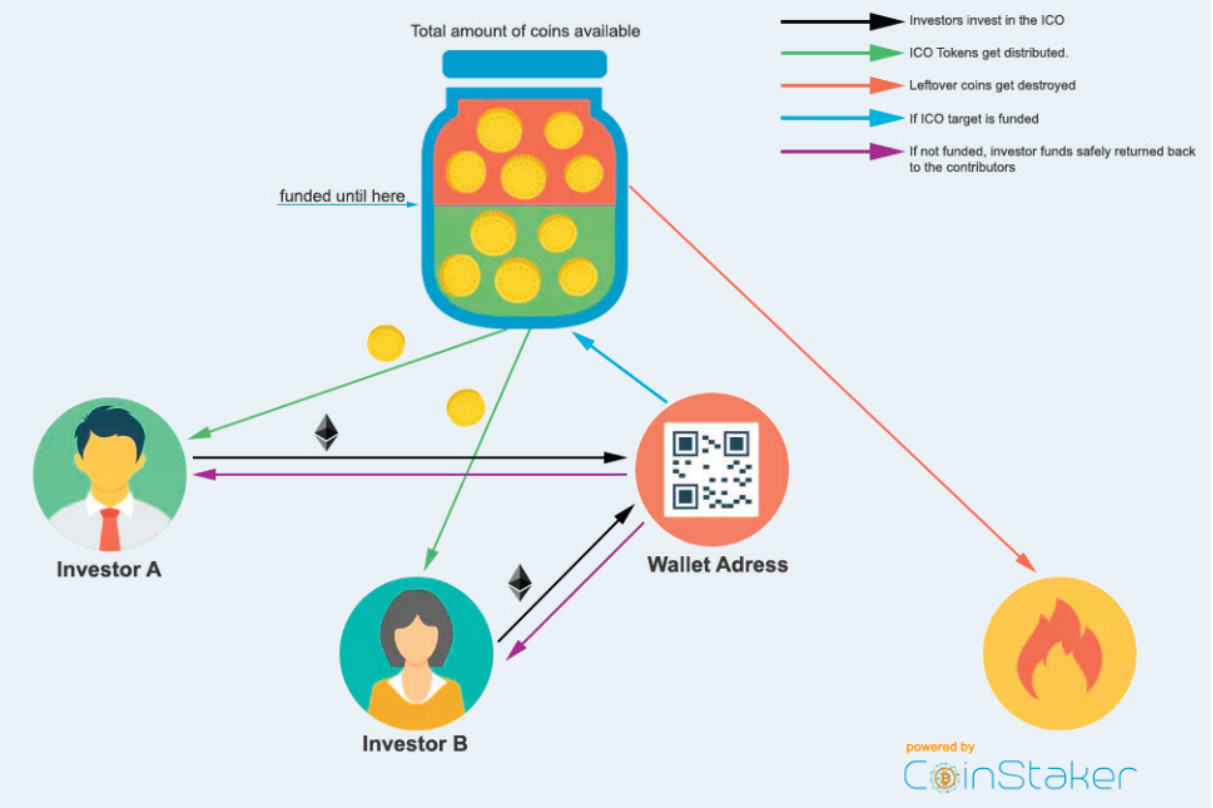
#	Name	Market Cap	Price	Volume (24h)	Circulating Supply	Change (24h)	Price Graph (7d)
1	Bitcoin	$94,642,972,382	$5,444.41	$4,468,980,864	17,383,500 BTC	-2.91%	
2	XRP	$19,462,955,655	$0.483291	$837,709,570	40,271,748,947 XRP *	-5.83%	
3	Ethereum	$16,935,675,757	$163.96	$1,900,260,812	103,290,802 ETH	-7.15%	
4	Bitcoin Cash	$6,589,977,251	$377.31	$275,681,696	17,465,875 BCH	-4.00%	
5	Stellar	$4,553,939,627	$0.236392	$101,422,637	19,264,393,114 XLM *	-5.61%	
6	EOS	$3,922,203,116	$4.33	$824,404,928	906,245,118 EOS *	-6.44%	
7	Litecoin	$2,370,746,416	$40.03	$375,860,849	59,221,038 LTC	-6.26%	
8	Tether	$1,751,194,291	$0.997024	$3,275,695,537	1,756,421,736 USDT *	1.06%	
9	Cardano	$1,481,387,290	$0.057137	$23,320,704	25,927,070,538 ADA *	-8.06%	
10	Monero	$1,406,055,899	$84.80	$16,359,274	16,580,954 XMR	-5.84%	

The list I present here is from last week and basically shows the top 10 cryptocurrencies listed in descending order of market capitalization. You can see bitcoin with about $94,000,000,000 market capitalization as of earlier this week, from a high of over $19,000 per bitcoin. It has now dropped to under $5,000. So, you can see there is tremendous volatility in the market and that is where some of the more philosophical questions arise. How do we reign this in? How do we stop market manipulation? How do we regulate this thing that is really decentralized and not inherently designed for regulation?

The second on the list is 'ripple', which was designed as a blockchain platform specifically for interbank transfers between financial institutions. The third one most people will have heard about is the Ethereum. Ethereum is not just a digital currency although Ethereum uses its internal currency called ETH (symbolized Ξ). Ethereum is actually a decentralized software platform that enables so-called smart contracts and distributed applications to be built and run, and actually a lot of the other cryptocurrencies and other tokens are built on the Ethereum blockchain. Which brings me nicely on to the second pillar of the presentation, which is initial 'coin offerings' or ICOs as they are sometimes called. 2017 and the first half of 2018 was really the year of ICOs. These are basically projects involving the creation of cryptocurrencies or tokens, and the promoters of these projects raise money for that project by preselling these tokens. Now we come to really interesting discussions of whether this is actually just traditional capital raising and should be regulated like any other securities offerings? Why are these people in a sort of unregulated vacuum where no one can really see what they are doing, and the possibilities for manipulating the market are endless?

What is an ICO? An analogy would be if I was going to start an airline – an airline that let's say would fly initially between Singapore and Hong Kong – and the way I would like to fund this airline is I say, "would you like to buy in advance, some frequent flyer miles for my airline?" Now, you might have a good legitimate business reason for buying frequent flyer miles in advance. The legitimate business reason in this case would be that you have a business that has branches in Singapore and Hong Kong and you need your staff to fly between the two destinations fre-

quently. You think you might be able to save some money by buying these frequent flyer miles in advance, but there are obviously a number of risks in doing that. The airline does not get off the ground, frequent flyer miles might change in value, the business needs might change by the time that the airline actually takes off. The basic idea is that you are buying something in advance that you can use later for some kind of business purpose. The terminology that has come to be used is what is called a 'utility token'. It is a token that has some utility value for somebody in some particular application. There are lot of people investing in these ICOs, and I would guess that nearly all of them are not doing it because of some utility. They are buying it as an investment, because they think the value will rise and that there will be a market in these and the price will go up. I offer speculation, but actually that is true for initial public offering of securities as well and other sorts of investments.



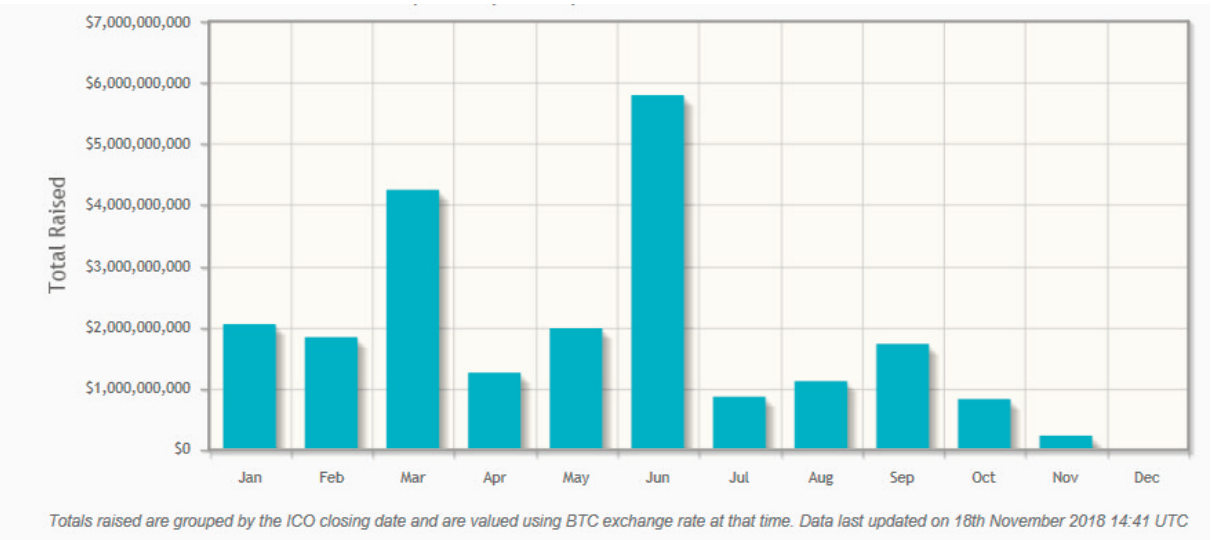
This slide is taken from a site called coinstaker.com. It gives us sort of diagrammatic picture of what really goes on. The big jar at the top with a yellow colour contains the tokens or the currency that is going to be created in this particular coin offering. The idea is that investor A (see the black arrow to the wallet address) is pre-purchasing some tokens, likewise for investor B who is doing the same. Typically, these ICO investments are made in bitcoin or some other cryptocurrency. Investor A and B make pre-purchases by putting bitcoin into a wallet address, which is then transferred to the owner of the jar. You are pre-buying tokens that may not be created for some time. Some of the tokens, the ones in the bottom half of the jar, will be distributed to investor A and B. The green arrows going down from the jar show this distribution. In this particular case, if not all of the tokens are funded, the ones at the top of the jar, the ones surrounded by red, would be destroyed.

Top Ten ICOs of 2018

Position	Project	Total Raised
1	EOS	$4,197,956,136
2	Telegram ICO (Private Pre-sale 1 & 2)	$1,700,000,000
3	Ruby-X	$1,196,000,000
4	Petro (Private Pre-Sale)	$735,000,000
5	TaTaTu	$575,000,000
6	Dragon (Private sale + Public Sale)	$420,000,000
7	Huobi token	$300,000,000
8	Bankera	$150,949,194
9	Neluns	$136,000,000
10	tZERO (STO)	$134,000,000

Source: https://www.coinschedule.com/stats.html. Accessed: 19/11/2018

This slide shows the top 10 initial coin offerings in 2018 so far. I will just talk about a couple of these. EOS is actually a funding to develop another type of blockchain to compete with Ethereum. Telegram ICO was a fundraising to develop a new type of instant messenger service. An interesting one for the TaTaTu that is a decentralized system that rewards users for viewing and putting social content onto the platform, streaming films, etc.



Source (2018 Fundraising Totals Raised Chart): https://www.coinschedule.com/stats.html. Accessed: 19/11//2018

This chart shows a histogram. The blue vertical bars of the amount raised in US dollars per month, each month in 2018. You can see the explosion of ICO towards the summer and then it dipped down from the autumn onwards. We can speculate as to the reasons why. My personal view is that because of the increasing regulatory scrutiny, and the dropping of the value of the main cryptocurrencies this year.

What are we seeing in the kinds of industry trends? As I said, we work a lot in this space and what we are really seeing is that these types of digital assets are becoming more mainstream. Essentially this was initially a retail phenomenon, but now we have institution at interest, and more sophisticated investors are moving into this space. We get a lot of hedge fund asset managers calling up wanting to invest in this new asset class, and the regulators are now starting to pay a lot of attention. There are a tremendous amount of cryptocurrency exchanges being formed. The first bitcoin related businesses are actually being listed on traditional stock exchanges. In Hong Kong we are working on the listing of a business, which involves machines that are used for mining bitcoin. The sophistication of the products is increasing. Initially people were throwing money at all sorts of stuff and it really was like a replay of the dotcom era of 1999. It was sort of throwing money at nothing, no value, no balance sheet. That is changing. There is also, interestingly, a lot of competition between countries. Everyone wants to be the next crypto valley, but they want to do so in a way that does not endanger the investing public. Singapore is doing particularly well in this space. Last week I was in Singapore for the Fintech Festival where there were 40,000 people. Christine Lagarde was there. She gave a very interesting talk about what the IMF is doing in this space. This is something that is not going away, but interestingly, it has been some of the smaller offshore countries which have realized that the traditional banking services industry is in retrenchment mode. Bermuda, Gibraltar, the Baltic states are some of the jurisdictions at the forefront of developing legislation to allow for regulation of this new type of technology.

What are the regulators doing? This is very important, and it ties into what was said this morning about policy makers and how do you explain to policy makers what is going on? In their sphere the regulators are chasing the market. The market is changing every month and the regulators are struggling to keep up. Partly what has been happening is the regulators are trying to up-skill themselves as well and to work out really what is going on in the market and how to deal with this.

The big focus so far has been to actually see what these tokens and cryptocurrencies should be classified as. Is it a commodity? Is it a currency? Are the tokens securities? Should they be regulated like securities? Securities issuances is highly regulated in the jurisdictions, and these utility tokens are really skirting the regulatory net completely. A big focus has been on the effects of bitcoin on anti-money laundering and counterterrorism financing. A lot of jurisdictions have really attacked it from this angle and have made all the cryptocurrency exchanges, but also all the banks dealing with everything to do crypto, have to pass heightened AML and CTF checks.

As I said, there have been some facilitative jurisdictions as well who have developed regulatory and legislative frameworks to deal with this. We are starting to do a lot of work in this space. So, we are advising the government of the Philippines to work on a new framework for their distributed ledger technology, legislation essentially. It is a really interesting time to be in this space.

The interesting philosophical question is what role does the state play now, in connection with these new digital currencies? As I said at the beginning, money is changing, the way we treat and handle money is changing. There is a huge amount of pressure on traditional deposit-taking commercial banks. What are we doing when the central bankers are no longer the trusted mid-

dleman and the trusted intermediary in this space? Last week, as I mentioned, Christine Lagarde was in Singapore and it is very interesting that the IMF is working on this as well and looking into whether states should be issuing digital currencies themselves. A lot of jurisdictions are looking into this quite seriously. Partly why they are promoting this is because it will really increase financial inclusion. If you think about the farmer in Kenya, he may not have access to a bank branch to draw money, but he will have a smartphone, and that's the future. So, actually a lot of regulators and super regulators like the IMF are actually into the idea of creating some type of state-sponsored digital currency, because it will enable the unbanked to be banked. Another aspect is that central banks can safeguard a certain amount of security and consumer protection, and particularly privacy in this space. A good example is the role of AI in determining credit ratings. We see a lot of activity in the robo-advisory space as well, enabling wealth managers to create investment portfolios for people. You do not go and see your bank branch manager anymore. An algorithm decides what you should be investing in and it looks at your spending habits.

Apparently, the people who buy frozen pizzas and beer should have a lower credit rating than the people who buy the organic broccoli. So there is a role for the state to play in making sure that AI is being used ethically and personal data is protected.

The last point I wanted to make on this is that, interestingly, the jury is still really out on what effect all these digital currencies, in the issuance of tokens, will have on financial stability. The FSB (the financial stability board under the G20 auspices) said this summer they do not think that cryptocurrencies have an impact on financial stability just yet, but they are looking at creating a risk management framework to deal with this.

I guess the message here is that this is here, this is here to stay, and we need to think about the role that we are all going to play in this new digital economy. I find this final slide particularly amusing and you can decide for yourself where you are based in this.

"I've come up with a set of rules that describe our reactions to technologies.
1. Anything that is in the world when you're born is **normal** and **ordinary** and is just a natural part of the way the world works.
2. Anything that's invented between when you're 15 and 35 is **new** and **exciting** and **revolutionary** and you can probably get a career in it.
3. Anything invented after you're 35 is **against the natural order of things**."

Douglas Adams, The Salmon of Doubt

Childen in Situations of Migration

Mária Herczog

To talk about children in the context of security and conflict may perhaps seem too romantic, too emotional or even too naïve, but based on what we have heard so far, it is quite clear that when it comes to crisis and conflict situations, human beings are the cause of both harm and good. The quality of our capacities and adult life is primarily based on our childhood experiences and on our upbringing in the widest possible context. My primary intention based on this belief has always been to work with issues concerning children in accordance with the impact on other relevant areas of life.

One of the main questions in relation to this is, how do we ensure that the developmental needs of children – their need for nurturing, and emotional support – are properly served? Throughout the history of mankind, and even today, even if it sounds too simplistic, many if not all conflicts and uncertainties are caused or actually created by people whose character, motivation, and attitudes are not exactly what we would call appropriate for the future of the world. I am talking in a very narrow sense about the welfare and wellbeing of children, a specific dimension of their life in relation to security and safety. I was asked to speak at this conference about children in migration situations and not about other extremely important areas like poverty, exploitation, social deprivation and exclusion of children that has had a huge global impact too and is of course closely related to all those situations that are the root causes of migration. I hope that I can demonstrate through data that we are in a crisis when it comes to child development all over the world, in the given context.

The UN Convention on the Rights of the Child defines the child as a human being below the age of 18. This means that everybody under the age of 18 should be considered as a child in whatever situation they are in, and obviously migration is one of those situations. When children are not considered as children when they are over 12, 14 and so on, and this is often the case, it has devastating effects. In the literature and in the everyday communication there are many different terminologies used for children, like minors, adolescents and young people, and also many for migration situations: migrants, unaccompanied, refugees, asylum seekers. We should use more universally accepted and clear terminology as it has a great impact on the legal provisions, policies and practices, data collection etc.

Talking about the available data on children, surprisingly when it comes to children in the situation of migration, there is a lot of reliable data, compared to the data available on children in general. Strong political reasons must explain the availability of a good quality data set, compared to other child related disaggregated data gathered and published. Children in migration situations can be divided into sub-groups, to those who are traveling alone (unaccompanied minors), those who are together with their families or guardians, and also children who are with adults that are not their relatives or members of their kin. Often times, sadly, these children are forced into child marriages and/or are exploited and they are accompanied by adults who are, at least formally, their partners.

There are some shocking facts we have to confront, because we are often not aware of the extent of the situation of the children in situations of migration. 1 out of 80 children live in forced displacement, which is a huge number if you look at the quality of life of the children and the risks, threats, and dangers they face. In 2016, there were 12 million child refugees and asylum seekers; 16 million children living in internal displacement due to local conflicts, violence, ex-

ploitation. Another seven million, have been internally displaced due to natural disasters; and there is a very special category of children we seldom talk about, children whose parents have left them primarily for employment reasons. In China alone, according to the estimates in 2017, there were 69 million children left behind by parents who could not work locally and had no choice but to move to cities where they could find employment and better incomes. China is in a very special situation because of the *hokuo* (household registration system) that only provides entitlement to health and educational services where one was born. If the parents take their children with them to the cities where employment is available, these children have no access to health and educational services. If they leave them behind, they can send money home and that may ensure a better life for themselves and for their children financially, but clearly the children will lack parental guidance and nurturing when facing challenging situations while left with relatives or neighbors.

This is not unique to China, but in Southeast Asia and in some parts of Europe (Moldova, Romania, Ukraine and many former Soviet Republics) and other regions. The United Nations estimates that more than 900 million people globally move away for work, often leaving their children behind who often face neglect, abuse, and lack educational opportunities. For example, in Cambodia 2 million people who work in Thailand leave their children behind, and this also places children in a migration situation as they are very severely affected by the fact that their parents have left. In addition, millions of children have moved within or across borders looking for better opportunities, access for food, education, health care and even family reunion.

Between 2005 and 2015, according to the UNHCHR data, the number of child refugees more than doubled, meaning that the situation of children in situations of migration has not been handled properly and there have not been proper policies and tools in place to stop the displacement and migration of children. In 10 years, if you look at this trend, this could mean that there will be between 4 and 9 million child refugees and displaced children around the world. Looking at the proportion of children globally, they make up one third of the world's population, while almost half of the refugees and children in other migration situations are children – this means over 50 million children. It is also important to note and should be taken care of, that 9 out of 10 refugee children remain in the same region of their origin. We should be much more conscious about the need for local services for local solutions, because most of the children are not moving very far from where they lived and need support.

Despite the UN Convention on the Rights of the Child and all other human rights provisions, over 100 counties currently detain children as a form of punishment for those in migration situations. This means that children are considered as offenders and not as victims of the migration situations. At least 300,000 unaccompanied and separated children who crossed borders without an adult were registered in 80 countries in 2015-2016. This also means that when it comes to identity, to opportunities, to be protected, these children are the most vulnerable because they are not accompanied by parents or any other responsible adult who could help when they are at risk of exploitation, abuse, or other forms of violence.

Although the world is relatively peaceful, almost 1 in 10 children around the world live in countries and areas affected by armed conflicts and over 400 million live in extreme poverty. This is one of the root causes why so many children and families try to leave their place of origin to look for better living conditions. Trafficking has also been a substantial reason why children are on the move. In 2016, 28% of all detected trafficking victims were children (20% girls and 8% boys), and this is considered a bigger organized crime business than the drug business. The effects of trafficking are devastating from the perspective of children's lives and future perspectives.

We should draw attention to the life chances or opportunities of the children effected by any of the migration situations, and the opportunities to make informed decisions about their own lives. The future, for better or worse, depends on how we take care of the children. Refugee children are 5 times more likely to be out of school than other children. Only 50% of refugee children are enrolled in primary school and less than 25% in secondary school. Many children in situations of migration are growing up in refugee camps, are almost constantly on the move, become stateless and at risk of abuse and exploitation. The UN Committee on the Rights of the Child has made several recommendations to the different state actors to provide better services and access to the basic needs of children at least and also aim to reunite children with their family members.

Narrowing the topic to Europe, one third of the refugees and migrants who have arrived in Europe are children. They come primarily from three countries: Syria (54%), Iraq (27%) and Afghanistan (13%). Most of the children come from Syria, and many of them end up in Turkish refugee camps. They have the largest refugee population in the world where almost half of the population are children in the camps. Refugee camps are also considered as form of institutionalized care for children, and de-institutionalization efforts to place children in family and community-based environments to ensure their developmental needs also focus on refugee camps as one of the worst forms of institutionalization. The same kind of harm is caused by isolating, locking up children, not providing proper access to health care, education, play and any future for children and young persons living in the camps. It is very important to consider the devastating long-term effects of refugee status itself, but also of the refugee camps on children and others. Many children grow up in refugee camps in different countries, not even knowing their own country of origin or having a chance to go and live there.

What are the needs of children in situations of migration? UNICEF had been working with its partners on a roadmap to provide guidelines to improve the care and protection of children in migration situations and especially those who are unaccompanied. Although it is common sense, it has to be repeated again and again, that children in situations of migration are mostly not being provided with safety, protection, proper health care, and adequate nutrition, not to mention their emotional needs. Many of them are starving and malnourished. Education, access to play, caring relationships, and psychological support to work on the trauma, need to be addressed as immediate needs.

It is extremely important to recognize and acknowledge the inter-linkage between the conflicts and the insecurities we have been talking about. The children in situations of migration are traumatized, most of them are suffering, many of them are angry and they will become the next generation who make decisions not only about their own lives but also influence substantially all of our lives and future. They are entitled, as all human beings, to a fair chance and a life worth living. If for no other reason, we should be at least selfish enough to provide them with a joyful and happy childhood, so they do not to ruin the world.

What should we do? We should support the long-term integration and inclusion of children in situations of migration into the communities where they are now, but also ensure their right to their identity, language, culture, and traditions, and return to their place of origin if this is in the best interests of the given child. It is the responsibility of the adults, decision makers, politicians, policy makers, professionals and everyone to contribute to the wellbeing and the development of children and their future.

The Sustainable Development Goals targets for 2030 are very ambitious but probably not very realistic, but they have to be kept in our minds and realized to the fullest extent possible:

- Every child survives and thrives

- Every child learns
- Every child is protected from violence and exploitation
- Every child lives in a safe and clean environment
- Every child has a fair chance in life

Despite of the challenges of the targets, it is essential at all levels to discuss and plan strategically and at least achieve some of the goals as much as possible. We should agree on what are the minimum requirements to implement as much as possible.

I would like to quote the statement of the children from the UN Summit in 2000: "We want a world fit for children, because a world fit for us is a world fit for everyone. … You call us the future, but we also want to be the present".

I guess we should think it over: if the world is suitable for children and is a good place to live in, then it is probably also a good place for all of us. It is essential to acknowledge that children are not only an investment in the future, and it is not all about us, it is also about their current life, their wellbeing, and joyful childhood and active partnership and participation. The years of childhood are nor replaceable, and the quality of their early years lasts forever. If children can feel that they are respected and valued human beings, who are listened to and their views and wishes taken into consideration, we can make progress and hopefully make the world a better place for all of us.

Narratives, Networks, and Knowledge: Finding Pathways to Sustainable Futures

Ilan Chabay

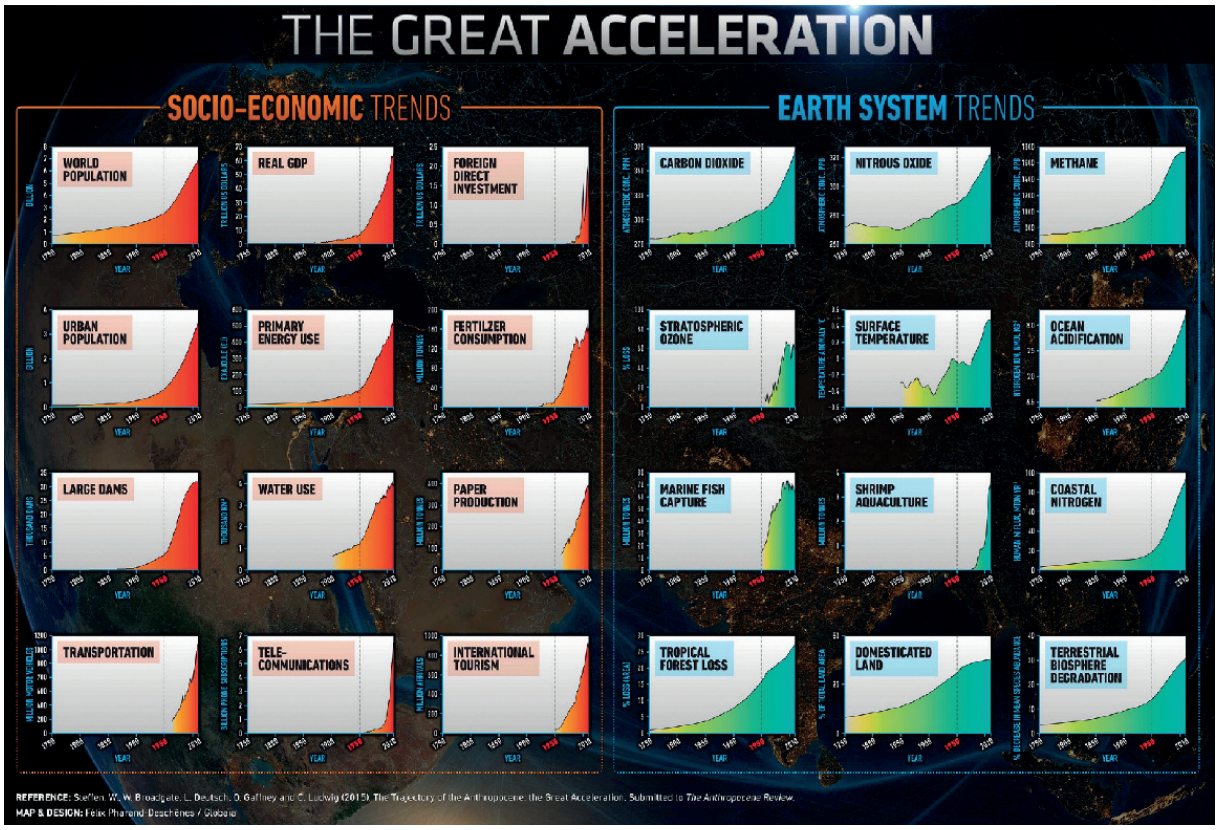
Let me start with some questions and a normative assertion that, as previously mentioned, we are living in the Anthropocene Era. We are in the midst of a great acceleration as well, which makes changing the patterns of unsustainability essential, even existential, and urgent. How can this kind of collective behavior change so more sustainable futures occur? That is really my fundamental question, because it is not just about separating your own garbage. It is a question of how communities, at whatever scale one would like to talk about, handle the kinds of fundamental changes in behavior as a community and as a collective, whether on a global, a regional, a national, or a local village scale – not only how do they change, but how do we make them coherent, so they are not competing with each other and canceling each other out. The questions that I would like to address are:

Can social movements for sustainable futures with justice and equity be catalyzed?

- I use the term 'sustainable futures' in preference to 'sustainable development' because development has different connotations and meanings as people understand it, and because the pathways and processes for moving toward sustainability depends on context and culture, rather than being uniform globally.
- What are the drivers and the hindrances of transformations to sustainable futures?
- What insights do narrative expressions of vision and identity provide in moving towards sustainable futures?
- How can narrative-driven role-playing games support moving towards sustainability by helping people grasp the consequences of living in the midst of a complex system, indeed a complex system of systems?
- I will talk about what I mean by narrative expressions a bit later.

We entered, but we can't just turn around and go back

We already know that we are in the Anthropocene at present, but how do we get out? We can't just reverse course, we must move forward and change the negative consequences of human behaviors. We can talk about planetary boundaries, but I will not spend time on this since it has already been discussed, except to say that the Earth's system trends are not separable from the social and economic trends. What we are facing is something that is a critical, perhaps existential issue, but one that is changing very rapidly, and indeed accelerating.



I like the ideas of Kate Raworth very much. She came up with the "doughnut" and she has written a wonderful book on "Doughnut Economics"

The doughnut of social and planetary boundaries (Raworth 2017)

The point there is that yes, we have the planetary limitations and boundaries, but what are we going to do about it? What would we have to change? How do we make that change? – that is my question. What Kate has done with this doughnut shows that on the outside are these hard limitations that have to do with the physical conditions, physical materials on earth, about 'planetary boundaries' like ocean acidification, ozone layer depletion, freshwater withdrawal, and climate change. The inside has to do with the social foundations and the fact that society operates within this physical environment.

How do we stay in this safe and just space for humanity is another way to look at this whole thing; and, of course, we have the Sustainable Development Goals, which are a major accomplishment in actually coming to such a comprehensive set. On the other hand, they are also a very complex set, because they are deeply interconnected and interdependent, and therefore they cannot be addressed simply by the kind of reductionist science that we have been using to teach and perform. There is also perhaps a question here too, at what scale does this make sense and how do different cultures, different conditions affect this? I worked for a few of years in the Arctic, in East Asia, and with a graduate student, who is working in the slums of Nairobi. In these different places, a sustainable future most likely would be quite different. What common pathways can be useful and which aspects of sustainability must be addressed differently in those different conditions and cultures? It is a difficult, but absolutely essential to consider how sustainability can be attuned to be successful in the local cultures, values, and contexts (e.g., political, demographic, economic).

Let me just summarize by saying that science is embedded in the natural systems on which it is entirely dependent, yet sometimes when you talk to people about ecology and sustainability, they say something like "there is a very nice forest about three kilometers over there." But you ask, wait a minute, what are you breathing, what are you drinking, what are you wearing? The point is that society itself defines what is relevant and valuable in the relationship to the local and global environment, including ecology, biodiversity and resources. It is not a given. Sustainability depends on how people conceive their relationship to their environment and each other, and therefore very crucially the terms "agency" and "responsibility" arise. What is your responsibility? What is your agency? What are you capable of doing? Maybe as importantly: What do you think you are capable of doing? For well-being and survival, I would say, in this case of really rapid indeed accelerating change, it means that societies must continually learn and innovate for societal needs. We cannot keep doing things the same way. We do not have a playbook. We do not have a textbook that says: 'just do this and we are fine'. We do know what to do in some fields like physics or biology, but how do we do this for society? That is a really tough question. The term 'codesign' is an important process that highlights engagement with society in the design of some types of research. I will talk more about that in a moment. Ultimately, I think the question is how do we change patterns of behaviors moving forward, rather than focusing on how to fix what we have screwed up and we continue to screw up? Let's get ahead of the curve and figure out how not to walk into the next trap.

In order to address these questions, about twelve years ago I started a project as part of the International Human Dimensions Programme in Global Environmental Change (IHDP). It was known as the Knowledge, Learning, and Societal Change Alliance, which I now call 'KLASICA' and now is based in Potsdam Germany at the Institute for Advanced Sustainability Science (IASS).

KLASICA ALLIANCE
Knowledge, Learning and Societal Change
An International Research and Action Alliance

IASS POTSDAM

KLASICA seeks to understand how knowledge, meaning making, and societal change are interconnected and in particular:

- identifying and understanding conditions under which collective behavior change (CBC) toward sustainable futures occurs (or fails) in different places and contexts
- using that understanding to advance solutions for and promote actions on pathways to sustainable futures.

The aim is to understand collective behavior change and to use that to catalyze movements along pathways to sustainable futures in different cultures with equity and justice. Let me iterate this slightly and expand it. It is about learning, innovation, negotiation, navigation toward sustainability. But there is an inescapable uncertainty, not because we are doing bad science or doing science badly, but because uncertainty and ambiguity are fundamental and inescapable in a complex system. In a complex system, one cannot necessarily assign causality. In many instances, people do not distinguish 'causality' from correlation. In a truly complex system, we simply cannot know for sure that we understand the fundamental causality. Second, there is a normative ambiguity due to the fact that multiple value systems and beliefs can influence the design and interpretation of science. The choices and actions taken now may have unanticipated, unintended consequences that come back and bite us later, maybe tomorrow, maybe 10 years from now, because we are not aware of all the loops, interconnections, and causalities in the complex system.

Earlier I mentioned the idea of co-design and my experience in the Arctic. In order to understand the context and local knowledge and priorities, we met with rights holders and stake holders in several places in the Arctic, including the Arctic Circle Conference and meetings of the Arctic Council Sustainability Development Working Group. Recently, I worked with communities dealing with earthquake recovery in a small town near Kumamoto in Kyushu, southern Japan.

Transdisciplinary dialogues

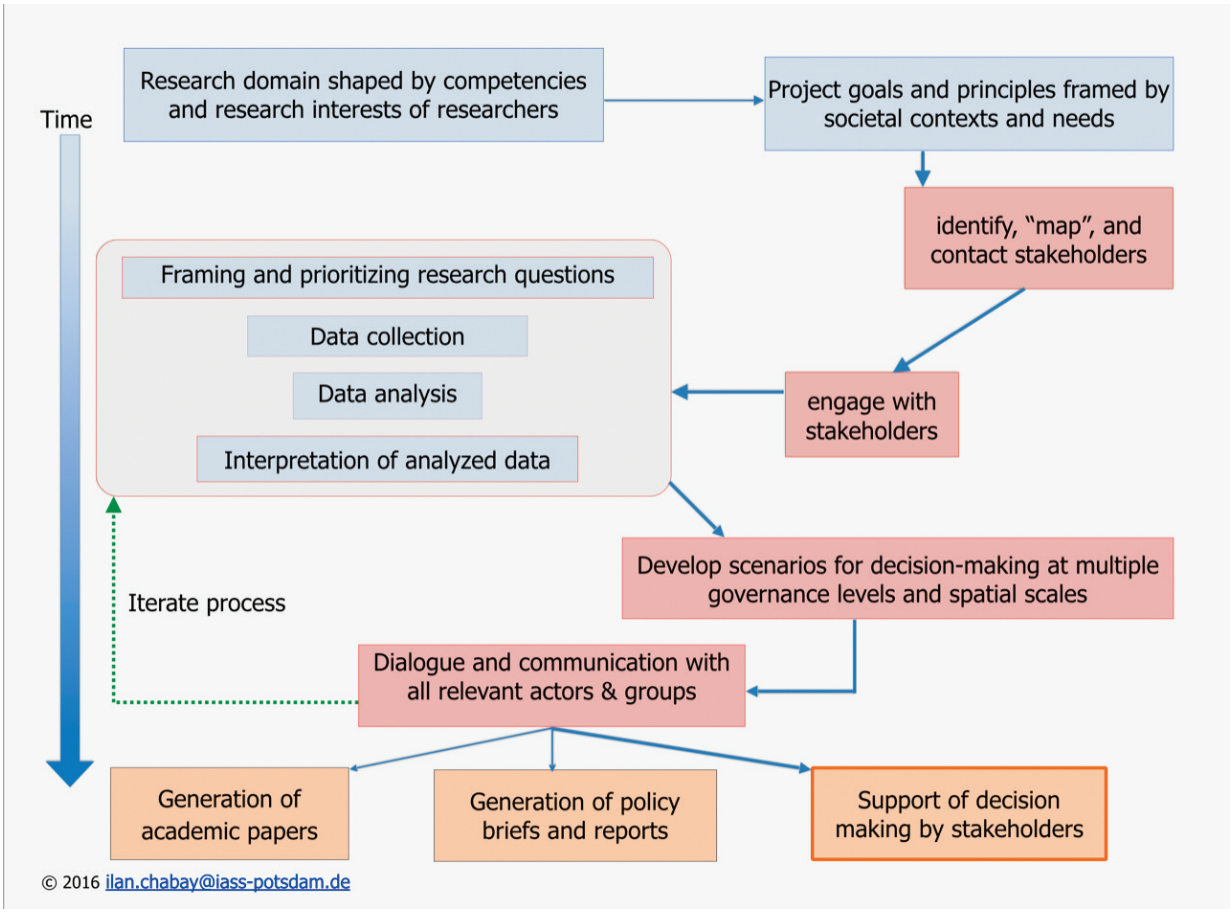
Stakeholder and rights-holder dialogue in Arctic Circle Conference, Reykjavik

Community earthquake recovery dialogue near Nishihara, Kyushu May 2016

Regardless of location or context, it is not about giving communities or society solutions; it is about employing existing information in a form that people can use in their context and aligning research with local priorities and concerns in order to support the capacity of stakeholders and rights-holders to make decisions about how to move forward towards their own sustainable future.

This is a schema that I developed for our Arctic project at (IASS).

Schema for Stakeholder Participation (Elements)



It shows schematically the elements needed to engage with the stakeholders, rights holders, and shareholders. The key point, which often gets missed, is the interpretation of data. Data does not speak to us. Here we are today in the Hall of Musicology. Let's say you are given a piece of paper with some lines on it and a bunch of dots and maybe some other symbols; you take an instrument and start playing each note, one after the other. That is not very interesting as music. What **is** interesting is the interpretation – how you play, how you make sense of it, and how the audience hears and makes meaning of the sounds – and that is equally true with science. We have data, we make a story, out of it, we try to make sense of it, but we do not all agree as to what that story really means. How we do that, how we interpret with the stakeholders and rights holders is absolutely essential in my view.

I want to speak a bit more about data computation and narratives. There are many kinds of efforts to model trajectories toward sustainability. I am involved in one project called The World In 2050 (TWI2050) that the International Institute for Advanced System Analysis (IIASA) in Austria and the Stockholm Resilience Center have organized. This project uses integrated as-

sessment models that look at trajectories from today through 2030, 2050 and beyond. Great, but what if society changes rapidly and the baseline or starting point for the trajectory shifts so rapidly and radically that the projection is fundamentally flawed? In the report that was issued in July 2018 at the UN in the High-Level Political Forum, attention was called to the fact that we really have to understand the social dynamics in order to make more meaningful long-term integrated assessment models by either forward or backcasting. We need to understand the social dynamics to have a better basis for considering potential societal bifurcations in their pathways and conditions.

That leads me to the question of narratives for critical insights that can be the basis for what I call 'provocative modeling'. We are not predicting – we cannot, we are not doing system dynamics where you start out with what the system description looks like and project it out. It doesn't work the same way in considering possible tipping points or bifurcations and emerging phenomena in coupled socio-ecological systems. Basically, the idea is that computation with big data allows us to make critical distinctions, recognize nuances, and not only to produce statistical averages of behaviors.

A rather novel source of data and insights into incentives and motivations for behaviors comes from narratives of vision and of identity. Of course, narratives are fundamental as human communication from earliest times. What I am focusing on are what I call "narrative expressions" meaning the condensed and affective expression distilled from longer narrative discourses. In some cases, narrative expressions take the form *inter alia* of songs, dance, paintings, or puppet theater, each of which gives the core idea resonance in particular contexts and cultures. Most people do not know the entire very powerful speech that M.L. King gave, but they do know the phrase: 'I have a dream'. In the case of children in a village in Taiwan, they don't know the whole story of their village and the loss of it due to a typhoon and mudslide, but an artist created the narrative in painting that can be understood and remembered. Picasso painted *Guernica* on a wall in 1937 that changed the way millions of people thought about war. Examples are shown below

From Narratives to Social Dynamics Models

Analytic concepts for categorizing narrative expressions

1. The type of *evidence* that is brought in to make the narrative convincing (associative plausibility),
2. The setting, scope or *context* that the narrative is being connected to (framing),
3. The core *value(s)* the narrative is affirming or pointing toward (normative affirmation)
4. The thing within the narrative meant to *catalyze emotional response* from the listener (Ortwin:"emotional identification")
5. The *emotional drivers* for action (motivational incentives)

There is also, unfortunately, the other side of the story. It is hard to imagine, but there was a campaign to outlaw sustainability that was successful in two states in the United States. They passed a law outlawing sustainability in Alabama and in Kansas, which is an agricultural state that has been suffering from drought for 35 years now. The point is they were operating with very different narratives. The narrative that drove their decisions was about individual freedom, not about sustainability *per se*. In terms of science, we need to pay attention to existing narratives and their significance in the communities and in the reasons for their emotional resonances. If we don't take these into account and address them in the communities where the narrative expressions resonate, we can't communicate meaningfully and we will be ineffective at best and actually counter-productive, at worst.

We developed a preliminary version of an analytic typology of narrative expressions in the 2nd Taipei KLASICA Symposium in September 2018. The analytical categories we considered were associative plausibility (relation to evidence), framing (scope and context), normative affirmation (core values), emotional identification (resonance with values), and motivational incentives (affective drivers of actions). We looked at the how narratives link with social identify or catalyze an emotional response and motivations or internal incentives for action. These come from, on the one hand, the vision (where do we want to go as a society and how do we express desire as a narrative) and, on the other hand, on identity, which plays a critical role, yet has been often overlooked. This comes up in people's discussion of identity politics. Why is that important? – because it is motivational; it is what tells me that I should act in a certain way because everybody around me with whom I am socially connected acts that way. An interesting example came from work discussed by Dan Kahan on farmers in rural Kentucky, in an area with relatively good farming and where the farmers were part of a community of conservative Republicans. He asked them about climate change, which they denied being human induced. In their fields they said that things were changing quickly and they needed to change practices to adapt to changes in conditions. The story seems to be that they identify with their community and the views of the community. This is important to them, because this is a small community and they are linked to and dependent on their community. If you say there is human-induced climate change, then you are at odds with and may be quickly kicked out of the community. You cannot rely on your neighbors for support which in rural farming areas is essential. These kinds of identity issues, therefore, play a real role in how people make decisions.

In the last part of my talk, I want to outline some of the ways we can engage people in experiences and dialogues that stimulate their interest and open their perspectives on the crucial issues of global change in the Anthropocene Era.

The relationship between science, as a way of making sense of experiences in the world, of models (often embedded in or generative of narratives) and learning need to build toward inclusive sustainable futures. We need changes in education, including lifelong learning, to better enable all members of society to engage meaningfully in the processes of moving to sustainable societies. Education is the infrastructure for the formal schooling. Informal learning also plays an important role, since we do more learning outside of the formal structure than we do within.

Among significant shortcomings in our education generally is that we fail to teach about and learn from models. We often mention theories without discussing how they evolved and were tested, or that they are models of our understanding of the world. When we teach physics, at least at the undergraduate level, we usually don't talk about the model, we talk about results of the models. Yet in my experience, even young children do really well at coming up with models, even if they don't know that is what they are doing. Upon encountering a surprising or compelling phenomenon, they spontaneously speculate or guess why something they see is happening. The question then becomes: what do you do with that guess? How do you do more than just express your guess or opinion. We have talked here in the Blue Sky conference already about falsification as a part of the social contract that is science. First you test every idea or model by trying to replicate results and to see if and how the model fails to produce the observed results. If you cannot find an instance of failure of the model, despite multiple efforts, maybe the model or theory is adequate for use and we can test it even more widely.

It is also particularly important in dealing with complex systems that one intentionally looks for multiple solutions, rather than focusing on finding a unique optimized solution. Brainstorming and finding multiple solutions can be a very productive (and fascinating) process done by collaboration with people who learn and think differently and not only with people who have been acclimatized into thinking the same way. Individually, and even more so in collaborative groups, it is difficult, but crucial to take intellectual and emotional risks, to try ideas that are exciting and potentially valuable, but may also fail.

Taking risks by questioning what may be accepted knowledge and then learning to sharpen inquiry is a fundamental aspect of doing science. I remember sitting in the chemistry department office at Stanford one day when one of my colleagues, a well-known, excellent scientist, complained that his graduate students in the lab just hadn't been doing well over the last couple of years. I asked: "Well, how did you pick them?", he said: "They were the best students; they had fantastic grades; they had great recommendations". I replied: "I think that is the problem. They know how to game the system, but they do not necessarily know how to ask the questions." If you are trying to do innovative research, it is essential to think about how to formulate the questions, otherwise you won't get very far.

Outside of the laboratory or scientific workspace, inquiry and experiential learning are key ideas for engaging publics. The point is to stimulate questions by nurturing curiosity, and supporting the ownership of ideas in thinking both individually and collaboratively. This stimulates opportunities for creative ideation with diverse groups of people who are thinking about some of the same problems, but in very different ways.

Engaging people with experiences that stimulate their curiosity and provide them with memorable experiences that can lead to their building a vocabulary for thinking. After leaving my first career in natural science research, I founded and ran a company in which we invented and developed a couple of hundred devices, which were produced for 230 museums around the world. I am glad that the exhibits have been used by millions of people. The question that arose for me was what is the ultimate impact of the experiences on how people look at the world around

them and do such exhibitions change in any way the attitudes, awareness, and behaviors of people as a consequence of their experiences?

I think to be able to experiment with complex systems is important. Already in the 1990s, I designed a game called "Stranded on Mars" which later became essentially the basis for the movie "Martian". Several years ago, Ortwin Renn, then at Stuttgart University, and I designed exhibits and a game for the interior of a truck that traveled around Baden-Württemberg state in Germany. Around 700,000 people visited the truck on the energy transition in Germany and used the exhibits and the game. Six people at a time could play the game, each in his or her virtual home doing laundry, the dishes, getting food, etc. At the start the players decide how much energy in the virtual town should be from renewable sources and how much from coal? If the players decide something like: we are going to be really forward-thinking want 80% renewable 20% coal. While playing for about four minutes (which is a virtual week), the problem soon arises that all the energy supplied by people with hand cranked generators, is not enough to provide for the group's activities if the renewables are not available (without storage) and you get a blackout. That comes as a surprise to the players, which then provides an interesting opening for discussion. Then you can play again, but give people necessary signals to allow players to avoid uncoordinated high peak loads on the power supplies. People do not forget this coordination exercise, because it is surprising, simple, and engaging.

Lastly, I will mention that a couple of years ago a few colleagues at the University of Rome and I were involved in the Kreyon Days project funded by the Templeton Foundation and Lego Foundation. We designed a game that I called "Gaming the Future" and, oxymoronic as it sounds, it was meant to be a simple way to understand complexity – not in detail, but to understand the consequences of complexity. The game is played on a large flat Lego board. You build a landscape on which you build components in any way and anywhere you want. Because of a video camera (like a satellite earth monitoring system) above and models that interpret the consequences of the structures on the landscape, you see the consequences of what you have done in terms of for example, air pollution, CO2 output, traffic density, river flow, and river pollution.

Kreyon City Prototype of GtF

Research at Univ. of Rome on creativity and social innovation with Templeton and LEGO Foundation grants

Vittorio Loreto, PI with Stefan Thurner Andreas Roepstorff

As you build or move components around, you make what seems like very simple decisions, such as I am going to build an extra apartment building because I need more workers in my factory or farm. Rather than just seeing the Lego bricks on the board, you would see the many kinds of possible consequences of the building on large screens above the board. Legos work well because they are physical devices that people know how to use and the construction is in a common space seen by all. This augmented reality, in a sense, works better because everybody sees what everybody is doing. This can lead to constructive dialogues about the consequences of actions and the questions raised.

I will close by saying that we are only in the initial steps on pathways towards our sustainable futures.

Uncertainty and Complexity: Scientific challenges in understanding the unsustainable present and preparing for an unknown future

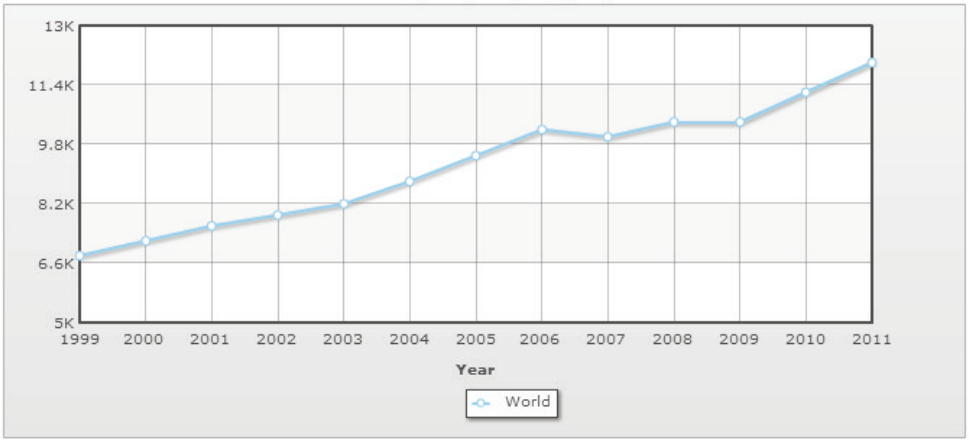
Janos J. Bogardi, Ilan Chabay and Sándor Kerekes

The Challenges Ahead

The "velvet revolutions" of the late 1980s and early 1990s ended abruptly the hitherto prevailing political bipolarity of the world. As one unprecedented feature this happened without the usual wide scale destruction, hatred, suffering and manslaughter usually accompanying major changes and turning points in human history. Once the imperative of the ideological confrontation was gone people hopefully realized the perspectives of democratization, cooperation and the real chance to join forces in addressing major global challenges of human security and well-being. Putting intellectual energies and financial resources together in order to achieve human aspirations for better life, education and environmental quality worldwide never looked more promising than 25 – 30 years ago.

The euphoria unfortunately did not last long and instead of rectifying the most urgent problems and the fulfilment of our most cherished hopes the world increasingly faced terrorism, a failing "Arab spring", political tensions and proxy wars to resurface. Thirty years after the unexpected but hopeful changes of 1989 the world might face again the cold war and a rearmament race.

The financial crisis of 2008 shook the economic understructure and revealed both vulnerabilities, ignorance and the lack of mechanisms to control financial greed. An unprecedented increase in inequality between poor and rich is occurring worldwide and the overall increase in global GDP is not shared equitably. While the GDP per capita of the world doubled between 1999 and 2011 (Fig. 1), population growth was "only" 20%. Thus, it could have been expected that the world was on the right track. There are some impressive indicators, like the threefold growth of the GDP of Hungary between 1995 and 2013; however, the distribution of this increasing wealth is heavily biased and geographically skewed. (Fig.2)



Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
World	6,800	7,200	7,600	7,900	8,200	8,800	9,500	10,200	10,000	10,400	10,400	11,200	12,000

Fig.1 Growth of the World GDP per capita (in Purchasing Power Parity) between 1999 and 2011

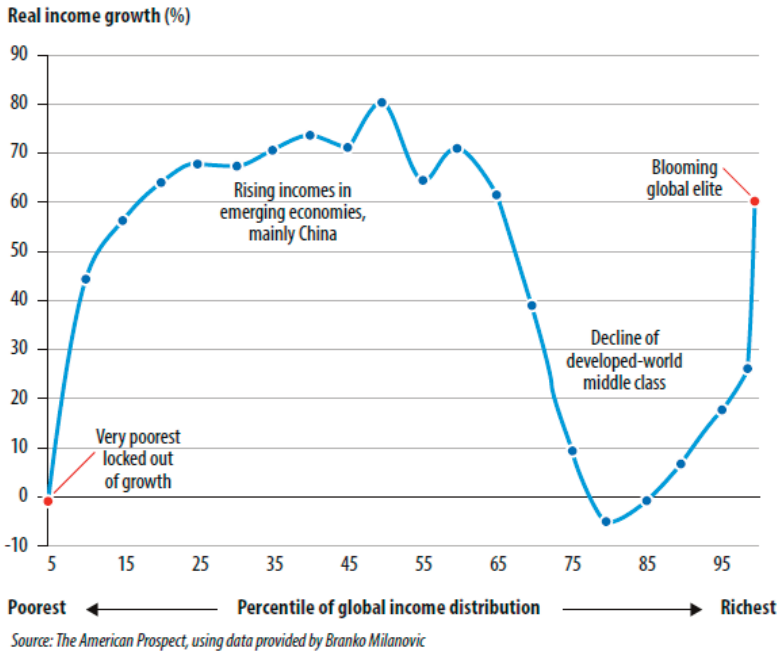


Fig. 2 Real income growth and decline for different social groups in different parts of the world

What seems to be the most dangerous social stressor worldwide is the complete reversal of income growth of the poor and middle class (rewarding labor) versus the income growth of the most affluent people (rewarding capital). Fig. 3 is a serious warning. The prevailing situation threatens social peace and consensus and could become a politically destabilizing factor. Ill-distributed wealth is unsustainable even if the wealth were generated without overstressing resources. Fig.4 indicates that our planetary stewardship was much less than optimal. Especially the genetic loss of biodiversity and the phosphorus and nitrogen cycles are alarmingly transgressing what scientists would consider as safe planetary boundaries. Even more alarming is that no consensus could be reached in the attempt to define planetary boundaries for functional diversity, atmospheric aerosol loading and novel substances.

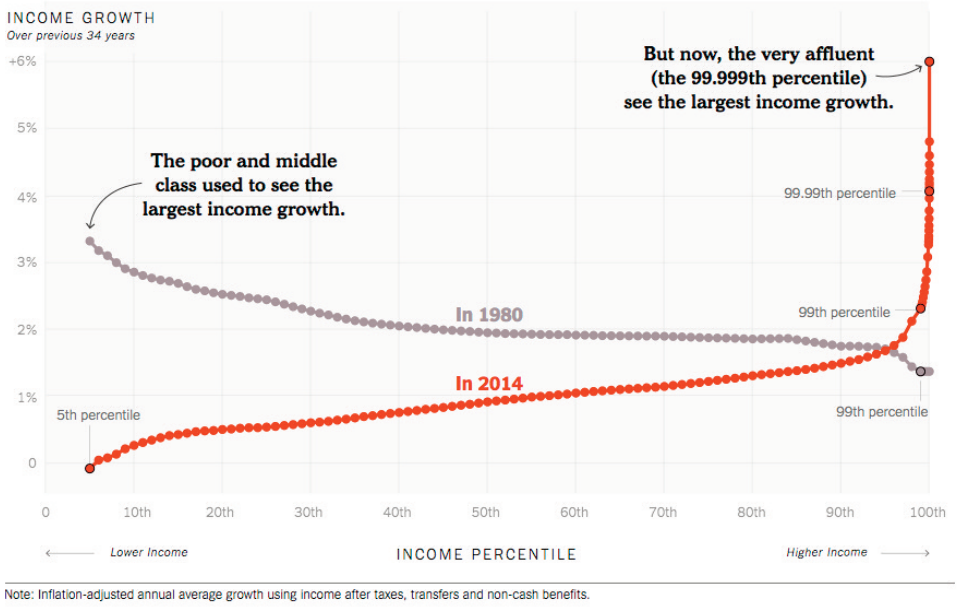


Fig. 3 Reversed distribution of income growth of different social strata between 1980 and 2014

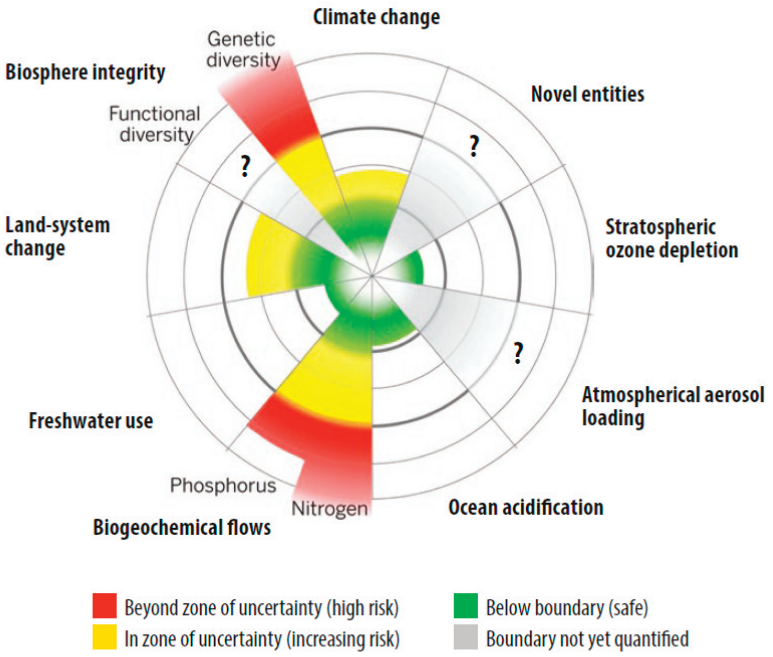


Fig. 1.4 Estimates of how the different control variables for seven planetary boundaries have changed from 1950 to present. The green-shaded polygon represents the safe operating space (Source: Steffen et al. 2015; http://science.sciencemag.org/content/347/6223/1259855)

Fig.4 Change of seven planetary boundaries since 1950

Environmental deterioration, irrespective of promises and not-to.be-kept agreements, continues, and is accelerating. The unbroken trend of biodiversity loss is estimated to be one of the worst in Earth's history. This gloomy outlook overshadows undeniable technological achievements and scientific advances. A few years ago scientists argued that we had entered the Anthropocene, a new epoch in Earth history where humans became the dominating force. Advances in artificial intelligence, robotics may harangue the dawn of a new industrial revolution with unexplored consequences for humans as active participants in these processes. Digitalization, but also social media and trade with personal data, so far defy the timid efforts of necessary control.

Our overreliance on advanced technologies without fallback options largely increased several dimensions of vulnerability. Climate change accentuated our reliance on an increasingly unpredictable climate. Population pressure, resource degradation, environmental stress and political repression, but also disasters and the availability of information technology and hence widespread access to information, triggered unprecedented population movements. Fleeing from rural poverty for perceived urban chances is accompanied by increasing cross-border and transcontinental migratory fluxes.

Without an ideological competitor the capitalist economic model quickly evolved into globalized, impersonal finance capitalism even across countries which kept their "party state" governance models after 1989. While goods, services and capital seemingly penetrate the whole world without much hindrance the control of these forces slid out of the hands of sovereign nation states. A more and more integrated economic world cannot be controlled and regulated by fragmented (and sometimes failing) political entities. Global governance mechanisms of the world (like the UN) are regarded by many as both antiquated and ineffective. Their structure does not represent the realities of the 21st century. The UN system and its specialized agencies are grossly underfinanced, thus deliberately prevented to perform the duties they have been created to perform. Yet, there are no serious efforts that aim to reform global governance. As hu-

manity is increasingly facing new technological, social, economic, but also biological and climatic challenges our ability to manage these changes is weakening.

Elites are perceived as unreliable and dishonest for not delivering on political promises. This leadership crisis refers in some circles unfortunately also to scientists. Even many of the scientific explanations end with referring to the overwhelming features of "uncertainty" and "complexity" regarding triggers, drivers, processes and consequences in our volatile world. While these features are undoubtedly true, they are not nurturing trust that scientists (and other leading elites) understand the problems and can quickly provide remedies. Understandably and probably inevitably, mistrust and identity concerns emerged. They provide fertile ground for mushrooming populist movements with their often simplistic analysis (and unsustainable, if not dangerous) political solutions.

The Sustainable Development Goals of UN

Irrespective of the weaknesses associated with the present global governance system, the need for comprehensive and coordinated actions was recognized. Member states of the United Nations have acted upon this conclusion. The Sustainable Development Goals were conceived and formulated as part of Agenda 2030 of the United Nations in 2015. (Fig.5)
Sustainability, or sustainable development (SD) needs to move swiftly from the phase of conceptualization and debates to the phase of implementation. While uncertainties still remain, the adoption of Agenda 2030 in 2015 (UN, 2015) provides a narrative and 17 goals (SDGs) with their inherent 169 targets which quantify the aspirations the Member States obliged themselves to achieve by 2030 or before.

Fig.5 The Millennium Development Goals and the Sustainable Development Goals

Thus, irrespective of the inherent uncertainties which are fundamental features of complex systems and acknowledging that more conceptual and scientific clarity would be desirable, there are 17 politically accepted goals. In the light of the recent warnings of the scientific community (among them the recent special report of IPCC (IPCC, 2018) implementing the agenda 2030 is more urgent than ever.

As the SDGs are the result of an UN brokered compromise. Hidden tradeoffs, contradictions and missing elements (like financial provisions) can be found and criticized. However, these shortcomings notwithstanding, the SDGs express universal will and dedication, a self-obligation of the signatories of Agenda 2030 to engage themselves in facilitating a world where human well-being, dignity and solidarity-based partnerships for development prevail, while aiming for a long-term harmony with ecological constraints and resources available on our overstressed planet. The performance of governments during the remaining 12 years (and certainly also beyond) can be assessed against these promises.

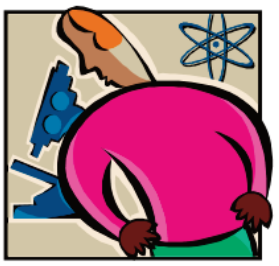
It is interesting to juxtapose the 8 Millennium Development Goals (MDGs) formulated by the UN in 2000 with the 17 SDGs (see Fig.5). While not all MDGs were achieved, the SDGs set even more challenging targets in an even more complex framework. Scientists have the right to criticize sustainability as an elusive concept, to highlight the shortcomings of the SDGs or express doubt about the reliability of the intended self-monitoring at national levels of more than 200 officially selected indicators. The lackluster implementation so far, even in well-to-do countries (UN Water, 2018, Kloke-Lesch, 2018) does not augur well for the overall and timely achievement of the SDGs. But beyond the right to criticize, scientists also have the moral obligation to help the SDGs to succeed in all of their dimensions and scales.

So far the SDGs are the most comprehensive and most promising political response given by governments to the scientific warnings issued repeatedly and more and more compellingly in recent decades. Thus, the scientific community should not succumb to the temptation to pursue exclusively a negative or fearful sustainability discourse by painting horror scenarios in which humanity would fail to move toward sustainability. Indeed, research has repeatedly shown that science and other communication focused on negative messages are generally not effective, largely because it fosters a decreased sense of agency and thus even less interest or willingness to engage further. Instead, scientists can best contribute to the implementation of the SDGs through research that helps understand and clarify the interconnected aspects of sustainability in diverse contexts. Critical comments can then be formulated as genuine research questions. Science provides suggestions of plausible options and associated consequences of actions based on continually improving insights, but it can't and shouldn't be used to dictate choices in value-based and contested issues.

The Wicked Problems We Face

The above description of challenges (both political, but also scientific) could be continued and detailed. No doubt that there are (widely unexplored) interactions between them. Already in 1973 Rittel and Webber (Rittel and Webber 1973) coined the term "wicked problems" and juxtaposed with the so called "tame problems" we are more familiar with to be exposed to and solved. The difference between the solutions of tame problems (cascading model) and that of wicked problems are juxtaposed in Fig.6.

Not all problems are wicked. In contrast, a *"tame problem"* is one for which the traditional linear process is sufficient to produce a workable solution in an acceptable time frame. A tame problem:



1. has a well-defined and stable problem statement,
2. has a definite stopping point, i.e. when the solution is reached,
3. has a solution which can be objectively evaluated as right or wrong,
4. belongs to a class of similar problems which are all solved in the same similar way,
5. has solutions which can be easily tried and abandoned,
6. comes with a limited set of alternative solutions.

Table 1. Description of "tame problems"

It is clear that the set of SDGs with their explicit and implicit interconnections (see also Fig.11) constitute rather wicked than tame problems. Table 2. summarizes the main features of "wicked problems". Thus, the SDGs constitute (next to the formidable political, economic, financial, ecological and technological and scientific challenges) also a theoretical and methodological problem that needs to be urgently addressed.

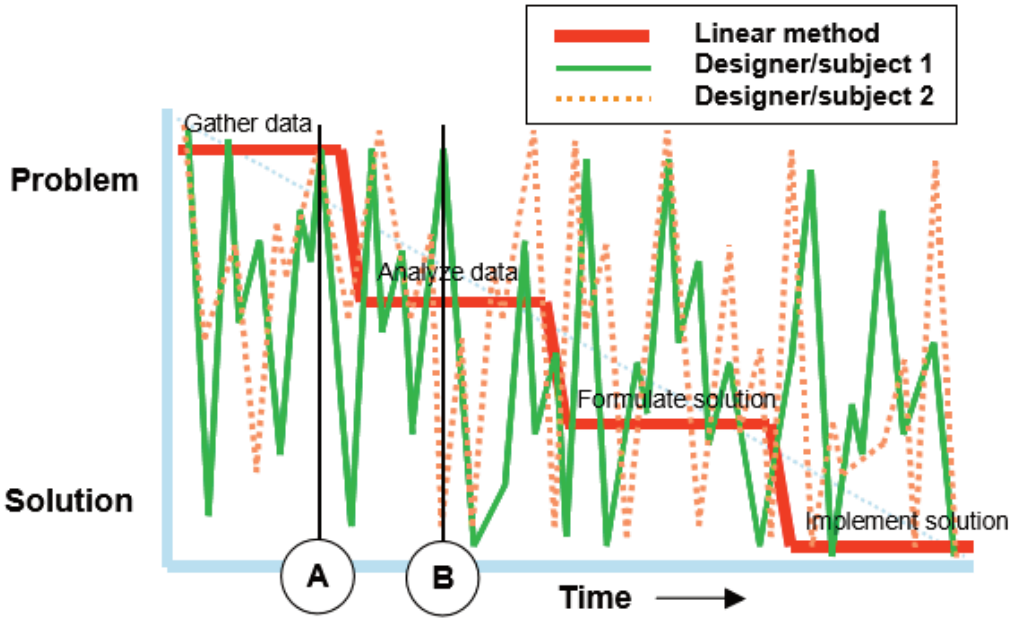


Fig.6 Comparison of the solution of tame and wicked problems. (Source: Rittel, H. and Webber, M. 1973. „Dilemmas in a General Theory of Planning," Policy Sciences 4, Elsevier Scientific Publishing, Amsterdam, pp. 155-159. Also Reprint No. 86, The Institute of Urban and Regional Development, University of California, Berkeley, California) http://www.cognexus.org/id42.htm. Chapter 1 of Dialogue Mapping: Building Shared Understanding of Wicked Problems, *by Jeff Conklin, Ph.D., Wiley, October 2005. For more information, see the CogNexus Institute website at http://www.cognexus.org. Wicked Problems, by Jeff Conklin, Ph.D., Wiley*

Table 2. Characteristics of wicked problems

1. There is no definitive formulation of a wicked problem.
2. Wicked problems have no stopping rule.
3. Solutions to wicked problems are not true or false, but good or bad.
4. There is no immediate and no ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a "one-shot" operation
6. Wicked problems do not have an exhaustively describable set of potential solutions,
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another problem.
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways.
10. The planner has no right to be wrong.

The Most Urgent Problems to be Addressed

Among the recognized problems and immediate threats faced by mankind probably climate change has received the largest attention in the last decades. Regardless of the fact that mitigation and adaptation to climate change are developing at a slow pace, most people agree that climate change is a serious threat (The Asahi Glass Foundation, 2017). But even if the agreed increase of atmospheric temperature by 1.5 degrees, compared to pre-industrial revolution levels is kept, the "genie is out of the bottle" and serious changes will occur during the course of the present century. Without disputing the seriousness of this evolving threat and the increase of related natural hazard events, the achievement of the SDGs, or more generally sustainability per se, is conditioned on the rapid rectification of the huge inequalities and social biases plaguing the world of today. These are not only going to evolve in the future, but already existing facts are disclosing enormous social, and also ecological tensions. The inequalities of the world today are summarized in Box 1. As the future course of climate change is predetermined by historical and current day emissions, the inertia in the dynamics of population growth implies that approximately 2 billion more people will inhabit the planet in 30 years.

Box 1. Inequalities of the contemporary world
(only categories affecting at least approximately 1 billion people out of the estimated population of the world as of 2018 (7.65 billion) are listed)

- 1 Billion Subsistence Farmers
- 1 Billion Undernourished People
- 2 Billion People with Dietary Deficiencies
- 1 Billion Slum Dwellers*
- 2 Billion People without Access to Safe Drinking Water
- 4 Billion People without Adequate Sanitation
- 1 Billion People without Access to Electricity

Even with obvious "multiple counting", this list implies that at least one third of humanity is excluded from "development" and have no access to several amenities of well-being. Subsistence farmers and inhabitants of "informal urban settlements" (slum dwellers) are distinctly different groups, though many subsistence farmers are migrating to urbanized areas.
*70% of urban population in Africa belongs to this category (The World Bank, 2013).
Correspondingly, as the UNDP Human Development Report 2016 confirms one third of humanity is living under low human development conditions.

The human development index (HDI) may not be a perfect metric to capture all aspects of human well-being, the recent display of the distribution of people living in low human development areas (Fig.7) reveals the global scale and distribution. Approximately one third of humanity live under conditions which should not be tolerated in the 21st century. More than 20% of these people can be found in countries which show a high or very high HDI on the national scale. Thus, we face a genuinely global challenge of inequities and development deficits within and between countries across all continents. As Fig. 8 reveals, increasing wealth does not lead automatically to more even distribution. Germany, while being one of the richest countries in the EU, has a distinctly more uneven distribution of wealth than either France or Spain.

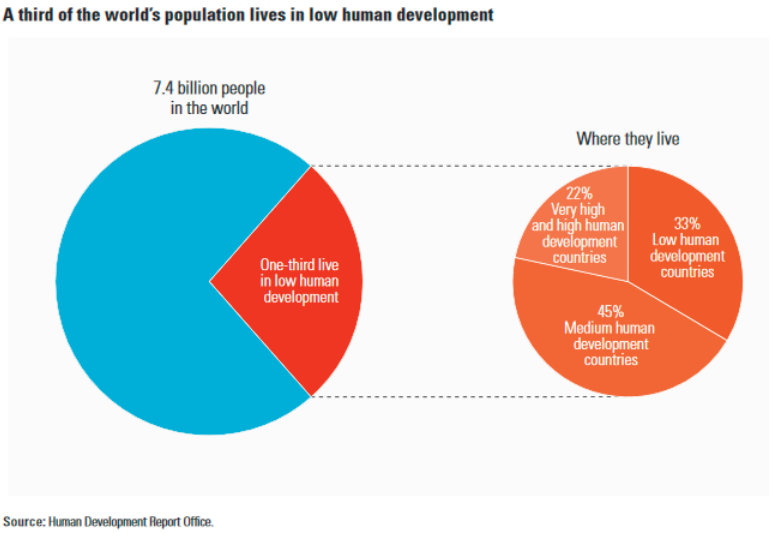


Fig.7 Visualization of the distribution of people living under low human development conditions in 2016

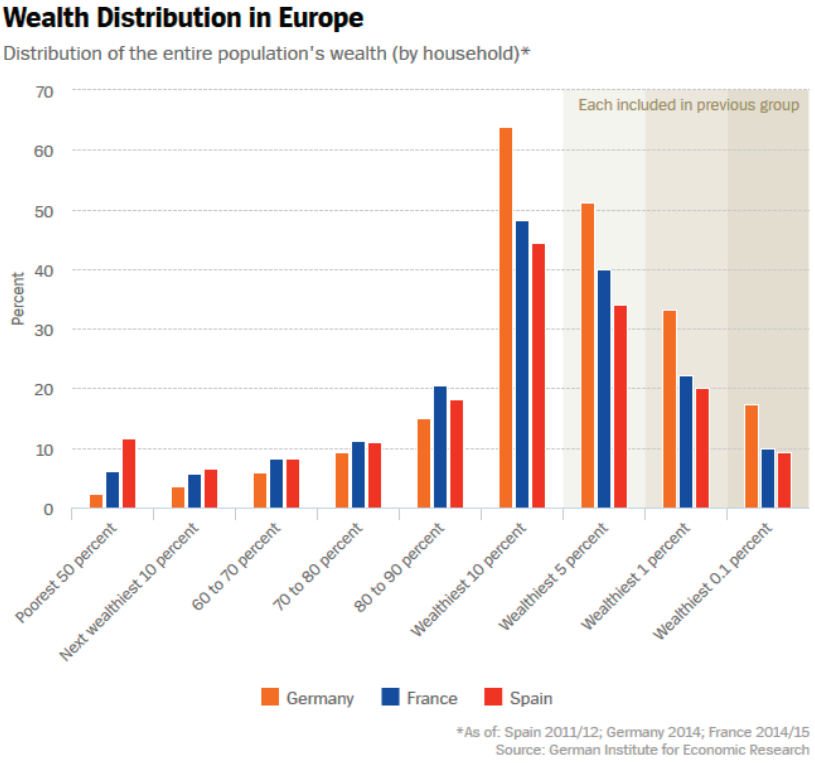


Fig.8 Distribution of wealth within large countries of the European Union

It is widely claimed that climate change will affect more adversely those countries located in or close to the "dry belts" of the world (See Fig. 9).

Fig. 9 Major parts of Northern Africa, Western and Central Asia as well as parts of Southern and Eastern Asia belong to the dry belt of the Northern hemisphere

Lower development status, lack of good governance, rapidly increasing population and corresponding resource, especially water scarcity, will emphasize the skewed nature of wealth distribution, opportunities and occurrence of conflicts in the world. Fleeing from misery and being attracted by perceived opportunities and the chance of a better life are potent drivers for migration. Unregulated urbanization, but also cross-border migration, will sever the once existing social fabric. Even if featured benevolently, as a long-term adaptive measure, it can (at least temporarily) destabilize societies both in the source and in the target countries. Labor migration, which is often praised as mobility, is very common within the EU. Next to its undisputed merits it leads to the depopulation of rural spaces and labor shortages especially in the East European EU countries.

Meanwhile, unemployment is a rampant social stressor in developing countries. While industrialized countries claim at present the wide scale lack of well-educated work force, there are serious warnings indicating that along the course of further digitalization and robot-based industries (sometimes labelled as disruptive technologies) millions of less qualified jobs will be lost especially in the developed countries. Thus, technical development, in spite of its positive aspects may perpetuate or even increase social stratification, contributing to the emergence of additional social tensions.

The Three Tests Humanity Faces in the 21st Century

With the adoption of the SDGs, the status quo political order (based on sovereign states) agreed and set a number of crucial goals to be achieved (now) within the remaining twelve years. SDGs address first and foremost immediate needs and inequalities. By securing equity, peace and sustainable well-being for all under the slogan "leaving no one behind" the SDGs and their achievement is more or less a decades-long task and the **credibility test** for the prevailing world order and its governance mechanisms.

By 2050, the course defined by the SDGs and their systematic implementation should be stabilized. An increasingly sustainable world is to cater to a world population somewhere around 10 billion people. It is assumed that population growth will gradually attenuate everywhere and in the second half of the 21st century and population dynamics will gradually decrease as a serious threat to the planet's sustainability. Refined planetary and societal boundaries, forming the "Raworth doughnut" (Rockström et al, 2009, Raworth, 2017, Nordhaus et al, 2012), should not be transgressed. The projection of these multidimensional (and interconnected) decision spaces to a (two dimensional) picture in Fig.10 visualizes the joint scientific, political, social (including economic) and ecological dilemma: how to keep the planet and human society(ies) sustainably within the light green colored space (shown as a "ring" in this projection).

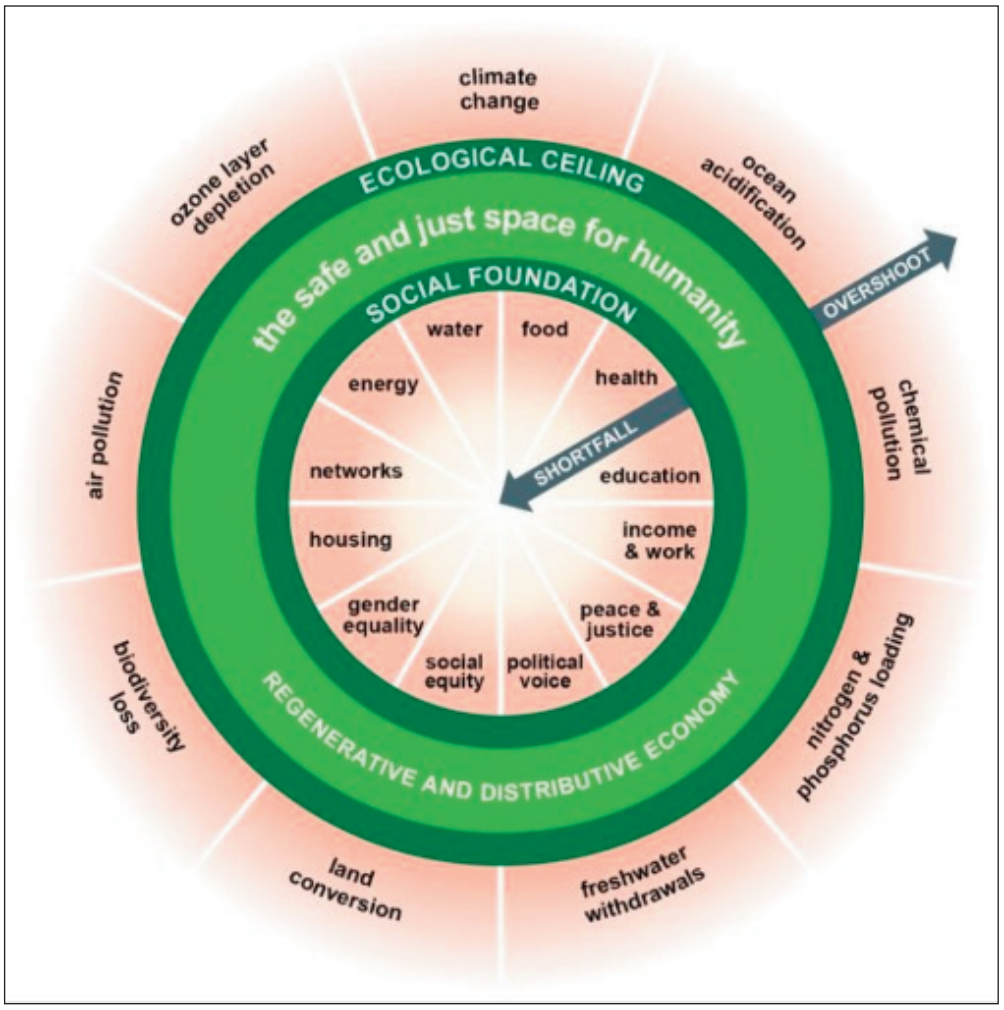


Fig.10 The "doughnut" of social and planetary boundaries (after Raworth, 2017)

Resource exhaustion and ecosystem degradations should be stopped and reversed while issues of social exclusion, poverty, hunger, lack of dignity, access to elementary services are competently addressed. A sustainable world for more than 9 billion people, operating within safe planetary boundaries and acceptable socioeconomic standards, is a generational task and will be the **stability test** for the world.

By approximately 2080, the world should prove its ability to ban sustainably the specter of global disaster due to climate change and environmental collapse. Irrespective of the enormous inertia of atmospheric processes, improvements must be significant and already measurable. A

sustainable world around 2080 is well adapted to the reality of a +1.5-degree warmer atmosphere. The efforts leading to this situation must be concerted and have to be already ongoing now, but their fruits can only be harvested not earlier than in about two generations' time or beyond. Combating climate change is a task for a century and is posed as the **survival test** for a world we want.

Would these three tests be passed? How well are we prepared to face them? What needs to be done to increase our chances? What are the threats to be reckoned with? We already know a number of trends which are largely undisputed as phenomena, but unknown or at least uncertain in their longer-term consequences. Hence, convincing potentially affected people and their elected leaders to act for desirable outcomes to be achieved well beyond their period in period or even lifespans a paramount task.

What Should Science Do?

Scientists should be ready to recognize, "grab" and use ideas and innovations when they appear "out of the blue". (This serves as an argument for why we need a sizable scientific community and something like "scientific biodiversity"). The unprecedented challenges faced by mankind require new scientific approaches. Scientists, if for nothing else but for the credibility of their threatening predictions, should leave their academic, and often disciplinary ivory towers. It is not enough to recognize and document the accelerating phenomena of global change in peer reviewed journals. Communicating to a broader audience, co-developing solutions are just as important as truly multi-, inter- and transdisciplinary approaches. Preparing the next generation of professionals and scientists for this broadened scope and multiple obligations is a paramount task and should be rewarded accordingly.

Acknowledging uncertainty in data, in our knowledge and forecasts, also requires a certain amount of necessary humbleness that is imperative to regain societal trust and strengthen credibility.

A number of questions are formulated and areas where additional scientific inquiry and scrutiny would be needed are identified.

General Questions:

- Do we need to cultivate further the sustainability discourse, or do the SDGs cover this concept adequately? How can we consider "situated sustainability"? (Meininghaus and Mielke, 2018).
- How can scientists (as well as other actors in society) best support a process in society of learning to navigate on pathways toward sustainable futures in a landscape of inescapable complexity?
- How can we reconcile the scale discrepancy between transnational companies and other global economic mechanisms and the (micro)cosmos within which human life normally flourish?
- Are breakthroughs likely to occur?
- What are examples of narratives that have fostered a long-term perspective on societal change (e.g., social movements for civil rights, women's suffrage)? Do these examples of affective expressions of narratives have valuable implications for how we engage people in long-term responses for sustainability? (This plays a very important role in motivating decisions and actions, often well beyond the impact of scientific knowledge).
- How can collectives and institutions build an effective and adaptive process for continually moving towards a sustainable future that is appropriate in their own scale and context?
- How can the message be formulated to be heard, understood and acted upon when the elites (including scientists) have seemingly lost credibility?

- Is our school / university curriculum describing fairly the real situation we are in, and ready to offer systemic responses?
- How can we avoid that cultural diversity diminishes like biodiversity?
- Whom should science address?
- Given the uncertainties and admitted knowledge deficiencies, how can science be considered as the compass helping to navigate societies through the unprecedented pace and scope of changes they experience?
- How should science communicate its messages to counteract mistrust?

Economics and Finance:
- How can budgeting practice be modified to enhance collaborative approaches exploring synergies and addressing tradeoffs between ministries responsible for different SDGs?
- How could a penalty/incentive system be devised which would help to eliminate unsustainable practices?
- How much (economic) competition is needed to keep innovations happening?
- How can we account for social and environmental externalities in economic policies and decisions?
- Would an International Sustainability Fund (mimicking IMF) or redesigning the Global Environmental Facility (GEF) be viable approaches for international (joint) financial engagement?
- What could be the mechanism to introduce a universally accepted new economic value system?
- How could our taxation systems support the necessary transformation?

Society and Human Behavior:
- Aren't humans hampered by the certainty of their finiteness from internalizing the principles and practice of sustainability?
- How much solidarity is needed to avoid irreparable political and social ruptures?
- How does charity interact with human dignity?
- What can (should) be the role of religions?
- How much tradeoff exists between achieving our own (usually short-term) aspirations and thinking of future generations? (How much long-term generational solidarity can be expected?)
- Embedded membership: how can people act across hierarchical scales as local, national and cosmopolitan citizens without being paralyzed by (inherent) contradictions and value differences and conflicting aspirations?
- Why do we see a big discrepancy between the prevailing narratives and agreements (like climate change and its consequences) and deeds (making 2018 the strongest emission year ever observed with 2% increase over 2017)?
- How can the human need for (cultural) identity, community, security be reconciled with seemingly unmanaged change (like digitalization, new technologies, new finance and economics etc.) happening in a supranational (global) space?

Governance and Political Frameworks:
- How could fundamental issues be seen and tackled by taking them out of the direct confrontational context of daily politics?

- Can (the necessary) major changes be conceived and implemented without preceding (global) cataclysms?
- How far does the collective historical experience predetermine society's response to present challenges?
- Revolutions, even those which were long overdue, ended frequently in terror and dictatorships (1789 French revolution, 1917 Russian revolution, Consequences of the "Arab spring"). Is this an unavoidable course of (successful) revolutions?
- How can the balance be found between inspiring and strong leadership and broad- based democracy?
- of successful revolutions?tal ft for desirable outcomesto be achieved well beyond their office period or even lifespanis a para
- How can we avoid the tendency for strong leadership to degenerate into dictatorship?
- How can present political system(s) manage the global evolution of the so-called disruptive technologies?
- How can we establish effective global governance, regulatory frameworks and justice?
- How can we restore the primacy of (democratic) politics?
- How could the constraint posed by (relatively) short election cycles of political leadership be avoided or mitigated?
- Should not critical services, resources and infrastructure remain in public hands and/or be renationalized in order to serve all without immediate obligation to make profit?
- How much political discontinuity can be absorbed by "sustainability"? Should precipitous sociopolitical changes like revolution, state collapse etc. be classified as rapid adaptation mechanisms or signs of unsustainability?
- Are our (domestic and international) institutions fit for the task to support the transformation in development? They mostly have been created for other purposes. Should their rules, structures, budgets and strategies might be reconsidered in the near future? Obviously, we don't need separate institutions for sustainable and „non-sustainable" development.
- Would the nation states be able to regain political control and leadership?
- Is the European Union in its present state an encouraging model of governance?
- How are our laws, regulations vetted before being taken by our parliaments / decision making bodies? Are there any agreed upon rules on what can be considered as an acceptable tradeoff; what is serving the transformation and what is slowing it down - even if based on good intentions?
- What should global governance imply? Justice, regulations, negotiating platforms? How could functional global governance be conceived and implemented? How can we measure its efficiency and effectiveness?

Assessments:

- How can we assess tradeoffs within the limited nexus contexts of SDGs, like water-energy-food-health?

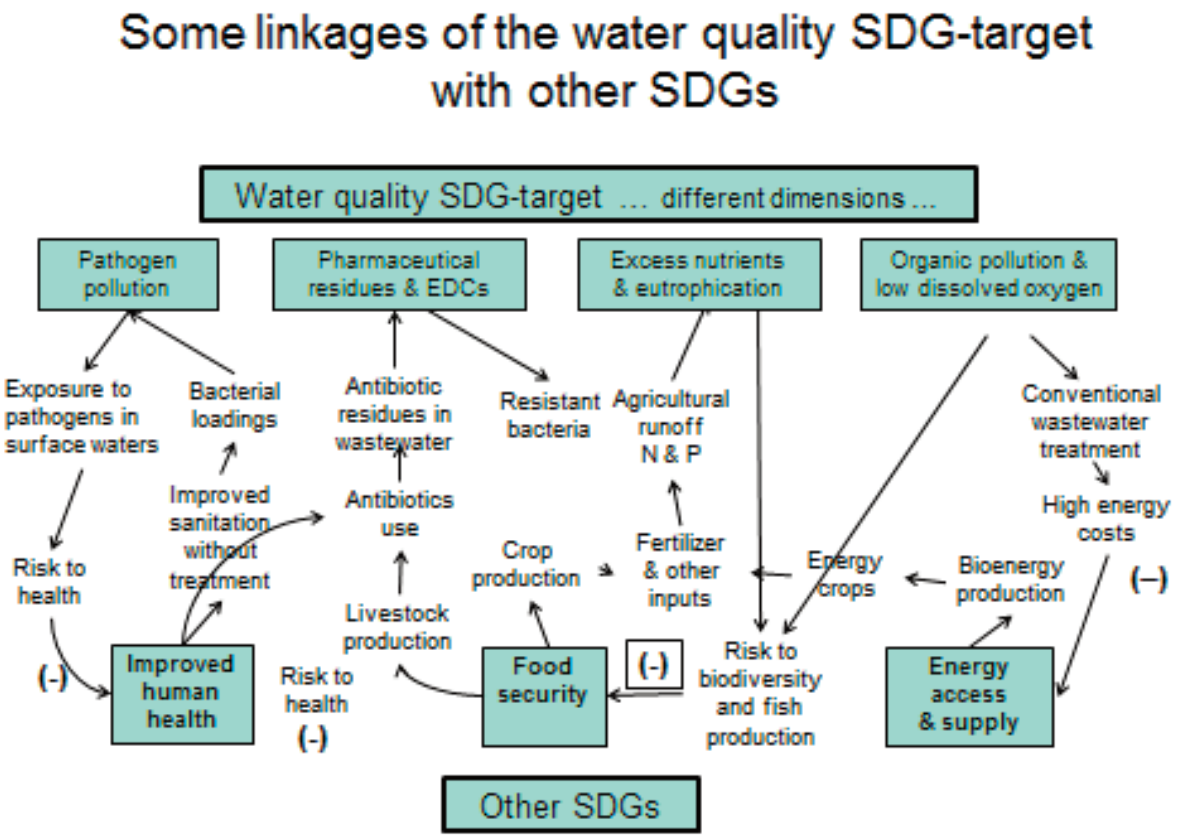


Fig. 11 Trade-offs and feedback loops between 3 SDGs and the water quality target of SDG 6 (Courtesy of Prof. J. Alcamo)

- Do we need aggregate sustainability indices and if yes how do we quantify and interpret them? How far could they be used to advise actions for political actors?
- SDGs are not a subset of climate change mitigation/adaptation mechanisms, but climate change accelerates exposure, vulnerability and unsustainability as the environmental capital deteriorates. How can we capture and quantify the opportunity losses due to (unaddressed) climate change?
- Are we able to factor in the different types of capital (human, social, natural, built, financial) into our development strategies and goals?
- How can the sustainability of a country be measured?

Conclusions and Recommendations

This paper is meant to be thought provoking. It warns about the unavoidable uncertainties of complex socioecological systems, while acknowledges the appeal of the concept of sustainability and especially that of the SDGs and subscribes to the human aspirations they encapsulate. Therefore, it is recommended to use sustainability as a "guiding principle", but simultaneously acknowledge the multitude of interpretations associated with it.

Efforts to enhance "sustainability" should be set within a global framework and aspirations as expressed in the SDGs. Being adopted by sovereign states the SDGs summarize a broad set of intertwined goals and even more targets. Monitoring of the implementation of the SDGs is man-

dated at the national level. However, the pace of implementation and the practical political/policy guidance so far is less than optimal (Kloke-Lesch, 2018).

The identification of measures and behavioural change should proceed at several scales, but the level closest to what may be called "human scale", corresponding with spaces where ordinary, everyday life occurs is the most important and likely be the most effective way to approach sustainability.

Actions should be spatially referred and delineated. Time boundaries should be set in a form of realistic time horizons and schedules. It is to be emphasized that sustainability is not equivalent to eternity. Improvements which are measurable on annual to ten-year scales could enhance social and political engagement.

Target levels should be set by multiple actor consensus seeking processes, and achievement levels are preferably quantified. Unless proper budgetary provisions are made and sensibly spent, sustainability would remain wishful thinking. Failing the first test could lead to a domino effect and ultimately jeopardize the future of humanity.

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