An Interdisciplinary Discourse on

R E G
U L A
T I O N

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Nota bene

The content of the contributions to this publication is the sole responsibility of the respective authors.

In the course of the preparation of this work, it was shown that the Dahlem Conference format can also be implemented without the usual personal attendance requirement.

However, the personal presence of the authors and face-to-face communication would have facilitated an even more profound exchange of knowledge and experience and experiences.

Memorandum

Biotic Self-Regulation: Model for Man-made Systems?

Guiding principle

Wisdom is not to depart from nature

but to be guided by it.

Seneca (58 AD), in his essay on "The Happy Life".

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2024

Foreword by the Editors

As the Institute for Earth System Preservation (IESP) of the European Academy of Sciences and Arts (EASA), we are pleased to publish the following memorandum. We want to thank Mr. Peter Wilderer, founder of IESP, for his initiative and tireless efforts in the preparation of this publication.

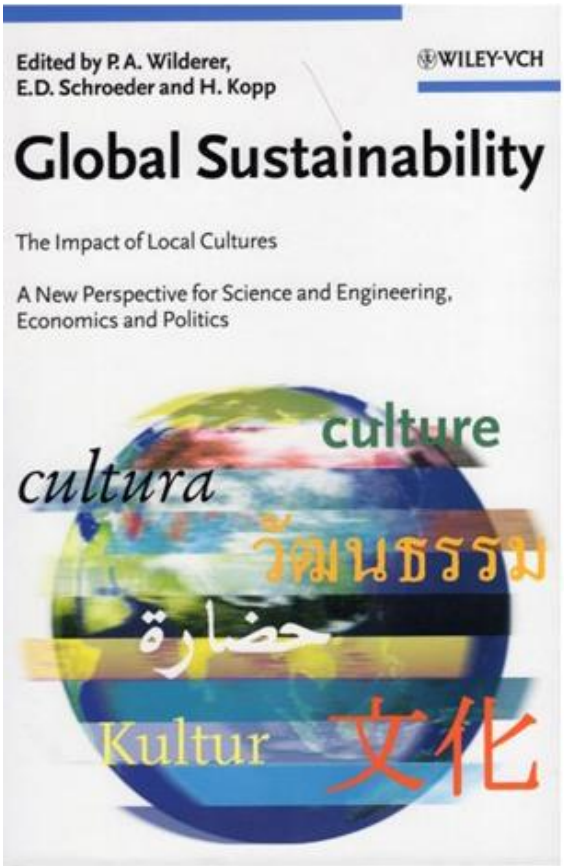
The question approached in the memorandum, namely to consider regulatory processes of nature as a possible model for our treatment of our planet, is of fundamental importance for our survival and challenge. This requires a thorough intellectual debate involving all scientific disciplines and is therefore well placed within EASA. The contributions provide a first high-level glance at the dimensionality of the topic. We are faced with the epochal task of uniting the many other aspects mentioned into an overall picture of the Anthropocene, ensuring the survival of mankind based on nature.

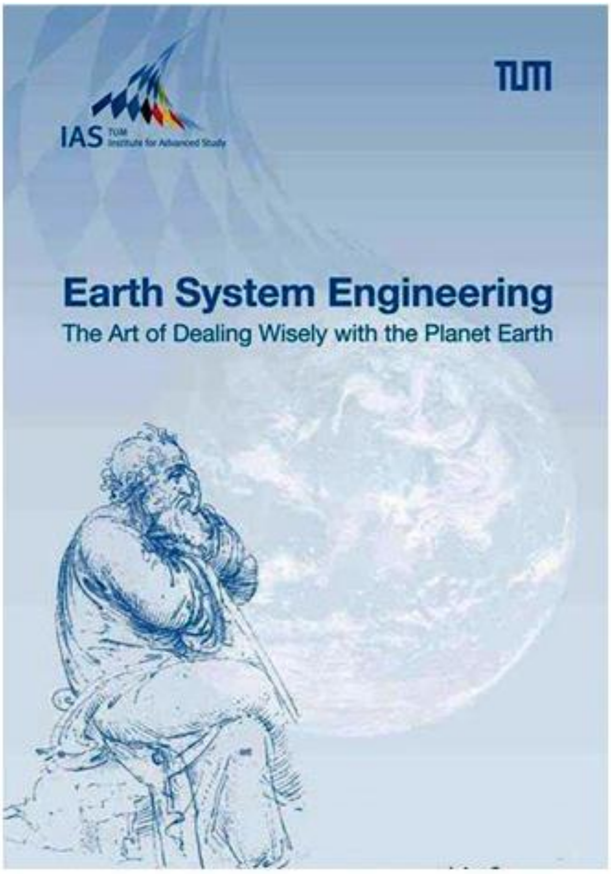
A start has been made! It arouses curiosity, it invites participation, discourse, deepening and controversy within EASA and beyond.

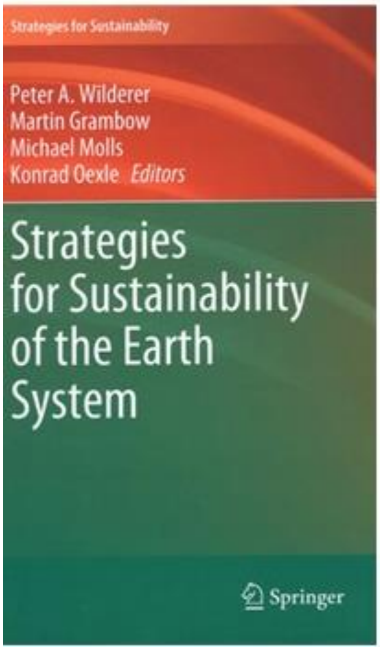
The Executive Board of the IESP

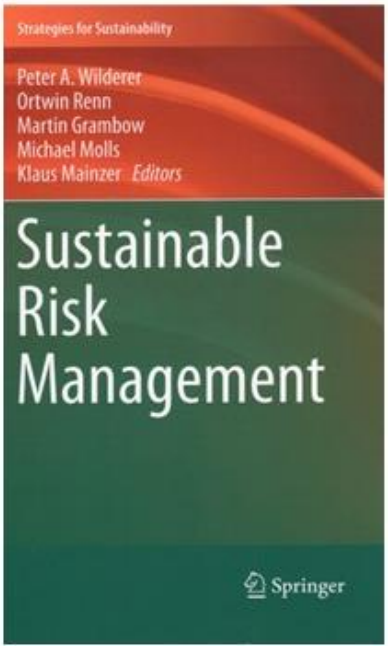
Prof. Dr. Michael von Hauff (Chairman of the Board), Prof. Dr. Klaus Mainzer (ex officio member of the Board), Dr. Martin Steger, Prof. Dr. Jörg E. Drewes, Prof. Dr. Wolfram Mauser

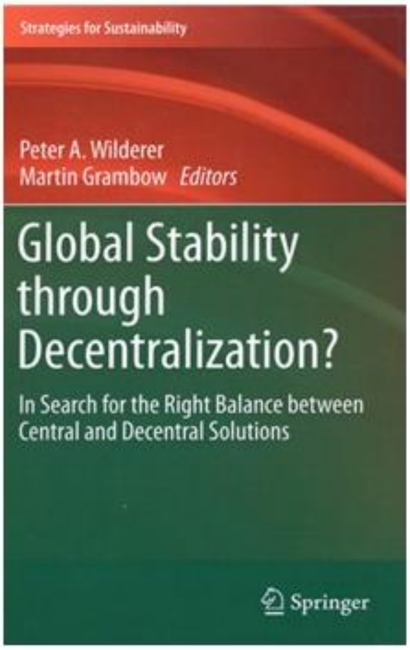
Selection of previous topics,
adressed by IESP in cooperation with TUM-IAS.











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Editorial

The question of whether biotic self-regulation can be considered as a model for anthropogenic systems can be answered with a "yes, but" after a critical examination of the contributions compiled in this anthology.

In principle, humans are part of living nature and at the same time - according to our understanding – an image of the functioning of earth systems. Our body reacts to internal and external challenges in a naturally self-regulated way. There is therefore no reason not to assume that biotic self-regulation can also be transferred to the human body. The transformation of biotic self-regulation from ecosystems to social or even economic and state systems is more complex than might be assumed at first glance. In living nature, social systems, such as bee colonies, are also self-regulated. However, in the social systems of humans, regulation is based on other anthropological preconditions. In contrast to other living beings, humans are characterized in their behavior by their own free will and a high degree of creative freedom and openness to the world. Added to this is their ability to generate knowledge, pass it on and use it in practice to change the environment.

Through their ability to attribute meaning and significance to their actions, people create their cultural biotopes, such as cities, industrial areas, agricultural production sites, recreational areas and much more. Although these biotopes are existentially dependent on the services of nature, they are shaped by artificial new worlds thanks to knowledge, technology and art. On the one hand, cultural biotopes are dependent on natural inputs, but at the same time offer cross-natural design spaces in which people can develop economic, social and cultural activities. This can lead to two dangerous self-deceptions: firstly, the illusion that natural inputs are guaranteed in the long term, regardless of how much humans intervene in natural cycles (technical hubris), and secondly, the naïve idea that a "return to nature" would automatically trigger humane and sustainable human development. The transformation from natural to culturally shaped biotopes is the only chance of maintaining humane living conditions for humanity in the future, at least given today's population density. At the same time, however, these transformations are dependent on the expansion of cultural biotopes not jeopardizing the existential natural cycles. Important keywords here are: Climate protection, preservation of biodiversity, minimization of harmful emissions and waste, and conservation of resources and land. It must also be questioned whether nature should only be regarded as a source of ecological services for humans, but whether it also has an intrinsic value independent of human needs. The inherent dynamics of natural cycles are therefore an important orientation for the creation of cultural biotopes, but can only be partially transferred to the design of these biotopes.

This insight makes it necessary to enter into a profound discourse on the parallels and differences between biotic and cultural regulation. A rethink is urgently needed and in a new dimension. Quotes from Sophocles, Confucius, Socrates, Seneca and many others show that even in ancient times, philosophers emphatically called for an active, reason-based attitude and the resulting actions of the individual and society - with the aim of justice and the preservation of social and spiritual order; in our thinking, however, their external framework was always limited by nature or the immovable creation and thus predetermined.

In this light, the Anthropocene, with its changes to the Earth system, not only describes a new geological era. Humanity's technical ability to influence this creation, which was previously regarded as God-given and therefore out of control of humans, now includes a significant influence on geophysical and geochemical cycles and thus includes the potential destruction of the systems that enable and sustain life. This has given rise to a new responsibility towards humanity as a whole, but also towards animate and inanimate nature, which surpasses all previous ideas. Only the philosophers of the 20th century, above all Hans Jonas, recognized this new ethical and political dimension and derived new conclusions from it, such as the ecological imperative. Replacing technical arrogance with holistic modesty is a piece of advice that should be understood as a principle. This is the only way to overcome the fatal tendency towards technical hubris.

Basically, as from antiquity to the Enlightenment, it is once again a matter of establishing a basic ethical attitude for people and human societies, but this time under new planetary boundary conditions. A sustainable counterpart to biotic self-regulation can be created in particular by overcoming destructive attitudes such as hatred, envy, greed and revenge. On this basis, it should also be possible to achieve a breakthrough in compliance with ethical standards concerning the surrounding nature. This requires a high level of education, persuasion and communication for all sections of the population. To be effective, however, education should be based on local and indigenous traditions and begin in childhood, or even better, in infancy. After all, it can be assumed that love, and thus also parental guidance is a building block for avoiding hatred and resentment. The experience of love, security and prosperity is therefore one of the prerequisites for ethical behavior with a lasting effect.

Instructions on ethical and moral behavior are not an invention of the Anthropocene. A large number of instructions have been developed since antiquity. Some have prevailed, others have been forgotten, many are recognized but not put into practice. Above all, the view of the superiority of human knowledge over the natural control loops emerging from evolution has developed into a destructive tendency for humanity and nature. Decisions and developments that were initially seen as beneficial have in many cases led to dramatic damage. The measures proposed by Paul Crutzen to combat the destruction of the ozone layer in the stratosphere can serve as an example of how to achieve a sustainable and balanced equilibrium between natural and cultural evolution. Many other positive examples, suggestions and proposals have been compiled in this anthology. There is a unanimous call for a rethink of the current myth of progress. Above all, the aim is to incorporate the creative power of humans into adaptive cycles to ensure resilient, nature-oriented and sustainable development.

Many of the contributions in this volume describe the achievements and further developments in specialist areas such as business, medicine, agriculture, architecture and water management. The enormous challenges of our time, triggered by climate change, the overestimation of economic growth and the belief in the omnipotence of technology, can only be overcome by questioning the status quo and being open to alternative solutions. The authors call on society to take advantage of the opportunities associated with a wealth of new findings and methods from science and practice. However, resilient and sustainable provision for the future is not ensured by romanticizing nature, but by the targeted and careful use of technology and innovative products. Here are two examples from the contributions: The targeted use of fertilizers for regenerative agriculture is mentioned as a new way of producing food in an environmentally friendly way. The intelligent use of artificial intelligence in all areas of science, business and administration is of great importance on the road to a resilient, sustainable future.

It is noteworthy that significant innovations are increasingly being created by multi-disciplinary and international working groups. This does not only apply to the scientific field. The implementation and bundling of knowledge from neighboring schools of thought, but also from practical experience and indigenous traditions, can bring humanity closer to the required balance between nature and culture with the help of interdisciplinary and transdisciplinary teams. However, this requires appropriate overarching quality control and the political will to support these activities with the necessary resources.

In preparing this work, scientists from different disciplines and countries were invited to contribute their respective experiences, knowledge and perspectives to answer the overarching question formulated in the title of this work. The format of the Dahlem Conferences served, in a modified form, as a model for the interdisciplinary discourse practiced here. To this end, contributions were compiled and opened up for discussion to develop recommendations for action for science, business and society. The selection of recommendations is printed in the final chapter of this volume and can be seen as an invitation to reflect, but also to criticize. The more and more intensively the relationship between nature and culture is considered and constructively debated, the more likely it will be to ensure a resilient and sustainable future for humans and nature.

Discussion

Question by Ortwin Renn: What is meant by "fractal of the functioning of earth systems"? (see above first sentence in the second paragraph)

The answer of Martin Grambow: The use of "fractal" is initially a semantic reference to Küppers' chaos theory and Maturana's self-organization. We live in a self-organizing chaotic system.

However, the term is also philosophically and scientifically charged: In my opinion, humans are a "typical" image of the earth system because they only function themselves through symbiotic biological processes within the body and, as rational holobionts, can only exist in interaction with the "external" nature.

Peter Wilderer is concerned with the question of whether humans stand out atypically from the non-anthropogenic natural ecosystem due to their intellect or - according to Helmuth Milz - due to their sense/thinking capacity, i.e. whether they are not a typical image or even form a kind of antithesis.

However, I am convinced that we humans are an inseparable and "intended" part of creation - which in turn is both an analogy to religious interpretations ("image of the Creator") and - according to James Lovelock - corresponds to a plan of creation (Gaia). Thus, man is both part of living nature and unique. This makes us - in my understanding - a typical reflection of the functioning of the earth system, which for a million years has been composed of basic biological, chemical and physical processes, and the intellectual performance of the mind of homo sapiens. Consequently, we (humans) are not there to destroy the earth, but on the contrary, to expand the life-sustaining, stabilizing repertoire of nature.

Examples of Biotic Self-Regulation

Introduction

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Since the existence of life on Earth, changes in the Earth system have had an existential importance for life on Earth as a whole and for individual living beings in particular. Today, we live in a time characterized by unique changes in the Earth system. This gives rise to the need to think about measures that will help maintain the Earth system's ability to function under these new influences. As Paul Crutzen has shown, this requires measures that fall into the realm of "geoengineering." Such far-reaching intervention should be well considered, however, because negative side effects are usually unpredictable in the application of technology and can rarely be ruled out.

In philosophy, the term "system" and thus also the term "Earth system" is understood as the combination of a manifold into a unified and well-structured whole, in which the individual occupies an appropriate position about the whole and to the other parts [1]. Thus, when applying measures to preserve the functioning of the Earth system, an appropriate, systemic approach is a mandatory prerequisite.

Massive changes in the Earth system, caused in the past for example by the impact of meteorites, have led to the repeated extinction of numerous species of living beings including the dinosaurs, but not to the extinction of life as such. The reason for it was in particular the ability of life to self-preservation. This existence-securing characteristic of life is given to every living cell as well as to all other organisms including the human being. Gorshkov et al. [2] called this life-sustaining process "biotic regulation", also called self-preservation instinct, self-regulation, or autonomous regulation.

In the definition of "system" the term "manifoldness" does not only refer to the global Earth system. Equally manifold are the different geographic, orographic, climatic, and traditionally shaped regions of the earth. The system concept described above applies to each region individually. It requires specially adapted solutions for the preservation of the functionality of the respective region including the preservation of the nature-given self-regulation ability of regions and their parts.

Mankind replaces on a large scale the phenomenon of biotic self-regulation by a willful, also cognitively based regulation of the Earth system and its subsystems. In the Jewish/Christian-influenced countries (also in Islam) this claim is derived from the Old Testament commandment, according to which man may or even should subdue the earth and thus the environment.

As Yuval Harari [3]) impressively points out in his eloquent account of human history, in the epoch of the Anthropocene the claim to use, often overuse, vital resources such as air, water, soil, and forests has now reached a level that seems threatening life on Earth.

It was Carl von Carlowitz [4] who, in his paper on "Naturmäßige Anweisung zur wilden Baum-Zucht" realized that overusing forests as a source of wood has detrimental effects on nature and economy alike. Thus, he demanded that, to ensure the sustainable use of wood, the felling of trees must be based on the growth of trees.

As is well known, the term "growth" has a time dimension. A tree takes several decades to mature for profitable gains. And so, the sustainability imperative initiated by Carlowitz also has a time dimension. This often goes beyond the imaginative horizon of man and his representatives in business and politics. Patience is required. However, finding patience is an even more difficult task than complying with sustainably effective measures.

The currently dominant forms of life and production have been critically questioned in recent years. To this end, the international community agreed in 1991 on a completely new paradigm in the form of sustainable development. It can be stated that there is a global acceptance of the sustainability paradigm today. It is important that we consistently use the opportunity to bring together ecology, economy, and social challenges, taking into account the global carrying capacity or the ecological guard rails.

Another constitutive element of the sustainability paradigm is equity. If we analyze the national sustainability strategies of the industrialized countries, there is still great potential for further implementation and acceleration of the transformation process. The potential is even greater in most countries of the global South. The industrialized countries have – to some extent - committed themselves to supporting the developing countries in their efforts.

The demand for a sustainable economy with effects beyond the day is to be understood as a turning point toward a rational survival model. A consistent regional and planetary application can also contribute to overcoming the pure pursuit of profit. Whether this target is facilitated and supported by the advancement of digitalization and artificial intelligence (AI) is a question that needs to be seriously explored. More specifically, is AI a replacement model for biotic regulation? This also depends on how the 2030 Agenda, with its 17 SDGs, is interpreted. So far, the 17 SDGs often stand side by side in national sustainability strategies. Instead, sustainability areas should be defined where goals are combined. Both digitization and artificial intelligence (AI) could make an important contribution here.

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2 Gorshkov, V, Gorshkov V., Makarieva M. (2000) Biotic Regulation of the Environment, Key Issue of Global Change, Springer, Chichester, UK

3 Yuval Harari (2011) Penguin Random House Publisher

4 Hanns von Carlowitz (1713) Natural Instructions on Wild Tree Breeding Sylvicultura Oeconomica, Johann Friedrich Braun Verlag

Discussion

Hermann Auernhammer remarks: For me (and certainly also for my colleague Wolfgang Haber), the concept of sustainability defined in Rio 1998 with economy, ecology and social issues remains open or incomplete.

Response from Peter Wilderer: This comment allows me to refer to the page, preceding the table of contents. It shows the covers of the books that were produced under the auspices of the European Academy of Sciences and Arts.

The first of these workshop series was held in 2003 on the premises of the Banz Monastery. The event was entitled "Global Sustainability - The Impact of Local Cultures". The workshop was introduced with a message of greeting from the former President of the Club of Rome, Prince El Hassan bin Talal, now King of Jordan. Regarding our current topic, I would like to pick out of his message two sentences: "*As Moderator of the World Conference on Religion for Peace I call for a global code of conduct while promoting solemn respect for the various faiths and their interaction*" and further: "*In the Club of Rome we added in addition to social, ecological and economic culture as the fourth pillar sustainability. Human values and global sustainability mean that an alternative must be found to the imagined and feared hegemonic and homogenetic processes*".

I also want to mention that Wolfgang Haber contributed his broad knowledge of the importance of natural ecosystems to the workshop on "Global Stability through Decentralization". His thoughts and recommendations are further discussed in the volume presented here.

Trees can do more than just store CO_2

Recension of an article published in Nature Water (2023) by Peter Wilderer

In the October issue of Nature Water (pages 820 - 823), an essay was published written by Erica Gies[1]. It is entitled "More Than Carbon Sticks". This essay can be seen as a mirror of the contributions collected in this collective work.

Right at the beginning of her essay, the author emphasizes the importance of the mutual exchange of knowledge across disciplinary boundaries in order not only to understand highly complex processes better but also to translate them into sustainable practical action. The rapid pace of climate change is a classic example of the result of highly complex interrelationships. Classic silo thinking may help to enhance the reputation of scientists and eventually lead to political decisions. However, Erica Gies uses a large number of examples to show that this does not exclude the possibility of wrong decisions. The overestimation of the importance of CO_2 as a cause of climate change is just one example among many.

Bringing together the expertise of scientists from fields such as mathematics, physics, chemistry, biology, ecology, medicine, hydrology, and the social sciences offers the opportunity to respond effectively to the challenges of our time. There are numerous developments for this, which were and are initially opposed by the supposed claim to the sole representation of classical disciplines, eventually followed by inhibition, and finally by acceptance.

As an example of this, the author describes the initial underestimation of water in its importance as a contribution to mitigating the effects of climate change. In this context, the forest, or more precisely the forest ecosystems, gains prominent importance. The author indirectly points out the self-regulatory processes that begin in the root zone and do not end at the leaf surface.

Numerous research teams have recognized that the evaporation of tree leaves has a direct impact on atmospheric water content, as well as on atmospheric water transport and the terrestrial water cycle. The work carried out by Anastassia Makarieva and her international team of experts over decades is described in detail.

At the very beginning of the author's remarks, Anastassia is quoted as saying, "*The climate problem is not just about carbon. It is mainly about water transport, which is strongly influenced by vegetation cover. This plays a big role in weather changes and weather extremes.*" She continues, "*Planting a million trees is wrong and misleading. Rather, the goal should be to maintain and, if necessary, restore*

[1] Erica Gies is a freelance journalist and author from Victoria, Canada, whose work has been reprinted in numerous prestigious science journals

ecosystem functioning. Just as mature trees with intact soil store greater amounts of carbon than young tree plantations, mature forests untouched by humans are highly effective at regulating water and climate."

The evaporation initiated by capillary forces and photosynthesis and the subsequent emission of water into the atmosphere are process chains that in principle also take place in grasses and arable plants. The only difference is that the area of a tree's leaves per square meter is much larger than the area of the blades of grass in a meadow.

The author points out that it is necessary to derive measures for regulation from knowledge of local conditions. This includes knowledge of the cultural and historical background of the particular region. In this context, Dettinger, a hydro climatologist, says, "*I believe strongly in what we can do in our own local and regional environments, but I get nervous when people extrapolate local to regional successes to the whole world*."

Dynamic possibilities of human self-regulation

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The human organism can dynamically adapt to the particular environment in which it lives. It can thus regulate its internal, biological milieu into equilibrium. This process is called homeostasis (1). There are functional limits for the body systems, which can be exceeded in the short term. Limits exist both physically, such as for blood pressure, fluid balance, body temperature, heart rate, respiratory rhythms, etc., and biochemically for blood sugar, electrolytes, blood gases, etc. Temporary imbalances occur, for example, during stresses such as growth or healing phases. Longer-term shifts require special coping capabilities. In the case of permanently high demands (distress), the target values of individual systems can shift and, if necessary, promote illnesses. Concerning the ability of human organisms to adapt, regulate or resist, we speak of resilience.

Many factors play a role in the ability of a specific organism to cope. These include genetic constitution, personal life history, social environment, age, and geographic and climatic conditions of the environment. Taken together, they determine the extent to which an organism can acclimatize, adapt and tolerate stress. With greater vulnerability, the limits of adaptive capacity are diminished.

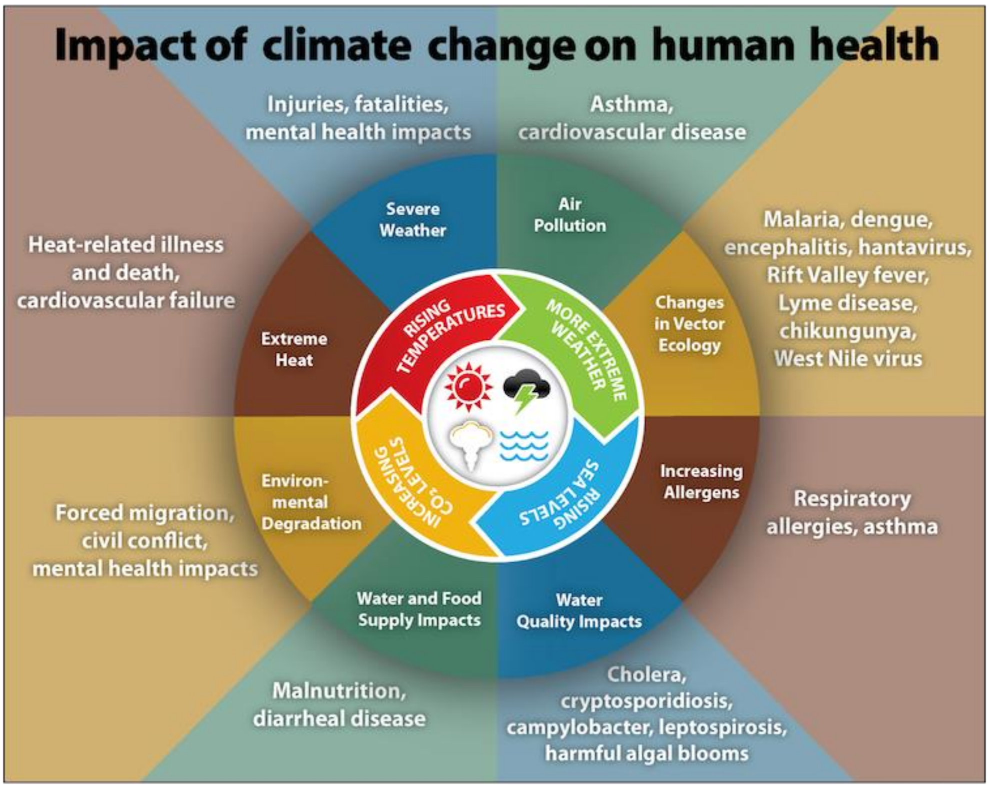
The range of human adaptive options includes individual or social and political protective measures, behavioral changes, and preventive services. These possibilities, however, may be countered by rejecting or denying attitudes and attitudes characterized by rationalizations, negations, or avoidance behaviors toward shared responsibility for well-being.

Biological self-regulatory capabilities cannot be separated from psychological, mental, or even spiritual dynamics. These domains interpenetrate and intermingle in many ways. Humans are endowed with personal and collective memory and knowledge. As a result, they can also learn much about the complexities and threats of current climate change. They are emotionally gripped in different ways and anticipate different threat scenarios.

Beyond that, political, social or even geographic power relations can significantly reduce or even prevent the respective individual adaptation options. In times of global climate change, however, some considerable local pressures, which are caused by transboundary influences, cannot be changed individually or locally alone; this can then only be done on a larger scale.

Climate change and health hazards

For years, there have been many differentiated findings on the extent of potential health hazards due to climate change. These are also increasingly published in the media. The diagram below (2) shows the main dimensions of health threats from climate change: CO2 increase, rising average temperatures, increased extreme weather events and rising sea levels. These lead to increasing stresses on the basic elements of all organic life: the earth, the air, the water and the heat. When these basic elements experience extreme long-term stresses or deficiencies, they promote a wide range of diseases that are exacerbated by nutritional deficiencies, fluid deficiencies, and pollutants in the air and soil.



Some populations, such as the elderly, pregnant women, young children, chronically ill people, malnourished populations, or those living in poor housing and living conditions, are disproportionately at risk.

Opportunities for expanded self-regulation to overcome climate change impacts.

From the plethora of possible aspects of action to better regulate these hazards, just a few, less prominent examples are highlighted:

1) In the wake of technologically-based notions of feasibility, many people believe that they can exist beyond the natural rhythms of time that are everywhere. However, modern research on chronobiology (3,4) shows that all organisms, including us humans, move, from molecules to consciousness, within relatively tightly defined, rhythmic, changing time structures, such as day/night, activity/rest, seasons, diurnal fluctuations, minute or second oscillations, and so on. However, these rhythms of the natural, "biological clocks" are permanently ignored and exceeded by mechanization, computerization, artificial lighting, constant air conditioning, 24/7 clocks of economy[2], trade, traffic or consumption, etc. This

[2] Permant availability 24 hours per day, 7 days per week)

causes significantly increasing sleep disorders, exhaustion, lack of concentration, accident risks, etc. Better reintegration of global and local lifestyles into natural rhythms could mitigate these problems and permanently strengthen the overall resilience capacity of the human organism.

2) In addition to adequate water, heat and air, human metabolism and nutrition are fundamental to life. However, this does not only concern the sufficient coverage of the daily calorie requirement, with as few pollutants or excluded toxicity as possible. As modern research on the microbiome shows, the composition and metabolism of food in the context of symbiotic microorganisms in the human intestinal flora are also crucial to health (5,6). In this context, there are clear links between the increasing soil changes caused by extensive agriculture or overfertilization (7), the declining CO2-binding capacity of arable land (8), and the increasing tendencies toward the spread of metabolic diseases (e.g., diabetes 2) or chronic inflammation. In this context, excessive amounts of animal foods as well as "Ultra-processed Foods (UPF)" play a negative role (9). This could be positively counteracted by more careful cultivation methods and the consumption of more plant-based foods. Corresponding scientific recommendations are available (10).

3) One-sided negative reporting on the potential dangers of climate change on human health (in addition to the many reports on the political crises) promotes considerable emotional stress, especially among younger people (11,12). In the psychotherapeutic-psychosomatic literature, these are summarized, somewhat fuzzily, under the term: "climate emotions" (13). A challenge for general media coverage, especially in counseling-therapeutic work with vulnerable groups and individuals, is to help find a tolerable level of information and facilitate positive engagement that counteracts both denial of the issues and frightening overload. This can reduce unnecessary fear, sadness or dejection as well as growing tendencies to retreat from the climate problem. Necessary changes need a positively contagious, rather optimistic attitude, but no climate defeatism.

4) Constructive contributions to improving the internal company or family climate discussion and action on issues such as sustainability, energy balance, food supply, transportation, necessary/excessive ecological footprint, healthier and healing urban and landscape planning (14), etc. are other aspects of possible (inter)human self-regulation.

Recommended Websites:

Deutsche Allianz Klima und Gesundheit (KLUG) https://www.klimawandel-gesundheit.de/

Robert-Koch-Institut, Klimawandel und Gesundheit:
https://www.rki.de/DE/Content/GesundAZ/K/Klimawandel_Gesundheit/Klimawandel_Gesundheit_node.html

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Guiding Principles of Anthropogenic System Regulation

Autopoiesis[3] and the Ethical Maxim of Retinity[4]

The natural philosophical basis of sustainability

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The natural philosophical basis of the concept of sustainability is the paradigm shift from linear-causal-mechanical to systemic models of thought. These are based on biotic self-regulation in complex, adaptive and autopoietic systems. In terms of social theory, the concept of social cybernetics is derived from this, with the aim of better understanding and controlling the complex interactions between ecological and social systems. Without taking these interactions into account, ethical and political control models remain at the symptom level and are constantly surprised by the often-unexpected side effects of measures. According to this approach, the ethical principle of sustainability does not mean the sum of ecological, social and economic goals, but their systemic correlation. Otherwise, it would not be a normatively meaningful principle, but a maximalist fallacy that encompasses almost all conceivable goals and therefore does not define (that means literally: limit) anything. Sustainability without a better understanding of biotic and social self-regulation degenerates into a conceptless promise of general world improvement. Rather, what is ethically required is the learning of systemic thinking about the conception of nature and the eco-social management of society.

The discourse on sustainability is the political offshoot of a radical change in the view of nature that began long before in the natural sciences and is still far from complete. Without this background, it is impossible to understand the complex dispute about sustainability's ethical and conceptual foundations. A central starting point for this paradigm shift is the changed concepts of time, causality and matter in quantum physics and the theory of relativity. The focus of attention is shifting from individual objects to processes. The consequences of this for natural philosophy and creation theology as well as ethics and society were developed in the process philosophy suggested by Alfred North Whitehead. In the meantime, many developments in the natural and social sciences have been added, e.g. the theories of autopoietic systems, as suggested by Maturana and Varela, or bionics, which was founded by Jack Steele and Werner Nachtigall.

The term "autopoiesis" was coined by Maturana in 1972 to characterize the autonomy and circular self-organization of living systems conceptually. The term is intended to serve as a key to understanding all biological phenomena, insofar as life is not defined by individual characteristics, but fundamentally by the ability to generate, organize and regenerate itself. Autopoietic systems are operationally closed and metabolically open, i.e. closed in terms of information and open in terms of material end energetic flows. Autopoiesis is the most intensively received interdisciplinary variant of self-organization theories. Niklas Luhmann's approach, for example, is essentially influenced by Maturana and Varela, particularly about the focus on the difference between system and environment as energetically open but informationally closed. Luhmann recognizes three types of autopoiesis: that of life (biotic), that of

[3] Autopoiesis is the process of self-creation and self-preservation of a system. It is a subset of the more generally valid ontological concept of emergent self-organization.
[4] Retinity means systemic thinking and acting. It is based on the model of "sustainability" and aims for synergetic networking of the environmental, economic and social sectors.

cognition (cognitive) and that of the social (communicative). Luhmann's autopoietic turn has revolutionized sociology and has had a far-reaching influence on social ethics.

Eco-social bionics

Bionics is a new type of scientific research that does not view nature primarily as a warehouse for human products but as a stimulus for discovering new ways of thinking. It aims to track down the secrets of nature's success in the organization of life and imitate them "biomimetically". In three and a half billion years of evolutionary history, so many ingenious adaptations have evolved that nature has become an almost inexhaustible "treasure chest" of sometimes surprisingly simple and robust solutions to complex problems. From this, "disruptive innovations" can be derived, i.e. innovations that do not make well-known models of technology a little faster and more efficient, but rather strive for completely new, previously unimagined solutions. The aim is to develop radically new procedures, processes, materials and forms of organization beyond the well-trodden paths of familiar thought patterns. A well-known example of a biomimetic innovation is the Velcro fastener: just as Velcro works with small barbs, it can also be used to connect items of clothing and save the hassle of tying and untying. Bionics stands for a new generation of technology that does not grossly exploit and destroy nature, but instead pays sensitive attention to its fine fabric and uses it intelligently for process and structural improvements. It wants more than individual material technology solutions. Bionics aims at fundamentally new forms of the relationship between humans and nature: less resource-, waste- and energy-intensive, with fewer pollutants, more durable, compatible with generations.

In my concept of sustainability, I have expanded this approach in terms of social theory as "social bionics", for example with regard to the allocation of competition and cooperation. It was a great one-sidedness of the theory of evolution, whose political conclusions overshadowed the 20th century, that higher development in nature was understood solely as the result of random mutation and selection and that politics and economics should also be organized as a struggle for existence. In nature, however, there is not only competition but also cooperation, "syngenesis" and a complex variety of mechanisms of higher development and order formation. Only those who cooperate win. Observing the differentiated balancing of competition and cooperation in nature more closely and learning from this for the design of social and economic processes is an important field of eco-social bionics today.

Retinity as ethical-political cybernetics

Cybernetics is the recognition, control and automatic regulation of interlinked, networked processes with minimal energy input. It dispenses with detailed pre-programming in favor of impulses for self-regulation and thus attempts to use existing energies as much as possible. Cybernetic models assume that there is no linear relationship between cause and effect in the majority of human activities and that the consequences of actions are therefore often delayed and occur in unexpected areas. Consequently, they pay particular attention to side effects in other areas, to threshold and limit values as well as oscillation and tipping effects, which are the real difficulty in controlling complex systems.

The cybernetic control of complex, non-linear systems in nature and society requires a political ethic that takes into account the variety of valuable side effects and thus the limits of predictability. It not only strives to maximize individual variables but also focuses on the networked overall structure. To this end, the German Advisory Council on the Environment (SRU) has developed the concept of retinity on the basis of Wilhelm Korff's and my socio-ethical research and described it as the key to environmental ethics. I would like to interpret retinity here against the background of biotic self-regulation and its social-theoretical interpretation as a political-ethical cybernetic: as an art of control for risk-minimizing networking of social, economic and ecological development.

The concept of the network underlying the idea of retinity takes up a central metaphor of ecology: Organisms are interconnected in a network-like manner through nutritional relationships. Living systems are networks at all levels, which are interwoven at many levels. It follows that nature is not simply a passive storehouse of material for human purposes, but - for example according to Bruno Latour's actor-network theory - a systemically acting network of more or less self-dynamic elements. Against this background, Retinity views co-evolution and resilience as new patterns of progress. It apostrophizes sustainability as a cross-cutting issue and accordingly aims to facilitate co-evolutionary synergies between different areas. The guiding principle is not the maximization of certain indicators, but resilient and risk-averse robustness in multiple crises.

Operationalization of ethics through systemic thinking

The primary relevance of the various systems theories for social ethics does not lie in new approaches to justification, but in the fact that they can be helpful at the level of operationalizing ethics for complex action and organizational contexts.

- This avoids the problem of the naturalistic fallacy, which is crucial from an ethical perspective: it cannot be directly concluded from biotic self-regulations that these should also be normatively binding for anthropogenic systems. For example, nature does not recognize justice (if one disregards the controversial debate about the social structure of some higher mammals). From the point of view of bacteria, which are insensitive to radioactive radiation, nuclear war might be desirable. But that does not make it "good". The maxims of practical philosophy cannot be deduced from nature.
- Ethics requires a cultural definition of desirable goals and norms. The most important basis for this are human rights as well as the criteria of justice and the common good, which is to be understood today as the global common good that also includes future generations.
- This does not mean, however, that the principles of biotic self-regulation are ethically irrelevant. However, their status is not that of an alternative justification of ethics, but that of a suggestion for a conditional operationalization and implementation of ethics.
- They do not answer the question of why I should do something, but rather the question: How should I do it? How do I achieve my ethical goals? How can I achieve a sustainable transformation?

By the maxim of retinity, which is based on the guiding principle of sustainability, environmental ethics should not be conceived as a specific area of ethics, but as a comprehensive integration concept for the complex development problems of late modern society. The guiding principle is not the paradigm of nature as an absolute limit to growth, but rather the model of a dynamic stabilization of complex human-environment relationships.

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Digital modeling of the self-regulation of complex dynamic systems: What can we learn from this?

Introduction

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For many decades I have been working on the (mathematical) foundations of complex dynamical systems, which are used as models for self-organization in nature and society. Computer simulation and AI open up new possibilities for simulation and prediction for early warning systems of critical and chaotic developments. This paper is a plea for technology design: modeling self-regulation must prove itself as a service for resilience and sustainability in nature and society. This is particularly evident in the example of a sustainable circular economy.

Complex dynamics of the Earth system

The Earth system is an example of a complex dynamic system with mechanisms of self-regulation. Complex systems consist of many elements whose interactions generate collective orders and patterns, but also chaos and turbulence. The laws of these dynamic processes are studied by complexity research - from complex atomic, molecular, and cellular systems in nature to complex social and economic systems in society (Mainzer 2007). Complexity research deals across disciplines with the question of how the interaction of many elements of a complex system (e.g., molecules in materials, cells in organisms, or people in markets and organizations) can give rise to order and structure, but also to chaos and breakdown. One then speaks of "emergent" properties of complex systems that cannot be attributed to the behavior of the individual system elements. Complexity research aims at identifying such emergent properties in complex systems. To this end, new basic concepts, measurement methods, models, and algorithms are introduced. Thus, collective orders can be characterized by order parameters. Orders, like chaos and decay, arise in critical states that depend sensitively on the control parameters of a system or organize themselves. These excellent states are often also called attractors because the dynamic developments of a system are quasi-drawn into the water vortex of a cast. Complex patterns of time series and other criteria are used to identify critical situations from process data in advance and to take precautions in time. Computer models play a crucial role in this process. The dynamic processes of complex systems 2 in nature and society can be analyzed in simulation models made possible by the increased computing capacities of computers. Organs such as the heart and brain are self-regulating complex systems of cells. Populations are equally complex systems of organisms. Ecological systems consist of populations and many other climatic and environmental conditions. During evolution, a complex system of equilibria has developed between the environment, and animal and plant populations. Local disturbances (e.g., extinction of animal and plant species) can be resiliently managed or can build up to global changes (e.g., disruption of the food chain) in the sense of the butterfly effect.

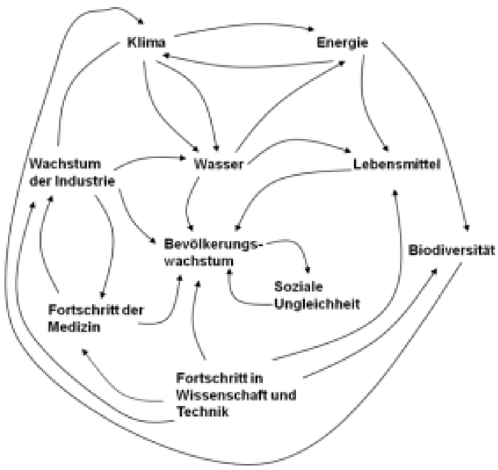

Fig.1 Complex feedbacks of the Earth system.

Ecological systems are part of the whole Earth system, in which climate and natural resources are linked to human civilization (Fig. 1). Growing Earth population and adaptation of lifestyles even in emerging and developing countries lead to ever-increasing overexploitation of resources and pollution of water, soil and atmosphere. In this complex system of feedback loops, extreme local disturbances (e.g., earthquakes, tsunamis, nuclear disasters) trigger a cascading propagation of effects that shake the entire system (Fig. 2). We therefore need early warning systems for crises and disasters in the complex Earth system. Nature, environment, and life cannot be totally calculated and controlled due to their complexity. However, we can analyze and understand their system laws to enable the self-organization of sustainable developments.

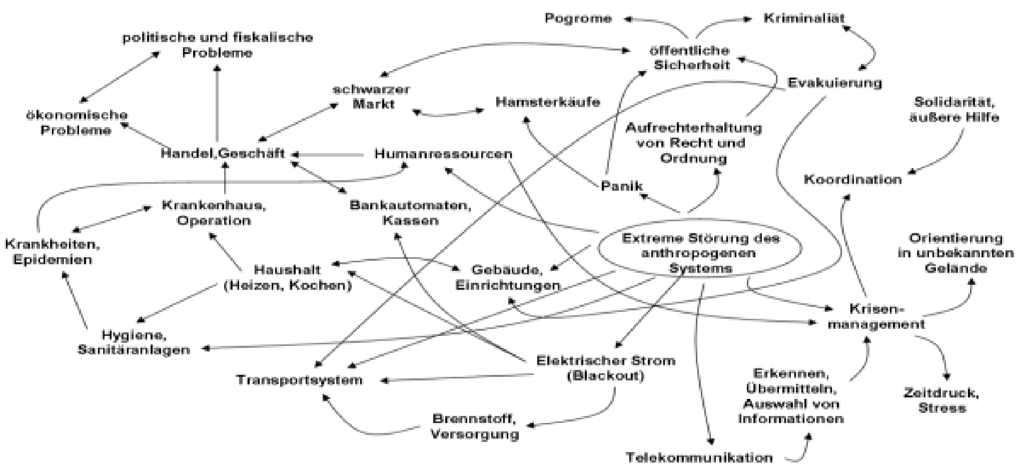

Fig. 2: Extreme local disturbances trigger global crises in complex systems.

Chaos and complexity in economy and society

People today operate in complex organizations and societies. What do we know about their dynamics? How is action and decision-making possible in such complex systems? People behave in groups and thereby generate typical behavior patterns, build up social orders, or let the whole system become unstable and crash into chaos.

The social behavior of humans shows remarkable analogies with models of nature (e.g. swarm intelligence), but they are completely different in other respects. For example, stock market data are already measurements of subjective beliefs, opinions, and hopes that influence economic dynamics, i.e., something changes measurably because we desire, believe, hope, or fear it. Characteristic feedback occurs between agents, their intentions, and models of social reality.

Markets and firms are examples of complex economic systems in which people interact in many economic functions. In the tradition of classical liberalism and analogous to classical physics of the 18th and 19th centuries, a linear equilibrium dynamic was often assumed, according to which the free self-organization of economic forces automatically leads to the "prosperity of nations". In the age of globalization, financial and economic markets are in fact based on non-equilibrium dynamics, whose phase transitions are associated with turbulence and chaos, but also with new bursts of innovation. Attractors of complex dynamics again correspond to order parameters and power laws between randomness and rigid regularity. Complexity research can thus identify signals to prepare in time for economic upheavals and opportunities.

From complex systems to artificial intelligence

Artificial intelligence (AI) has long dominated our lives without many being aware of it. Smartphones that talk to us, wristwatches that record our health data, work processes that organize themselves automatically, cars, airplanes, and drones that control themselves, traffic and energy systems with autonomous logistics, or robots that explore distant planets are technical examples of a networked world of intelligent systems. They show us how our everyday life is determined by AI functions. In 1950, Turing defined a system as intelligent in the test named after him if it is indistinguishable from a human in its responses and reactions (Turing 1950). The disadvantage of this definition is that humans are made the standard. Indeed, biological organisms are also examples of "intelligent" systems that, like humans, evolved more or less by chance and can solve problems efficiently more or less on their own. The current hype of Artificial Intelligence is made possible by the increased computational capacity of computers that Machine Learning can realize. In Machine learning, neural networks modeled on the self-organization in the human brain play a dominant role. The breakthrough of AI research in practice is largely related to the ability of neural networks to apply large amounts of data (Big Data), e.g., in pattern recognition, autonomous driving, robotics, and Industry 4.0 with effective learning algorithms. Although technical civilization increasingly depends on these AI algorithms, they are associated with significant security risks. Therefore, verification methods are needed to calculate and guarantee the security standards of neural networks (Mainzer 2020). They are a necessary condition for issues of security, ethics, and responsibility.

Chaos and complexity in communication and supply systems.

A central requirement for sustainable economic activity is the transformation into a circular economy in which all production and consumption goods are returned to the goods cycle in an energy- and environmentally-friendly way. In this context, a sustainable solution to the energy problem becomes a prerequisite for digitalization and artificial intelligence, which require enormous energy consumption. In this respect, a sustainable circular economy must first secure the energy consumption of digitization. Conversely, however, a sustainable circular economy can only be effectively realized through IT and AI because of the complexity of their interactions. In summary, then: digitization through sustainable circular economy and sustainable circular economy through digitization!

What do we learn from the dynamics of complex systems?

In summary, we note that the theory of complex dynamic systems studies self-regulation in nonlinear processes of nature and society. Examples are the challenges of globalization, environment and climate, life sciences and information overload. Changes, crises, chaos, innovation and growth spurts are modeled by phase transitions in critical states. The goal is to provide explanations and forecasts of these processes, as well as early warning systems for extreme disruptions. Self-organization is indeed necessary to cope with the increasing complexity of this development. However, it can also lead to uncontrollable momentum and chaos. Complex dynamic systems therefore require monitoring and controlling. Nature has shown us this in the evolution of organisms. This also applies to technical, social and economic systems. The goal is sustainable infrastructures as a service for us humans, which help to cope with an increasingly complex world and make it more livable. For this, we will need responsible AI.

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Systemic Risks and Polycrisis:
The need for an integrative approach

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In recent years, German society has been exposed to several serious crises. Risk researchers call them polycrises (Homer-Dixon et al. 2024; Homer-Dixon and Rockström 2022). First came Corona, then came the further manifestations of climate change, for example floods, draughts and forest fires, the war in Ukraine, food crises in the world, inflation, galloping energy prices, and there are more every day. The hallmark of polycrises is the mutual amplification of nested, interconnected risks. For example, supply chains were disrupted as a result of the policy measures to combat Corona pandemic. In addition, so-called domino effects occur when, for example, the Ukraine war triggers bottlenecks in grain supplies. Russia's invasion of Ukraine plunged the global economy from incipient recovery into inflation and threatens to trigger a war between the world's two major nuclear powers. Now the effects of war, pandemic, and extreme weather conditions in India, China, Africa, and Europe are compounding each other, leading to food supply shortages and increased hunger across the planet (Trabucco 2022).

Every crisis - whether political, epidemiological, military, economic or environmental - forces society to redefine and reshape its everyday understanding of what is normal and what can be expected shortly. One moment, a pandemic is shaking the foundations of society; the next, the continued existence of liberal democracies is seriously in question; and then politicians and the media are talking about the possibility of nuclear war. This juxtaposition of crises shows that we are dealing with a complex web of superficially different but in reality, deeply interwoven crises (Lawrence et al. 2022). And it is precisely because these crises are so causally and functionally interwoven that they cause damage worldwide that is far greater than the sum of their damages.

Essential characteristics of today's polycrises are (WPKS 2023):

- multiple parallel crises that influence and reinforce each other. The climate crisis is only one among many, but a particularly powerful one,
- the absence of dominant solutions that score better on all criteria than alternative courses of action,
    - the need for a comprehensive systemic understanding of the interactions between social, natural, technological and cultural domains,
    - the need to clearly identify conflicting goals and to make appropriate and ethically defensible trade-offs that have a high degree of resilience, especially against existing and future crises,
- refraining from one-dimensional optimizations, because they are usually associated with disproportionate losses on other, (equally important) criteria,
- need for unvarnished communication that addresses the conflicting goals,
- need to involve stakeholders and affected populations in weighing conflicting goals and to search for common solutions without wasting precious time.

The analytic tool to understand polycrisis: the systemic risk concept.

If we take a closer look at the global ecological, economic and socio-cultural transformation phenomena that we characterized above by introducing the term polycrisis, we discover a number of interlinked and mutually influencing risks that are not given sufficient attention and that the relevant actors such as governments, business enterprises or civil society groups around the world still have great problems to govern and limit to an acceptable level.

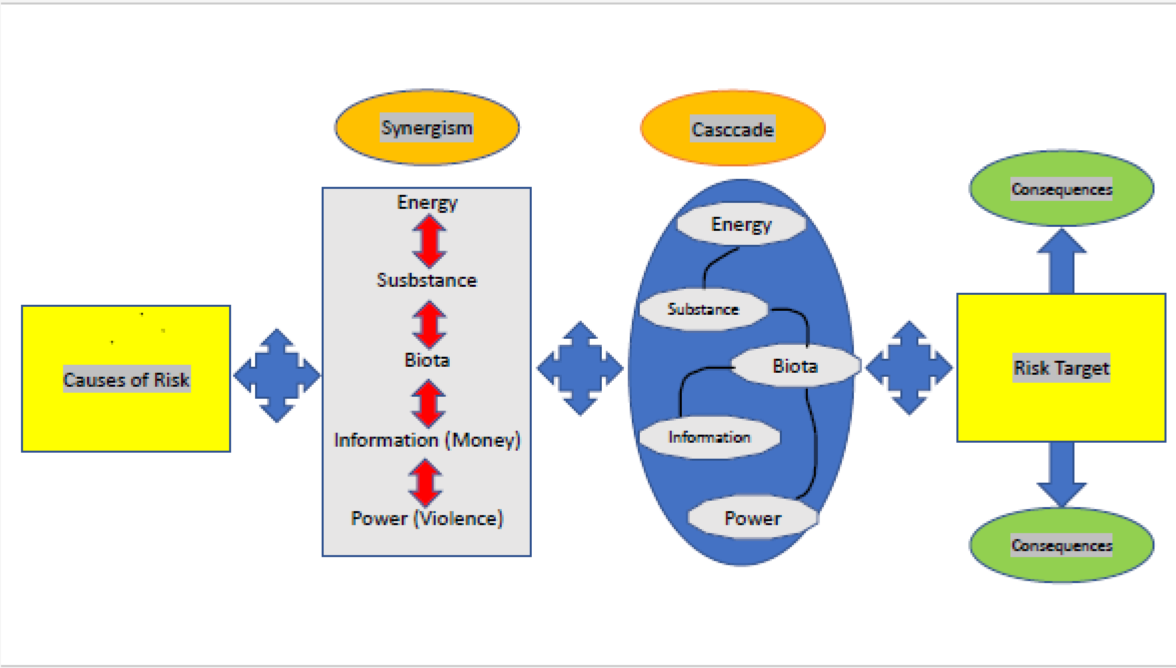
These insidious risks that threaten people's welfare can be evidenced by the term systemic risks (Renn et al. 2021; Renn 2020). The cause-and-effect models that have been common up to now are less and less effective in a world that is characterized by systemic interactions between allegedly independent risk sources. This applies to the world as a whole, but equally to its numerous subsystems. For this reason, everyday phenomena in nature, technology and society can only be understood if they are viewed as dynamic processes in complex systems. Instead of the linear multiplication of individual data sets, systemic interrelationships are increasingly moving to the center of analysis. This applies in principle to all systems and processes, be they in nature, in technology, in medicine, in the economy or in society. To a particular extent, the systemic view is relevant for risk research, in which technical, natural, and socioeconomic processes interact with social processes of reaction and discourse.

Accordingly, these risks are referred to in the literature as "systemic risks" and include, but are not limited to, global warming and the associated accumulation of extreme events, zoonotic disease outbreaks, declining biodiversity, increasing economic inequality, financial system instability, ideological extremism, cyberattacks, increasing social and political unrest, and geopolitical imbalances (Schweizer 2021). Most of these systemic risks have become more severe, disruptive, and dangerous than in previous decades. Risk research has referred to this as risk amplification. (Kasperson et al. 1988) And in most cases, the likelihood and magnitude of these risks are also increasing more rapidly now than in the past.

The interplay of risk agents: a further level of abstraction

The need for mapping the interdependencies between systemic risks in multiple global contexts may easily lead to the usual spaghetti diagrams that try to illustrate complex causal connections but may miss some crucial connections that have a dominant influence when studied in more detail, overemphasize others that show only weak ties in the real world or propose causal connections that are all plausible but, in the end, connect everything with everything. To be more focused on the nature of such interconnections and to be analytically precise, it may be helpful to identify the key agents that have the potential to cause harm and concentrate on how they interact with each other.

Within the framework of systemic risks, such an approach of isolating key risk agents has been proposed and explored in several publications (Renn et al. 2022, SAPEA 2022, Renn 2020, Schweizer et al. 2021). The main idea is that whatever the cause of risk may be, its potentially destructive force will manifest itself in three physical and two social agents (carriers or media). The physical agents are: energy (in all its forms), substance (in particular toxic substances to humans or pollutants to ecosystems) and biota (viruses, bacteria, fungi, etc.)- The two social agents are: Information (including money) and power (including violence). The sequence of a polycrisis can in principle be modeled in a simple causal diagram starting with the risk triggers and ending with the consequences in different physical and social domains (see figure):



Caused by some kind of trigger (events such as earthquakes or floods and activities such as polluting or warfare) one or more of these agents are released. An earthquake would release kinetic energy, a technical accident in a chemical factory with toxic material or the tight coupling of animals and humans could lead to the emergence of a new pandemic. New rumors (information) about a company's performance may alter its value and impact the distribution of wealth or the power of an autocratic system may use violent means to conquer an independent country. These one-dimensional encounters between a risk agent and a risk target (or risk absorbing system as it is called in the IRGC publications, 2018, 2019) constitute familiar cases for traditional risk assessments that link the probability that these agents are released with the degree of extent of consequences that these agents cause among the exposed targets). In a polycrisis situation, all these agents interact and amplify or attenuate each other.

There are two potential pathways of interaction (Lawrence et al. 2022). The first pathway is the *risk cascade:* The earthquake may lead to the explosion of the chemical factory, which releases toxic substances, that are not or wrongly communicated to the exposed public with the consequence that the responsible communicators may lose their power and, in the chaos to follow, new hazards are released that, for example, aggravate climate change with its own consequences. The five agents are all interacting in a sequential way, often with several parallel sequences that again interact with each other.

The second pathway refers to *risk synergism:* Related or unrelated triggers release simultaneously several of these agents which influence each other immediately and aggravate the potential loss. For example, the risk of climate change and the risk of losing credibility in the light of the Russian invasion of Ukraine may cause a simultaneous release of substances that lead to higher global temperatures (for example CO_2 emitted by using liquid natural gas for heating houses) and a desperate communication strategy to explain the obvious contradiction of buying climate-sensitive liquid gas from autocratic countries outside of Russia and sustaining a policy of strict climate protection. This likely-to-fail communication strategy may trigger a loss of credibility in government, a shift in power in the public discourse and a new trend towards populist movements.

Both, risk synergisms and cascades overlap and form specific patterns of interactions that can be identified, sometimes formalized in mathematical models and, if that is not possible, to be transferred into coherent narratives of a polycrisis cycle. The limited number of agents facilitates the comparison of different cycles or even cycle types and provides a powerful toolbox for developing a more abstract and generic taxonomy of polycrisis. At this point, these conceptual ideas have not been further tested or applied to empirical case studies. However, the approach provides some promising potential to improve our understanding of polycrisis and also our ability and capacity to govern polycrisis more effectively.

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Diversity of Thought for Self-Regulation

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In societies around the world, people consciously or unconsciously intervene with the planet and the environment, altering its natural systems and ability to self-regulate. Today's rapid climate change is one of the results of human interventions. Given the geographic, climatic, cultural, and social complexities across the world, innovative approaches to sustain life on Earth will have to mirror the multitude of dimensions of the Earth system. Innovation requires diversity of thought to enable self-regulation.

While climate change has been broadly acknowledged, many of the current efforts to reverse the trends have been driven by one-dimensional efforts within the established siloes of each sector, yet have fallen short of expectations to realize sustainable improvements. This is not by the least surprising to me: as we continue to ask the same type of people the same type of questions, we naturally get the same type of answers and solutions. To disrupt our current thinking and realize breakthrough innovation toward climate protection, we need to address both parts of this equation and empower people with non-traditional backgrounds, unusual experiences, and alternative perspectives to ask new questions. With the new business-as-unusual environment being dynamic, unexpected, and ever-evolving, we need to look for inspiration in unconventional places. And it has been proven that innovation is born through diversity-rich organizations. This requires active listening, the willingness to engage in courageous conversations, bold experimentation with unfamiliar ideas, and an unlimited curiosity to rethink future approaches.

What are the benefits of diversity?

In recent years Diversity, Equity, and Inclusion (DEI) programs have become en vogue and part of the expected focus of all organizations. During dates such as International Women’s D, it is heartwarming to see the flurry of posts and celebrations. By the same token, it is then dispiriting to observe how quickly so many of these public statements are replaced in the feeds by the next flavor of the day leaving the unsettling feeling of representing lip service only. To me, this misses the point of DEI: Instead of a branding opportunity, DEI is a critical prerequisite to establishing a mindset of resilience, adaptability, and continuous innovation.

In light of this misrepresentation, I wonder how we move DEI beyond being viewed as an opportunity for promotional and reputational activities to leverage the true benefits and business case for companies and organizations. What are the economic benefits of diversity? Below is a summary of the facts and findings suggested by ChatGPT:

- Broader talent pool: By actively seeking out diverse candidates for open roles, organizations can tap into a larger and more varied pool of talent, gaining access to talented and bright minds.
- Increased empathy: When people work with others who are different from each other, they are forced to consider alternative viewpoints and experiences, which can lead to increased empathy and understanding. This, in turn, can lead to more innovative solutions that take into account a broader range of needs and perspectives.
- Increased cultural awareness and understanding: When people interact with others from different cultural backgrounds, they gain a greater understanding and appreciation of different perspectives.
- Broader range of experiences & knowledge: When people with different backgrounds and experiences collaborate, they can draw on a broader range of expertise and knowledge, which can lead to more comprehensive and effective solutions.

- More creativity: When people work with others who are different from them, they are exposed to new ideas and suggestions that can inspire them to be more creative in their thinking and approaches.
- Increased problem-solving ability: People with different backgrounds and experiences can approach problems in unique ways, leading to more effective and efficient problem-solving. Their collaboration can spark new approaches to solving challenges that might not have been considered otherwise.
- Better decision-making: When a diverse group of people is involved, they are more likely consider a wider range of options and perspectives, leading to better decision-making.
- Increased innovation: When people from unique backgrounds and experiences come together, they bring a variety of perspectives and ways of thinking to the table, which can inspire new ideas and innovative solutions to complex challenges.
- Better communication and collaboration: Diverse teams can bring a range of communication styles and approaches, which can lead to more effective collaboration and teamwork.
- Enhanced engagement: When team members feel valued and included, they are more likely to be engaged and committed to their work. This can lead to improved productivity and job satisfaction, which can benefit the organization as a whole. A diverse workplace can create a sense of belonging and inclusivity, leading to higher employee satisfaction and engagement. It takes into account the unique needs and concerns of different groups.

Overall, the business case for diversity is strong, with benefits that include broader talent pools, increased empathy and cultural awareness, improved creativity and innovation, better decision-making and problem-solving, better communication and collaboration, and enhanced engagement.

It seems that artificial intelligence is fully grasping the rich economic benefits of diversity, equity, and inclusion. How do we ensure human intelligence follows suit?

What is diversity?

When reflecting on diversity, it is important to consider the wide variety of perspectives required to drive change, from intergenerational, to gender, and intercultural as well as cross-functional diversity. This highlights the diverse aspects of diversity. In the context of organizations, diversity refers to the representation of different groups of people within the workforce. A diverse workforce includes individuals from different backgrounds, experiences, and perspectives, who bring unique strengths and talents to the organization. A commitment to diversity means valuing and respecting these differences and creating an inclusive environment that supports and leverages the unique gifts of all employees, regardless of their differences.

Many factors contribute to diversity in the workforce. These include:

- Demographics: Diversity can be created by recruiting and retaining employees from different demographic groups, such as race, ethnicity, gender, age, and socioeconomic status.
- Education and Experience: Diverse educational and professional backgrounds can bring unique perspectives and skills to the workplace.
- Geographical Location: Recruiting team members from different regions or countries can add diversity to the team, bringing different cultural and religious perspectives and experiences.
- Personal Characteristics: Diversity can be created by valuing and promoting diversity of thought, communication style, and problem-solving approach, regardless of demographic background.
- Inclusivity: Inclusive policies, practices, and culture help retain diversity, and create a sense of belonging for diverse employees in the workforce.

Diversity encompasses both visible and invisible differences and can be seen as a reflection of the complex and multifaceted nature of human experience. Overall, creating a diverse team requires a commitment to valuing and promoting differences, actively seeking out and recruiting colleagues from diverse backgrounds, and providing a supportive and inclusive environment for all employees.

Diversity as practice

Lastly, leading disruptive innovation through diversity is also a leadership practice with the three elements of courage, curiosity, and calmness.

1) Curiosity refers to the active choice of overcoming our own assumptions and admitting that we do not have all the insights.
2) Leaning into different views and perspectives of others requires Courage to be comfortable with the uncomfortable.
3) Taking into consideration the emotional reactions of ourselves and others, we need to consciously choose to be Calm and Collected, especially when others do not immediately relate to our suggestions.

Overall, making diversity a practice involves being mindful of our own biases and assumptions, seeking out diverse perspectives and experiences, and actively managing our emotions as we choose to promote inclusivity and respect for all individuals. Innovation through diversity for enhanced self-regulation requires active listening, the willingness to engage in courageous conversations, bold experimentation with unfamiliar ideas, and an unlimited curiosity to rethink future approaches.

Call-to-Action

Recognized as one of the 20 most powerful women in water, I am finding myself increasingly “consciously biased” toward people from the most different walks of life. I realize I have a role to play in providing opportunity and fostering a world that celebrates diversity. I am a strong believer that the diverse landscape of geographic conditions, societal requirements, and human expectations needs to be reflected in the makeup of the solutions we offer to protect our Blue Planet.

The inspiring message by Michelle Obama in her book "The Light We Carry" resonates with me. In a world where so many of us feel different and still, as an "only" in our environment, she emphasizes that each one of us carries an inner brightness, something entirely unique and individual, a flame that's worth protecting. She encourages us to seek out a community in which "one light feeds another" and "one engaged community can ignite those around it." Together, we can develop solutions that exceed our individual capabilities and reach of one-dimensional perspectives. Given the geographic, climatic, cultural, and social complexities across the world, innovative approaches to sustain life on Earth will have to mirror the multitude of dimensions of the Earth system. Innovation requires diversity of thought to enable self-regulation.

Towards a better understanding of the Earth system through an expanded model of the Anthropocene, and the derived rules for a reasonable reaction

Anthropocene overforming is for the environment of humans

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As beautiful as our earth is - more and more alarming changes, from climate change and ocean pollution to growing conflicts and war, are burdening our souls. The term "Anthropocene"[5] used for these phenomena of modernity refers first of all to the period in which humans have significantly shaped their environment. At the same time, it also describes the effects of ubiquitous human behaviour on our biological-physical environment as well as indirectly on the socio-political environment. In this way, a model of understanding or worldview is created that helps to recognize the consequences of action (“supply chains”) and, above all, to propose actions to overcome the critical effects.

The changes in the world that have led to the Anthropocene era are composed of intended developments as well as unintended side effects. The intended developments are the technical possibilities created by our inventiveness from the construction and the reclamation of the landscape to the production of goods. They are the sum expression of our culture and civilization[6]. The resulting negative side effects, the most prominent of which is the emission of climate gases and the climate change induced by them, however, threaten the positive development of our civilization in the meantime.

A derivation of three basic mechanisms of action (primary, secondary and tertiary consequences and mechanisms of action), which in sum lead to the effects described as Anthropocene for the earth system, shall open the way to the urgently needed response strategies. The questions to be decided include whether we can aggressively stabilise the Earth system through even more extensive technical interventions, whether it is sufficient to reduce the further influence on the Earth system in the sense of consistent and sufficient behavioural change, or whether we must actively reduce the critical human influence on the entire ecosystem or the Earth system including its subsystems to such an extent that the systems can stabilise themselves again (cf. theory of resilience[7]).

Primary triggers and consequences for our environmental system

Primary triggers of the Anthropocene are caused more or less directly at every place on earth where people live and can be observed there. These are the purposeful, i.e. quite intentional cultural achievements of urbanization, landscape shaping and production - in each case including their unintentional or accepted unpleasant side effects.

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[5] P.J. Crutzen:, „Geology of mankind“, nature, according to Nobel Prize winner Paul Crutzen, the Anthropocene is the current “geological epoch” shaped by humans, which follows the Holocene in terms of geological history. Crutzen: „*Unless there is a global catastrophe — a meteorite impact, a world war or a pandemic — mankind will remain a major environmental force for many millennia. A daunting task lies ahead for scientists and engineers to guide society towards environmentally sustainable management during the era of the Anthropocene*“.
[6] Legitimised in the Christian cultural sphere by the temporary interpretation of the bible, “Be fruitful and multiply, and fill the earth and subdue it […]“ (Genesis I, 28s), cf. in this context René Descartes, 1637, humans are "rulers and owners of nature" („maîtres et possesseurs de la nature“), Discours de la méthode et Essais. Charles A
dam und Paul Tannery (Hrsg.), Léopold Cerf, Paris 1902, S. 62.
[7] B. Walker und D. Salt: *Resilience thinking*, Island Press, 2007

Physical changes to the landscape: The landscape in most of Europe has been transformed into a cultivated landscape. In Europe, 2/3 of the forests and approx. 84 % of the wetlands have been converted into agricultural land or settlement and traffic areas as a result of reclamation. Among other things, there are hardly any significant surface waters left that have not been altered by humans - straightened, diked, expanded or dammed. A return to original (Holocene) conditions is neither desirable nor realistic. However, it seems that we have reached an optimum between economic use and ecological compatibility and have now exceeded it. This is accompanied by changes in biocoenoses.

Impact on biocoenoses. The biocoenoses of the landscapes have led to far-reaching changes as a result of a variety of human influences. Many habitats, especially in soil and in surface and groundwater, have permanently altered ecological conditions and with them the biomatrix (just as an example: "species extinction").

Additional influence is exerted by the increase in entropy caused by chemicals (production and consumption as well as waste products) is putting increasing pressure on regional ecosystems, and also on global ecosystems.

Physical changes to the landscape: The landscape in most of Europe has been transformed into a cultivated landscape. In Europe, 2/3 of the forests and approx. 84 % of the wetlands have been converted into agricultural land or settlement and traffic areas as a result of reclamation. Among other things, there are hardly any significant surface waters left that have not been altered by humans - straightened, diked, expanded or dammed. A return to original (Holocene) conditions is neither desirable nor realistic. However, it seems that we have reached an optimum between economic use and ecological compatibility and have now exceeded it. This is accompanied by changes in biocoenoses: the biocoenoses of the landscape have undergone far-reaching changes as a result of these and other human influences. Many habitats, especially underground and in bodies of water, have been permanently altered and with them the biomatrix ("species extinction"). Additional influence is exerted by the

The increase in entropy caused by chemicals (production and consumption as well as waste products) is putting increasing pressure on regional ecosystems, and now also on global ecosystems.

Indirect or secondary triggers and consequences

Secondary triggers and consequences (of the Anthropocene) should be understood as all those phenomena which

- result from the accumulation of extensive and long-lasting consequences (impact) of the primary triggers, which are
- are supralocal, i.e. also outside the original areas of origin and
- have a lasting effect on parallel and superordinate systems, and thus
- for the Earth system and relevant subsystems in turn have a significant impact.

Such effects are in particular climate change and diffuse species extinction and their respective further consequences such as water shortage, and loss of resilience through the collapse of stabilizing biotopes (forests, reefs). The transitions between primary and secondary consequences can be fluid.

Tertiary effects: Dynamic increase in knowledge and respect for complex systems.

(οἶδα οὐκ εἰδώς)[8]

A sensible assessment of the Anthropocene and an adequate strategy to ward off against unwanted changes requires not only an understanding of the primary and secondary triggers and consequences, but also a reflection on our (un)knowledge and the risks of complicated complex due to the deep intervention in the huge, complicated and complex earth system that has taken place in the recent past.Here we have to contend with three phenomena:

1. We are far from fully understanding our vital systems and their complex interactions. This means that there is a partial lack of knowledge about their positive effects on the entire ecosystem and a growing risk that damaged systems will trigger secondary burdens.
2. we have only partially understood the negative effects of our primary and secondary drivers. Therefore, every few months new assessments of long existing chemical substances or interactions in biological processes appear.
3. the interaction of poor understanding of existing systems and ongoing anthropogenic changes with primary and secondary consequences increases the likelihood of non-resilient developments.

Fundamental proposals for dealing reasonably with the Anthropocene

In the Anthropocene, we have not only significantly influenced the development of the world, but implicitly inherited responsibility for the future. Mother Nature can no longer "save" us through her self-regulatory capacities; the rules of the game for our survival increasingly depend on our behavior. With each of our collective interventions, system resilience is weakened and the danger of side effects grows. The further development of this earth system, which has been over-formed by anthropogenic interests, must now be assessed as critical. This can end fatally - see climate change - and is probably ethically unjustifiable.

This realization leads now with some characters to a renewed hubris that they (homo sapiens) are like the creator and can actively control the earth with further technical measures (large-scale use of geoengineering). Not much better is the simple mental expectation that the ecosystem or even the creator must come up with something under these circumstances or would already have a plan B.

Both technical science[9] and ethics[10] come to a different conclusion: We have to take over responsibility by shaping our actions within ecological constraints! The benchmark for future security is sustainability and system resilience.

In the current state, we seem to have overstretched this resilience. To prevent the destruction of the system through exponential deterioration, we need to advise:

a. We should finally take the numerous signs of critical system changes seriously. It is precisely the knowledge of our unavoidable uncertainties or lack of knowledge that demands a responsible approach to the resulting risks. A "business as usual" approach is ethically and economically irresponsible from a risk perspective.[11]
b. Our technical developments and their ubiquitous application have led to a kind of unintended, "induced" geoengineering. The purely technical answers to system stabilisation through globally applied geoengineering are conceivable, but according to current knowledge neither safely,

[8] Sokrates *"I know that I do not know"*, i.e. *"known not-knowing"* as an important part of knowledge
[9] Notably James Lovelock, The Revenge of Gaia: Earth's Climate Crisis & The Fate of Humanity, 2007 und E. U. Weizsäcker et al., Wir sind dran. Club of Rome: Der große Bericht: Was wir ändern müssen, wenn wir bleiben wollen. Eine neue Aufklärung für eine volle Welt, 2017
[10] Notably Pope Francis II, Encyclical letter Laudato Si of the holy father Francis, *"on care for our common home"*, 2015 und Laudate Deum, *"to all people of good will on the climate crises"*, 2023
[11] Hans Jonas, *Das Prinzip der Verantwortung*, Versuch einer Ethik für die technologische Zivilisation, 2020

effective nor safely controllable. Nevertheless, the existing techniques must be subjected to critical discussion and binding national and international provisions must be set up quickly.[12]

c. The clearly more coherent response is to reduce anthropogenic influences on the ecosystem to such an extent that the system can stabilise itself again.
    a. This is to be achieved by avoiding further interventions as well as proactively through area-wide measures in the city and in the countryside for landscape regeneration.
    b. Positive examples are the approach of EU environmental policy (EU Water Framework Directive, European Green Deal) or also the current water strategies in Germany (regeneration of the regional water balance).
    c. The hope is to apply and combine technically known and feasible measures such as extended wastewater treatment, chemical avoidance, zero emission, climate gas avoidance, hedge structures, riparian strips, residual water, erosion prevention, biotope conservation, forest conversion towards more natural forests, etc. on a large scale, thus creating "responsibility-based geoengineering".
d. Special attention shall be focused on the stabilization of the terrestrial water balance, the soil and the forests.[13]
e. In parallel, research and development in these areas must be advanced in the national interest. This applies in particular to the water balance, which is the basis for every resilient ecosystem, and to the soil research.
f. Investment in permanent gains in knowledge and the resulting corrections of system-relevant measures for the conscious control of the Anthropocene are a permanent task! Every condition that is assumed to be good today can be downgraded again tomorrow due to an increase in knowledge. The effects of the Anthropocene continue, with the consequence that the pressure of stress increases with it.

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[12] Institute for Advanced Studies TU München, IESP e. V., Zugspitze Declaration: Dealing Wisely with the Planet, 2008
[13] The global preservation of natural groundwater levels seems to be of central importance

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Discussion

Questions of Peter Wilderer: In his article, Martin Grambow explains that the term "Anthropocene" should not only be understood as a period of time in world history. According to the author's proposal, the term also stands for a philosophical debate and thus as a call for ethical and moral action. The resulting responsible action would then be understood as a fundamental obligation of humanity with all its facets and is therefore also an important contribution to anthropogenic regulation. If this assumption is correct, it would be helpful if the dual meaning of the term "Anthropocene" were explained in more detail and deepened.

This global call for responsible action is associated in the article with sustainable "geoengineering". This term may seem catchy, but it does not really fit the context because "engineering" is to be understood as the application of scientific principles and mathematical methods to solve practical problems. Does this also include social, economic and governmental problems? And are responsibility and sustainability a priori anchored in the term "geoengineering" in this definition? It would therefore be helpful if the author could provide a brief clarification of these contradictory meanings.

The answer of Martin Grambow: I think the Anthropocene is initially just a description of a state and a process: certain processes (pollution, transformation over-shaping) were initiated in the Anthropocene that led to critical changes. However, together with the knowledge of sustainability and resilience, the Anthropocene also gives rise to imperatives for collective action.

This also leads to the second part of Peter Wilderer's question, the use and further development of the term geoengineering. In my opinion, the discussion here is not yet closed (see also Wolfram Mauser's comments). I tend to characterize both cultural techniques that, when used globally, produce significant global changes (e.g. to the earth's climate or species) as "unintentional geoengineering". James Lovelock comments: "If geoengineering is defined as a purposeful human activity that significantly alters the state of the Earth, we became geoengineers soon after our species started using fire for cooking, land clearance, and smelting bronze and iron" (Lovelock, 2009, p. 139ff). Admittedly, such a definition disturbs the pure doctrine of "engineering", which only has the intended effect in mind. However, if it is known that the application of a certain cultural technique has a negative cumulative effect with global consequences on climate, for example, leads to the extinction of species or destroys the soil, and I do care - am I not engaging in geoengineering? And vice versa, if we now develop new or improved cultural techniques - e.g. degradable plastic or more eco- and climate-effective forestry - with the secondary or even main goal of developing the effects of the Anthropocene in a consistent, sustainable direction - what do we call such action? Geoconsistent? Natural geoengineering?

We still need to agree on the right terms here. James Lovelock proposes another definition of geoengineering that I agree with: "Geoengineering methods fall into three main categories: physical means of amelioration such as the manipulation of the planetary albedo; physiological geoengineering that includes tree planting, the fertilization of ocean algal ecosystem with iron ... and, finally, active or Gaian geoengineering that involves the use of the Earth's ecosystem to power the process, or to change the nature of climate feedback from positive to negative" (Lovelock ibid. p 141).

And yes, these issues are linked to all social, economic and governmental problems. We only have the problem of limited knowledge; we mainly have a socially, economically and politically driven problem of implementation.

Peter Wilderer on a completely different form of geoengineering: Should measures to combat invasive species be seen as a unique form of geoengineering? This question refers to the control of Neophytes and Neozoa using technical or chemical measures. In contrast to such measures the immigration of not-indigenous species as the result of self-regulation should be tolerated. In this case, observations would be an indication of biotic adaptation to climate change, which should be welcomed, even if the result is an often-painful compulsion to abandon economic profit.

Why it is Urgent to take a Proactive Attitude towards Protecting the Existing Natural Forests

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Much of what we know today about forests was already known to our ancestors in the distant past. Forests are sources of food and medicine; they provide wood for building and heating homes and oxygen to breathe. Modern people should understand these forest functions equally well since they are part of our economy and commerce. However, with the development of science, people received fundamentally new and extremely important information about the forest. This new information is now also gradually becoming common knowledge, but its internalization till has a long way to go.

First, it turned out that forests and other natural ecosystems impose a huge impact on the environment and climate in comparison with processes in inanimate nature. One of the first to pay close attention to this at the beginning of the last century was a Ukrainian geochemist Vladimir Vernadsky. According to Vernadsky, living organisms are a “huge geological force” (or indeed “the geological force”) that determines the conditions of their existence in the biosphere (Vernadsky 1998).

Estimates of life’s huge environmental impact first outlined by Vernadsky were later confirmed by international scientific teams using modern methods of studying the Earth, including satellite data. For example, it was found that terrestrial ecosystems, mostly forests, are responsible for the major part of evaporation on land (Jasechko et al. 2013)[14]. Total solar power used by terrestrial vegetation for evapotranspiration exceeds the power of modern civilization by more than a hundred times (Gorshkov 1995).

In the general case, a huge impact can be constructive or destructive, stabilizing or destabilizing. However, it was found that natural ecosystems interact with their environment in a non-random way. A Russian theoretical physicist Victor Gorshkov analyzed the available multidisciplinary evidence related to the life-environment interaction (from geochemistry to genetics and ecology) and concluded that they have only one non-controversial explanation: the biotic regulation of the environment. Natural ecosystems regulate the environment maintaining it in a state favorable for life (Gorshkov 1995).

The opposing processes of synthesis and decomposition of organic matter serve as the two levers of biotic regulation. Plants synthesize organic matter; all the other organisms (bacteria, fungi, animals) decompose it. Owing to the huge global power of these processes, even a small imbalance between the rates of biochemical synthesis and decomposition could have destroyed life-compatible conditions on Earth in a very short time. For example, the store of inorganic carbon (carbon dioxide) in the

[14] In the process of photosynthesis, the stomata of green leaves open to pick up carbon dioxide from the atmosphere. While the stomata are open, water vapor evaporates into the atmosphere from the internal wet milieu of the leaf. This process is called evapotranspiration. Per each molecule of carbon dioxide fixed, several hundred water molecules evaporate.

atmosphere, which is of the order of 1000 Gigaton C (1 Gigaton is equal to one billion tons), could have been changed by the biota by 100% in just ten years, because the rate of global synthesis and decomposition is of the order of 100 Gigaton C per year.

However, the atmospheric CO_2 concentration has retained its order of magnitude over tens and hundreds of millions of years! This means that natural ecosystems can maintain this concentration in a suitable for-life state compensating for deviations from the optimum. In other words, to keep the atmospheric composition stable, the synthesis and decomposition of organic matter must be strictly controlled by the natural biota.

Gorshkov (1995) made a crucial inference that, if the biota is monitoring and synchronizing powerful biogeochemical fluxes in the short term, then it must be exerting a strong compensatory reaction on the modern anthropogenic disturbance of the global carbon cycle. This conclusion is distinct from the implications of the Gaia hypothesis, which implied that the stabilizing biotic impacts are pronounced on a geological timescale and could be "extremely slow compared with current human concerns" (Lovelock 1986). The Gaia hypothesis recognized that the destruction of (some) natural ecosystems could impair planetary homeostasis. However, it did not recognize that the remaining natural ecosystems exert a strong compensatory response to anthropogenic environmental perturbations. Neglecting this response gives rise to a misleading conclusion that some ecosystems, like boreal forests, may not be indispensable for planetary wellbeing.

The biotic regulation concept draws a fundamental distinction between ecosystems that retain their climate-regulating function and those that have been disturbed beyond their sustainability threshold and have lost their climate-regulating capacity. This distinction has enabled Gorshkov (1995) to solve the so-called "missing sink" enigma long before this solution was recognized in the mainstream literature (Popkin 2015). The conventional view in ecology had been that natural ecosystems function on the basis of closed biogeochemical cycles (Odum 1969) and can only increase their productivity if the concentration of a limiting nutrient increases. Since terrestrial ecosystems are known to be limited by nitrogen and phosphorus (this knowledge comes from agriculture), no one could have expected that undisturbed forests could increase their productivity and ensure a CO_2 sink in response to the rising CO_2 concentrations. Why should they? How could they, if there is no matching rise in nitrogen and phosphorus? Finally, even if there were an increase in synthesis, why would not there be a matching increase in the decomposition – especially as the soils are warming and metabolic rates of bacteria and fungi increase?

Therefore, when atmospheric measurements became sufficiently precise to enable an accurate assessment of the global carbon cycle, and it was found that the known sources and sinks do not match, and there was a large missing sink of an unknown nature, there has been a persistent resistance from the ecological and Earth Science communities to ultimately admitting that this sink is mostly ensured by natural forests (Popkin 2015; Makarieva et al. 2023a).

Within the biotic regulation, this response was straightforwardly predictable. Natural ecosystems must react to the excessive atmospheric carbon by removing it from the atmosphere and storing it in an inactive organic form. As there is no comparable increase in nitrogen and phosphorus, the excessive carbon should be removed as carbohydrates that do not contain nitrogen and phosphorus (Gorshkov 1986). But only those ecosystems that remain sufficiently intact (least disturbed) should be able to perform such a stabilizing response. Other ecosystems like arable lands should be a source of carbon as their regulatory mechanism has been broken. This is exactly what the changes in the global carbon cycle look like: there is a sink ensured by relatively intact forests (and oceanic ecosystems) and a source from land use and net deforestation (Gorshkov 1995).

Therefore, one can view the anthropogenic disturbance of the global carbon cycle as a planetary-scale experiment that has confirmed the biotic regulation predictions. This has been a very costly experiment for our planet. Its results should be thought through very seriously and practical conclusions made. Carbon is a major life-important environmental constituent, but it is not the only one. Water is a key factor enabling life on land. Thus, as they have been able to regulate carbon, natural terrestrial ecosystems should also be able to regulate the water cycle. This regulation has two aspects: one is the regulation of the cloud cover and another is the regulation of the atmospheric moisture transport.

Recent research has revealed that natural forests possess a strong capacity to modify the cloud cover and moisture transport and stabilize the water cycle (e.g., O'Connor et al. 2021; Cerasoli et al. 2021; Duveiller et al. 2021; Makarieva et al. 2023b). We now know, as did Vernadsky in the beginning of the twentieth century that ecosystems do impose a huge impact on the Earth's cloud cover and atmospheric circulation – i.e., those very factors that are recognized as the biggest source of uncertainty in the current climate models (Zelinka et al. 2020). It will take more time until the stabilizing nature of these impacts will be demonstrated in precise quantitative terms as it has been demonstrated for the carbon cycle. We can wait until the corresponding publications reach a critical mass to apply for a paradigm shift, while natural forests will continue to be destroyed. Alternatively, we can use the results of the "global carbon experiment" and make the logical inference that the natural forests must have evolved a stabilizing impact on the water aspects of climate as they have evolved it for carbon – and then take urgent measures to preserve these efficient climate regulators. This will require, in the words of Nassim Nicholas Taleb (2007), "intellect, courage, vision, and perseverance".

As soon as we stand on the position that natural forests have evolved to regulate climate, we immediately recognize that this climate-regulating capacity cannot be maximized alongside commercial uses. Why? Maximum wood production is not compatible with the complex natural selection criteria under which the life-supporting forest-climate homeostasis evolved. Beyond a critical disturbance, level, forests become unable to stabilize climate and bring water on land and to terrestrial ecosystems via the biotic pump. Plantations and forests disturbed by logging are more prone to fire and contribute to landscape drying, not wetting (Laurance & Useche 2009; Bradley et al. 2016; Oliveira et al. 2021; Lindenmayer et al. 2022; Wolf et al. 2023).

A specific and sufficient network of intact natural forests must be exempted from ongoing exploitation to prioritize their evolved climate-regulating function and bring water to land at large There is irreplaceable value in forests that still possess their climate-regulating capacity (now, or in the relatively near future). Natural forests fully restore their climate-regulating function during ecological succession, which takes more than a century (i.e. several lifespans of tree species). In the current climate emergency, losing existing natural forests' climate regulation is irrevocable.

Artistic visualization of a natural tropical rainforest
(unknown author)

Self-grown forests with substantial time since the last large-scale disturbance (old and old-growth forests) are primary targets for climate-stabilizing conservation while protecting other key values (proforestation, Moomaw et al. 2019). Regional, national, and international cooperation is required to preserve our well-being and the common planetary legacy of existing climate-regulating forests. Clear and unbiased interdisciplinary collaboration is needed to identify resource-production areas vs. old-growth and climate-regulating networks (Makarieva, Nefiodov & Masino 2023).

While fundamental science is being advanced, the precautionary principle should be strictly applied. Any control system increases its feedback as the perturbation grows. Therefore, as the climate destabilization deepens, the remaining natural ecosystems should be exerting an ever-increasing compensatory impact per unit area. In other words, the global climate price of losing a hectare of natural forest grows as the climate situation worsens. We call for an urgent global moratorium on the exploitation of the remaining natural ecosystems.

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Discussion

Comment by Erica Gies, USA, science journalist: I find it difficult to explain how intact ecosystems have an overwhelming impact on climate. It would be helpful for policy makers if there was a way to quantify not only the carbon dioxide equivalent stored in ecosystems, but also the impact on climate through cooling of plants and soils, the water cycle, etc. I realize that this is an emerging science - that's what my article in Nature Water is about. But I wonder if Anastassia or anyone else can point to a more comprehensive source?

One general data point is that about 20 percent of current greenhouse gas emissions come from land use change. So, from deforestation, tillage, etc., which release stored carbon.

In terms of sequestration in natural ecosystems, some studies show that mangroves in Indonesia store three times more carbon than the Amazon forests or something like that. But is there a global accounting of the total storage capacity? Or the ability of restored ecosystems to store carbon (as opposed to expensive, unproven technologies)?

Is there a way to quantify the positive impact of the water cycle on the climate and compare it to these carbon balances?

Answer of Anastassia Makarieva: It would be helpful for science communicators and policy makers to have a source of systematic evidence, e.g. that primary forests are more resilient to drought than secondary forests, that native vegetation prevents devastating fires and produces cooling clouds, that intact forests warm less than non-intact forests in global warming, and so on.

But for such evidence to become part of the peer-reviewed scientific literature, a paradigm shift is needed. And this is not about CO_2. It's about how modern science views the interaction between life and the environment. The current paradigm, which relies on adaptation and limitation as key concepts, does not overlook such evidence, but actively resists it, so it remains scattered. (A striking example of such a contradiction, the "Odum Paradox.")

James Lovelock, who proposed Gaia, had a holistic view thanks to his space studies and the ability to see our planet as a whole. Victor Gorshkov, who formulated the concept of biotic regulation, had a comprehensive view of a physics theorist who spent years in the Russian wilderness. Richard Dawkins, one of the most visible opponents of the idea that intact ecosystems regulate climate, is an evolutionary biologist.

Modern evolutionary biology, which is based on "survival of the fittest", is hostile to the environment. Survival of the fittest" is not a tautology, as it may seem ("the fittest is the one who survives"). It contains a very strong statement: there is always someone ("the strongest") who survives! If you postulate survival, you no longer need to worry about environmental destruction. A certain compatibility with life is axiomatized.

Modern ecology is based on the principle of limitation, which sees life as limited by external conditions. This false but deeply rooted view goes back historically to early human observations made in agricultural ecosystems. Agricultural systems are limited by fertilizers. Natural ecosystems are not; they create and maintain their own optimal environment.

In a mental institution, it is not possible to study how a healthy human psyche function. Nor is it possible to assess the value of natural ecosystems in a disturbed environment.

The problem of people viewing life through the skewed mirror of our disturbed environment and damaged ecosystems is compounded by the fact that intact ecosystems are rapidly being lost - further reducing the chance that we will ultimately understand and utilize their importance. As I mentioned earlier, a strong and conscious intellectual effort is needed to counteract these dangerous trends.

Intact ecosystems stabilize the climate. The more we disturb them, the more unstable the climate we have becomes.

Not everything that is green is the same. Like an angry genie let out of the bottle, a disturbed but very productive biological system can destroy the environment very quickly.

Question of Peter Wilderer: The connections Anastassia Makarieva makes in her chapter relate primarily to deciduous forests. How do the processes in forest ecosystems characterized by deciduous trees differ from those in which conifers dominate? Is the "biotic pump" concept limited only to deciduous forests, or do spruce forests, for example, have a comparable importance for the water cycle?

Answer of Anastassia Makarieva: The main difference in the biotic pump function is not between deciduous and evergreen forests, but between disturbed and undisturbed forests. In the boreal zone, the primary forest can be dominated by evergreen trees such as spruce and fir. These natural forests provide the most active biotic pump and ensure a steady flow of moisture. Especially in spring, with the first warm days, the evergreen forest can start evapotranspiration and switch on the biotic pump transport. The influx of cool, moist air masses from the Atlantic ensures a smooth transition between the seasons. When the primary forest is cut down, ecological succession sets in, dominated by deciduous trees such as birch or aspen. In spring, these trees do not yet have leaves and cannot transpire. This leads to additional warming of the soil, resulting in various weather extremes.

Experiences from Practice
and Suggestions for an Innovative Approach

Progressive Thinking in Economics

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Initial situation

All scientific disciplines are characterized by continuous development with different dynamics. This is true for the social sciences (including economics), the engineering sciences, the natural sciences, the humanities as well as for other sciences. In this context, one often speaks of scientific progress, which can be seen, for example, in the diverse sub-disciplines of economics. However, controversies arose in various scientific disciplines. The question of the "right direction or quality of progress" was at stake. Controversies of this kind occurred several times in economics, for example. These were not only the major controversies such as "bourgeois economics versus Marxism," but also, for example, the controversy that arose in the 1970s: monetarism versus Keynesianism. Accordingly, there were different assessments in the economic sciences with regard to progress but also with regard to an economic equilibrium.

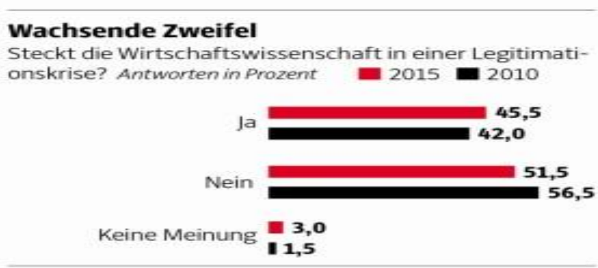
If we look at the current discussion in the context of economics, we can also observe different currents today, which lead to different assessments of economic progress. Without claiming to be exhaustive, there are various examples of this. On the one hand, there are representatives who evaluate the economic mainstream positively overall and thus consider only a few "corrections" to be necessary. In this case, progress in economic science is viewed positively overall. On the other hand, the manifold economically relevant crises of the last decades have led a growing number of representatives of economics to question whether economics is in a crisis, or whether it has even failed. The discussion has been particularly intensified by the global financial and economic crises, but also by the worsening climate crisis. In this context, the book by Lesch and Kamphausen entitled "Die Menschheit schafft sich ab (Mankind abolishes itself)”. The Earth gripped by the Anthropocene" (original title: "Mankind aborts itself. The Earth gripped by the Anthropocene") attracted a great deal of attention. This raises the question of whether or to what extent one can still speak of economic progress.

The belief in progress is crumbling

As a result, the contribution of modern economics to explaining economic processes and solving challenges has been increasingly questioned in the recent past. This has given rise to considerations, both among students of economics, for a reorientation of the content of economics. Students in many countries, for example, increasingly articulated their discomfort with mainstream economics curricula. In some cases, they have joined together to form initiatives. In Germany, for example, the "Network Plural Economy" should be mentioned. The criticism is mainly directed against neoclassical economics as the dominant paradigm in economics, which shapes our daily lives in many ways.

In 2015, a survey of members of the Verein für Socialpolitik/Germany was conducted as part of "New Thinking". The target group consisted of economists from Germany, Austria and Switzerland in academia and practice who had at least a PhD. It became clear that there was a growing unease among many economists about their own discipline. While 51.5% of the economists surveyed denied that economics is in a crisis of legitimacy, 45.5% acknowledged that it is. What is striking here, as can be seen from the chart, is that in the period from 2010-2015, the proportion of those in favor increased from 42.0% to 45.5% and, correspondingly, the proportion of those denying that there is a crisis of legitimacy decreased from 56.5 to 51.5.

Survey of economists on the legitimacy crisis of the economy



Survey of economists on the legitimacy crisis of economics.

Source: Lisa Bucher 2015

The new paradigm of economics

For a long time, it remained hidden in economics that in 1992, at the conference in Rio de Janeiro, the community of nations agreed on a completely new paradigm for the 21st century, sustainable development. It contrasts with the neoclassical ecology in that the three dimensions of ecology, economy and social affairs are to be brought together in a balanced way. This requires a completely new way of thinking about progress, in which economic and social processes have to be arranged or subordinated within the framework of the ecological planks. In the long run, man is not viable if nature is continuously overexploited, whereas nature is already overexploited in many areas. Therefore, economic and social fields of action alone cannot be sustainable. Therefore, the international community has decided that all member nations of the United Nations have to develop a national sustainability strategy in accordance with the 2030 Agenda by 2015 and implement it in a consistent transformation process by 2030.

This challenge has been taken up by some countries. In these countries, for example, there are research institutes for sustainability, universities that are increasingly addressing the topic in their teaching and research, and companies that are taking on the challenges of sustainable development. There are also approaches to implementing sustainable development in politics in some countries. Nevertheless, there is still great potential in education, research, politics and business in these countries as well within the framework of a sustainable transformation process. In contrast, most nations are still largely at the beginning of the transformation process. As a result, we are forcing future generations to face worsening crises that will have a devastating impact on their living conditions and quality of life. Mankind has not yet recognized the challenges of sustainable progress-thinking in the necessary scope and urgency or refuses to do so.

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Discussion

Question of Ortwin Renn: How can the schools of institutional economics, evolutionary economics and ecological economics be categorized here?

Answer of Michael von Hauff: **The school of Institutional Economics** teaches that institutions are rules of the game that structure economic or social action. Their main purpose is to reduce uncertainty in economic processes and in the social context by providing a stable order in daily life. Therefore, institutions are "... any kind of constraint ... for organizing human interactions." (North1992. p.4, one of the founders of institutional economics). The contribution of institutional economics to sustainable development is to define restrictions in the sense of limits, for example through ecological guard rails, but also scope for action. However, institutional economics in this sense has not yet been sufficiently introduced into the paradigm of sustainable development.

The school of Evolutionary Economics teaches: evolutionary economics, which is based on the Austrian economist Schumpeter, is to be classified in contrast to neoclassical economics or theory. This field of economic research emerged in the 1980s and deals with the role of knowledge, its change and its limitations for the economy. With its focus on technology, learning and institutional contexts, evolutionary economics has connections to social science technology research. There are intersections with sustainable development in this context, but these need to be worked out more clearly.

School of Ecological Economics: Ecological economics was introduced by the work of Nikolas Georgescu Roegen , Kenneth Boulding and William Kapp in the mid-1970s. So far, however, there is no unified school or coherent body of theory. It stands in stark contrast to neoclassical economics and also emerged in this context. A key point of agreement with sustainable development is the realization that humans cannot survive without stable ecological systems. The existence of economic activity and social processes is only possible within the framework of nature and its limits. However, there is a difference in that ecological economics neglects the social dimension of sustainable development. For a long time, representatives of ecological economics strictly rejected economic growth. However, both disciplines are now beginning to discuss "sustainable growth".

Contribution of the Building Sector to the Preservation of the Functionality of the Earth System

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Director of the Oskar von Miller Forum

Preliminary remarks

To understand and define the ecological impacts of human activities and the carrying capacity limits of our biosphere, the concept of planetary boundaries was proposed in 2009 by a group of internationally renowned Earth System and environmental scientists under the leadership of Johan Rockström [1], then director of the Stockholm Resilience Centre.

These planetary boundaries include (1) climate change, (2) biosphere integrity and biodiversity conservation, (3) stratospheric ozone depletion, (4) atmospheric aerosol loading, (5) ocean acidification, (6) biogeochemical cycles (nitrogen and phosphorus), (7) freshwater use, (8) land use change (e.g. deforestation), (9) inputs of man-made substances, chemicals, and radioactive particles. The crossing of each of the boundaries threatens the stability of the earth's ecosystem and thus the basis of our existence.

Since 2009, the database has been expanded and deepened. According to the latest published state of research in this area [2], human activities currently exceed six of nine ecological stress limits or thresholds. This is evidenced by the sharp (1) decline in biodiversity, the continuing increase in (2) input of man-made substances, the ongoing (3) emission of greenhouse gases, the growing (4) input of nitrogen and phosphorus, the continuing (5) change in land use, and the excessive increase in (6) freshwater use, posing a serious threat to the continued existence of humanity [3].

The role of civil engineering in stabilizing the ecological balance

Because the ecological stress limits have been exceeded, the building industry is strongly called upon to make a comprehensive contribution to stabilizing the ecological balance. This is especially true for the critical areas mentioned, such as greenhouse gas emissions, biodiversity decline, the input of man-made substances, the input of nitrogen and phosphorus, land use change and water use.

<u>Greenhouse gases</u>

In 2021, construction accounted for 34% of total global energy consumption and 37% [4] of energy- and process-related CO_2 emissions. Given the continuing increase in the world's population and the expectations in emerging countries about a better standard of living, the measures taken to date to fundamentally minimize CO_2 emissions and to achieve climate neutrality [5] enshrined in the European Green Deal are not considered sufficient to minimize global CO_2 emissions comprehensively. This becomes even more critical in the coming decades, as studies have shown that the global building stock will double by 2060 concerning all floor areas existing in 2017 [6].

The path to CO_2 neutrality as set out in the European Green Deal is highly relevant. Achieving fundamental decarbonization of all sectors of the economy and society requires clarifying the scope and speed of implementing the necessary measures. At the same time, the strategies for the implementation of EU measures for comprehensive decarbonization have to be simultaneously applied on a global level to achieve the necessary, fundamental reduction of greenhouse gas emissions.

The implementation of relevant sustainability strategies, such as the complete conversion of the energy supply to the use of renewable energies and the comprehensive use of renewable raw materials, as well as the transformation of our economy to circularity as a core principle, are of crucial importance here, both in the construction sector as well as in all other economic sectors.

Biodiversity and land use change

The construction of buildings with associated areas for development, mobility, recreation and infrastructure currently causes land consumption of around 55 hectares per day in Germany [7]. This results in the progressive destruction and fragmentation of habitats for plants and animals. Given the continuing increase in per capita land requirements for housing, it is necessary to ask how the principle of frugal use of land as a resource can be communicated in social terms. Given the strong global increase in the demand for land for construction, this question must also be asked on a global scale, following the principle of sufficiency [8]. To this end, responsible urban planning and design can help to prevent urban sprawl and preserve and expand green spaces to promote biodiversity and protect ecosystems, especially in urban environments. The comprehensive consideration and implementation of green infrastructure in urban planning has the potential to create habitats for plants and wildlife and to contribute to urban biodiversity [9], [10].

Input of man-made materials and resource use

Materials used in the building sector, such as concrete, steel, aluminum and glass, currently (2022) account for about 9% of total energy-related CO_2 emissions. In addition, around 100 billion tons of waste are generated worldwide by construction, renovation and demolition activities. 35% of this ends up as waste in landfills. According to current forecasts, raw material consumption in construction will double on a global level by 2060, with corresponding consequences for raw material demand and manufacturing-related greenhouse gas emissions [11|. In addition, the use of chemicals in the construction industry must be fundamentally questioned to reduce the input of harmful chemicals, such as volatile organic compounds (VOCs), as much as possible.

Given these daunting challenges, the application of fundamentally sustainable construction practices is imperative. Therefore, sustainable building has to be based on the following fundamental principles:

Sufficiency: Clarifying how much of a particular good is needed in terms of frugality. The goal is to minimize the use of resources such as soil, water, materials, energy, etc..

Consistency: Extensive use of renewable energies, renewable raw materials and implementation of closed material cycles. The goal is to prevent the exploitation and use of non-renewable resources and to avoid negative environmental impacts such as greenhouse gas emissions and waste.

Efficiency: Minimization of renewable as well as non-renewable resource consumption to minimize effort, costs, resource depletion and negative environmental impacts.

These basic principles must be examined in terms of their feasibility in the early stages of planning construction activities in order to anchor and implement the corresponding sustainability goals in cooperation with all stakeholders in the planning process.

Water use and nitrogen and phosphorus flows

Global freshwater use has increased six-fold over the past 100 years and has been steadily increasing by about 1%/year since 1980. Agricultural use accounts for about 69%, industrial production and energy generation for about 19%, and municipalities for about 12% [12]. It can be assumed that the demand for freshwater will continue to increase strongly until 2100 due to the further growth in the world population [13], which will also increase the existing global challenges such as unevenly distributed availability and, in part, poor quality [14].

In terms of construction, a much more efficient use of freshwater through the extensive use of water-saving technologies and the use of rainwater and greywater to reduce the demand for water in toilet flushing and for the irrigation of green spaces is therefore of crucial importance. This also applies to unsealing open spaces and implementing separate drainage of wastewater and stormwater to help conserve local freshwater resources through an on-site infiltration of stormwater.

About the urgent need to avoid the release of excess nitrogen and phosphorus into ecosystems (eutrophication), attention has to be given to appropriate wastewater treatment. This also applies to the avoidance of the input of micropollutants and microplastics [15].

Life cycle-based life cycle assessment to evaluate environmental impacts

To implement the sustainability goals in all phases of the life span of buildings, it is necessary to be able to assess the environmental impacts of alternative planning concepts at the early stages of the planning process. In this context, the life cycle assessment method [16] offers a way to determine and assess the environmental impacts of buildings over their entire life cycle. This involves determining all the environmental impacts that arise from the production, use, operation, dismantling and disposal of a building, as well as from all upstream and downstream processes. An essential component for the preparation of a life cycle assessment [17] is the building material-related Environmental Products Declaration (EPD) [18], [19].

The EPDs contain, among other aspects, core indicators for the environmental impact and parameters for describing the use of resources and other environmental information.

Indicators for assessing environmental impact

- Global warming potential fossil (GWP-fossil)
- Stratospheric ozone depletion potential (ODP)
- Acidification potential, cumulative exceedance (AP)
- Global warming potential biogenic (GWP-biogenic)
- Potential for formation of tropospheric ozone (POCP)
- Potential for depletion of abiotic resources non-fossil resources (ADPE)
- Eutrophication potential freshwater (EP-freshwater)
- Global warming potential luluc (GWP-luluc)
- Eutrophication potential saltwater (EP-marine)
- Water withdrawal potential (WDP)
- Eutrophication potential land (EP-terrestrial)
- Global warming potential-total (GWP-total)
- Abiotic depletion potential fossil fuel (ADPF)

Parameters Resource use and other environmental information

- Renewable primary energy as an energy source (PERE)
- Renewable primary energy for material use (PERM)
- Total renewable primary energy (PERT)
- Non-renewable primary energy as an energy carrier (PENRE)
- Non-renewable primary energy for material use (PENRM)
- Total non-renewable primary energy (PENRT)

- Total renewable primary energy (PERT)
- Use of secondary materials (SM)
- Renewable secondary fuels (RSF)
- Non-renewable secondary fuels (NRSF)
- Use of freshwater resources (FW)
- Hazardous waste to landfill (HWD)
- Non-hazardous waste to landfill (NHWD)
- Radioactive waste disposed (RWD)
- Components for reuse (CRU)
- Materials for recycling (MFR)
- Materials for energy recovery (MER)
- Exported electrical energy (EEE)
- Exported thermal energy (EET)

Additional environmental impact indicators

- Potential toxicity comparison unit for humans - non-carcinogenic effect (HTP-nc)
- Potential toxicity comparison unit for humans - carcinogenic effect (HTP-c)
- Potential human exposure effect for U235 (IRP)
- Potential incidence of disease due to particulate matter emissions (PM)
- Potential soil quality index (SQP)
- Potential toxicity comparison unit for ecosystems (ETP-fw)

Conclusions

Although complete information on all indicators is not available for all available construction materials, it is clear that we are already able to identify in construction the environmental impact indicators that contribute significantly to the current exceedance of the thresholds of the ecological stress limits of our planet.

All those involved in the construction industry are therefore called upon to consistently use existing methods, such as life cycle assessment, in all areas of the construction industry in order to identify and implement the levers and necessary measures to stabilize and maintain the functioning of the earth system.

Existing certification systems, such as the Assessment System for Sustainable Building (BNB) for public construction projects and the DGNB certification system for non-public construction projects, offer valuable approaches to demonstrably make a significant contribution to preserving biodiversity, stabilizing our climate, freshwater and land use, minimizing the input of nitrogen and phosphorus as well as artificially produced substances and limiting the progressive pollution of our environment and exploitation of resources.

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Discussion

Comments of Peter Wilderer: How do proposals such as "Sponge City" fit into the concept of sustainable urban planning and urban infrastructure?

Could the implementation of such proposals be categorized as the equivalent of biotic self-regulation?

Answer from Werner Lang: In view of the increasing frequency of heavy rainfall events, the aim of the sponge city concept is to help ensure that rainwater can be temporarily stored and infiltrated with a time delay. In this way, the risk of flooding is to be reduced and the groundwater level stabilized. Key measures to achieve these goals include unsealing surfaces and increasing the proportion of green spaces in cities, which, in addition to providing ecosystem services such as shading and evaporative cooling through plants, leads to an increase in biodiversity. The effective interplay of green and blue infrastructure in the city creates spatially limited, largely self-regulating biotic systems that make a very valuable contribution to the implementation of sustainable cities, both in socio-cultural and ecological terms.

Sustainable management of rainwater runoff in sealed areas

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Infiltration of precipitation

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Humans significantly impact the earth's natural habitat due to their habit of living sheltered in houses and apartments. Through the construction of housing and the associated infrastructure, such as roads, squares, etc., more and more natural areas are being sealed with impermeable materials such as asphalt, concrete, or bricks. This is associated with a disturbance of the local natural water balance, which consists of evaporation, infiltration, and runoff of natural rain. Evaporation and infiltration are the most important factors in most areas. For evaporation, it is essential that rainwater is temporarily stored in soils and plants and then evaporated or evapotranspired, as it happens naturally.

However, due to the growing population and demographic changes, the need for more living space is increasing, particularly in large cities and megacities, and with it, the pressure to increase or densify the already often cramped urban space to meet social challenges. For a long time, sustainability was not a priority. Until now, the focus in planning neighborhoods has been on living space. Architectural competitions have only addressed the issue of rainwater management in a very rudimentary way. In the future, it will therefore be important that all stakeholders from the fields of architecture, open space planning, landscape architecture, and urban water management work with the authorities and the people affected to develop a sustainable solution from the outset.

With the realization that climate change is already shaping our lives now and, in the future, a rethink towards sustainability is slowly taking place. However, despite the beginning of this rethink, implementing sustainable development will still take some time, mainly because old structures have to be broken up and changed. It may be too late to avert human and monetary damage.

The consequences of climate change are heavy rainfall, prolonged periods of rain, and drought. In densely built-up and sealed urban areas, rainwater can no longer be stored and infiltrated due to the sealing of natural surfaces with traffic areas and roofs, and there need to be more plants that promote evapotranspiration. In the event of heavy rainfall or prolonged rainfall, the sewer system cannot absorb all the rainwater runoff. Flooding occurs and the amount of damage increases. The prevention of infiltration also interrupts natural groundwater recharge and thus jeopardizes the drinking water supply. However, if it rains too little, i.e., if there are droughts, the lack of vegetation in heavily sealed urban areas means there is no possibility of air conditioning through evaporative cooling. As there are often few or no trees, sealed surfaces such as asphalt roads also heat up due to the unhindered solar radiation, hurting the urban climate. Dense development can lead to urban heat islands, especially without fresh air corridors.

Economic considerations often drive building projects. Housing should be affordable and investors want the highest possible profit margin. In the future, this must not be the driver of housing construction; the pure profit motive must take a back seat.

Proposals for achieving sustainable resilience in technical solutions.

From a water management perspective, ecology, economic, and social challenges can be brought together by planning and implementing water-conscious residential development. It has been shown that the targeted introduction of elements of the water-conscious city, such as green roofs, façade greening, above-ground infiltration systems, wet biotopes, rainwater storage and utilization systems, water-permeable surface coverings, and multifunctional areas can make an essential contribution to maintaining the natural water balance, despite the increase in living space.

Green roofs instead of conventional gravel flat roofs or tiled roofs, for example, can significantly reduce rainwater runoff despite the area remaining the same. For example, replacing an existing gravel flat roof with a green roof can help to restore the natural water balance. Remaining precipitation runoff can be stored and used for irrigation in dry periods or seeped away in a targeted manner. Foresighted water balance modeling and adapting buildings to the natural water balance on-site play an important role here.

Façade greening not only helps to increase evaporation and thus urban air conditioning, it also helps to shade buildings and thus reduce energy costs for air conditioning.

Multifunctional areas primarily function as parks, sports grounds, playgrounds, etc. In the event of heavy rainfall, they can take on the function of storage when the drainage system floods and thus protect the settlement from damage.

Synergies can arise between establishing planting in the settlement and managing rainwater runoff from sealed surfaces. For example, infiltration swales can now be planted with grasses, perennials, shrubs, and woody plants, including trees [DWA-A 138-1, 2023]. This was not the case in former times, when infiltration swales were just planted with grass seeds. Establishing biodiverse planting is now possible through cooperation with people working in green and urban planning, as well as through scientific studies. This increases the acceptance of the infiltration systems in densely populated areas and means no more land is "wasted". The biodiverse planting pattern contributes to the well-being of people in the settlement, increases evaporative cooling and insect diversity can also be increased. Nevertheless, the main task of the infiltration swales remains the drainage function and, thus, groundwater recharge.

Trees play an essential role in maintaining the local water balance in the settlement [Berland et al., 2017], but space for species-appropriate planting pits is limited in dense development. They are often built into a sealed surface and have an insufficient water supply. Under certain circumstances, the irrigation is still sufficient for a young, 10-year-old tree. As it develops over the years, the root area increases and needs more water. However, the optimal evaporation performance of the tree can only be guaranteed if sufficient water is available [Franceschi et al. 2023]. The targeted use of rainwater runoff from sealed surfaces can ensure optimal irrigation in the long term. In this context, the pollutants from such runoff must be removed beforehand to protect the tree and not endanger the groundwater into which unused water can seep. Therefore, interdisciplinary thinking is also required here.

The bottom line is that sustainable rainwater management can contribute to reconciling ecology, economy, and social challenges. In this context, all those involved in urban development planning must pull together from the outset. The initial question of whether biotic self-regulation can be considered a model for anthropogenic systems is indeed associated with a "yes, but". With every intervention that humans make here, based on the best of their knowledge and conscience, they intervene in nature again and change it once more.

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Discussion

Comments of Peter Wilderer: In her contribution, Brigitte Helmreich reminds us of the importance of sustainable rainwater management in the municipal environment. The climatic changes to which we are currently exposed require a departure from the method of dealing with rainwater in urban and settlement planning that has been practiced for decades.

Until now, the motto has been to collect rainwater in residential areas alone or mixed with municipal wastewater and, at best, to discharge it into a nearby watercourse after treatment.

In unpopulated areas, the water seeps away naturally and helps to stabilize the groundwater table. Extensive pumping of groundwater in the settlement area and in the adjoining agricultural areas inevitably leads to deficiency situations. Direct infiltration of rainwater within settlements could help to avoid or at least reduce such deficiency situations. The only problem is that the water running off roof surfaces and roads is contaminated with a variety of pollutants. If they are not removed before infiltration, these pollutants will accumulate in the soil and in the sediment layers below. This would result in so-called contaminated sites, which is incompatible with the maxim of sustainability. Research, development and persuasion are needed to find sustainable solutions. This closes the circle that leads to holistic anthropogenic approaches to regulation.

Thoughts and proposals for a rules-based and sustainable agriculture

Consequences of technical interventions in natural resources

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Early quantification of the external effects of land management on water, soil, climate and biodiversity is essential in order to assess the consequences of agricultural production processes. The impacts on water resources in terms of quantity and quality require special attention. Equally important is the protection of soil from erosion caused by heavy rainfall events and wind drifts as a result of climate change.

The establishment of the "Munich Agroecosystems Research Network" (FAM) was an important step for me and my department towards a comprehensive approach to land management. This was carried out by a large number of chairs and institutes of the TU Munich-Weihenstephan Campus and the GSF Neuherberg Campus over 12 years on the land of the Scheyern monastery estate. The results were published in 2005 in the book "Agriculture and the environment - a field of tension".

In the chronological sequence, the concerns of climate protection increasingly came to the fore. In this context, I had the opportunity to work on a project with a well-known climate researcher. The project was about reducing the climate impact caused by cattle. The client was a pharmaceutical company that was able to produce hormones, e.g. insulin, using genetic engineering. Another hormone, bovine somatropin (bST), was able to increase the performance of dairy cows by around 10 %. In an initial approach, this would make it possible to reduce the number of dairy cows by 10 %. This would also be associated with a considerable reduction in methane emissions. Apart from the ethical concerns of regularly injecting animals with hormones, a comprehensive analysis showed that the expected savings would not be achieved. Ultimately, unlike in the USA, this hormone was not approved in the EU.

More recently, we have been dealing with another challenge at the Chair, namely the preservation and promotion of biodiversity. Over the past 70 years, plots of land in Germany have been enlarged to enable sensible cultivation with machinery. The state has promoted "land consolidation". In addition, farms became more specialized. As a result, structural elements (hedges and copses) have disappeared, fields have been significantly enlarged and more of some crops (e.g. maize) have been cultivated. All of this is at the expense of biodiversity. It also increases the risk of erosion. The challenge now is to focus on protecting natural resources and the climate at the same time.

We must recognize that the protection of resources is multifunctional. That is the current challenge. In this context, it should be pointed out that agriculture plays a threefold role, namely as a polluter, as an affected party and as a protector, e.g. through increased carbon storage. Once again, it is a question of resolving conflicting objectives in terms of sustainable development, i.e. a compromise between ecology, economy and social issues.

How land is currently managed in practice cannot be described as sustainable. This was also the conclusion reached three years ago by a "Future Commission on Agriculture" set up by the then German Chancellor Angelika Merkel. The interdisciplinary commission voted unanimously in favor of increasing the resilience of agriculture.

The two main points of criticism that were highlighted and justified during the Commission's deliberations relate to the EU's funding policy and the external costs caused by agriculture. The expansion of organic farming called for by some groups cannot be seen as a comprehensive solution, even though organic farming has clear advantages in terms of resource conservation. However, this is offset by lower yields and higher costs. The aim must be to make conventional agriculture more resource-efficient so that ultimately significantly fewer external costs are incurred.

Significant improvements must also be achieved in the area of animal welfare. Success in this endeavor will also result in higher food prices. Consumer demand will also have to change.

The EU's subsidy policy will continue to play an important role in the future. The current approach of a single area payment linked to environmental requirements has been described as inefficient in scientific circles for many years. In 2018, the ECA found that the then pending reform of the Common Agricultural Policy (CAP) did not meet its own objectives. Nevertheless, a fundamental reform was not carried out again. The next reform is due in 2027.

I can fully endorse the ZKL's recommendations on the 2027 CAP reform, which read: "*In particular, the Common Agricultural Policy (CAP) must therefore make a significant contribution to managing the transition to a sustainable food system in the EU and to enabling farmers to make their indispensable contribution to achieving climate protection, animal welfare, soil protection, air and water pollution control and biodiversity targets and to comprehensively protecting the environment. This requires that the current area-based direct payments from the first pillar of the CAP are gradually and completely converted over the next two funding periods into payments that make concrete services in line with social objectives economically attractive*". These recommendations also fit well with the Green Deal adopted by the EU.

A second approach is to avoid the external costs arising from agriculture, as the elimination of negative externalities costs much more money than the avoidance of negative externalities. A common demand in environmental economics is that negative externalities must be internalized. The instruments available for this are based on the polluter-pays principle, i.e. polluters are required to comply with a certain level of resource protection. The market mechanism then ensures that the polluters seek the most cost-effective way by using the technical possibilities. Ultimately, the additional costs are passed on to the price. There are limits to this approach if, with open borders, products that are not burdened with these costs come onto the market or if it is considered that the higher costs cannot be imposed on the population in the form of higher prices. In this context, state payments could be granted for the avoidance of environmental pollution. A correspondingly reformed CAP would provide for payments for services that go beyond the legally stipulated level; in simple terms, these would be payments for services of general interest. The public service principle would apply here.

Progress of Regulation in Modern Agriculture

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As the world's population has grown, more and more natural resources were extracted from nature to produce and supply food. Humans began using tools and energy at an early stage. Their use made it easier to work economically thanks to more advanced manual skills and at the same time produced higher and more stable yields.

The use of fossil energies and industrialized production of machinery and equipment led to an enormous increase in roductivity in arable farming, while comparable changes in livestock farming took place much later and in much smaller steps.

Almost simultaneously, chemical products in the form of mineral fertilizers and pesticides and advances in breeding enabled previously unimaginable increases in crop yields. Economically, however, increasing costs led to greater specialization, with a reduction in the diversity of machinery and a restriction to fewer crops on the farm.

Also, the additional use of electronics, sensors and automation did little to change this situation. On the contrary, as investment costs continued to rise, they caused even greater concentration in field management with a reduction in crop diversity and monocultures due to increasingly restricted crop rotations.

On the other hand, electronically controlled technologies for feeding livestock opened up the first individualized supply systems. For the first time, animals were able to decide on their own feed intake according to their needs, just as in nature.

Yield and nature - a contradiction?

From this development, which is only briefly summarized, the impression could arise that the farmer, in accordance with his task, had always oriented all measures to food supply (and profit) without regard to nature. However, this would put his actions in a false light.

It has always been an objective of all measures on the farm to maintain soil fertility in order to achieve reliable harvests in subsequent years and to provide the land in an orderly condition for future generations. And it was also a matter of course, despite many structural restrictions in animal husbandry, not to inflict suffering on the farm animals. In a compromise between animal protection from the rigors of the weather and especially the locally very cold winters with snow and frost, the daily supply had to be ensured around the year. Thus, the so-called tied-up stall for dairy cows has to be seen as a "milking barn" to realize the daily milking as an object of animal husbandry under tolerable working conditions, seasonally independent without additional effort.

At the same time, innovations and further developments were incorporated and implemented whenever operational conditions permitted. This is illustrated by two selected examples of revolutionary techniques in livestock farming and field cultivation.

Tied-up stalls become loose housing systems

With the development of the cubicle barn in the mid-20th century, the cow was given back its first, but still limited, freedom of movement within the enclosed barn. In addition, with the cubicle, the individual animal was given an individual space to accommodate its undisturbed need for rest and ruminating, as under conditions in the wild.

At the same time, the development of milking parlors made work easier for the farmer in a way that was previously unimaginable. Now, in an upright position, the twice-daily milking work required could be carried out 365 days a year. At the same time, in addition to visual animal monitoring, it was also possible to monitor performance based on the milk yield. Based on the latter, it was also possible to add the individual performance-related amount of concentrate to the cow's intake during the milking process [1, 2].

Regulating instead of battling

Since the beginning of land cultivation 12,000 years ago, the farmer has had to ensure that his crops thrive in the face of natural competition (Thorns also and thistles shall it bring forth to thee, ... , Genesis 3:18). Sowing seeds thus initiated a continuous effort to secure yields, or in other words: the farmer was forced into a permanent battle against nature and biodiversity.

Here, the definition of the "damage threshold principle" in 1957 heralded the first serious paradigm shift. Only if the expected damage due to yield reduction is greater than the effort required for plant protection measures, then control is necessary and sensible. For the first time, economic considerations and decisions led to a tolerated coexistence of crop and competitor plants [3].

However, as soon as the damage threshold was exceeded, competitor plants could then be removed manually or mechanically using a hoeing machine. In the case of fungal or insect infestation, on the other hand, the now available chemical plant protection agents with selective effects and precise application technology had to take over the regulation with fungicidal and/or insecticidal impact. As soon as selective herbicides became available, chemical pesticides could also be used to control competing plants, making comprehensive plant protection possible in purely economic terms with just one mechanization technique. This eliminated the previous labor and energy expenditure for mechanical hoeing measures. By dispensing with repeated soil opening, water and wind erosion were also eliminated and the resulting humus depletion reduced.

Precision Livestock Farming

Despite possible freedom of movement for the dairy cows in the cubicle housing system, the animal still had to subordinate itself to the daily rhythm for feeding and milking set by humans. This is changing with the development and introduction of electronic systems.

In the first approach, concentrated feed retrieval technology was developed and introduced. According to the performance, each cow now received the amount of concentrate due to her in several portions per day via an individual RFID recognition [4] in the concentrate feed dispenser. This made it possible to avoid possible rumen acidification, while at the same time allowing the cow to decide when to consume the concentrate. The fact that the amount of concentrate not consumed indicated animal health, among other things, was a valuable additional effect of this technology.

In a further step, the required amount of concentrate was then linked to milk yield and animal weight and an initial electronically controlled regulation system was set up. If the body weight changes about milk yield, the required amount of concentrate must be adjusted and/or health monitoring must be initiated while the basic feed quality remains the same [5, 6]. By 1985, the foundations for precision livestock farming had already been laid (Fig. 1).

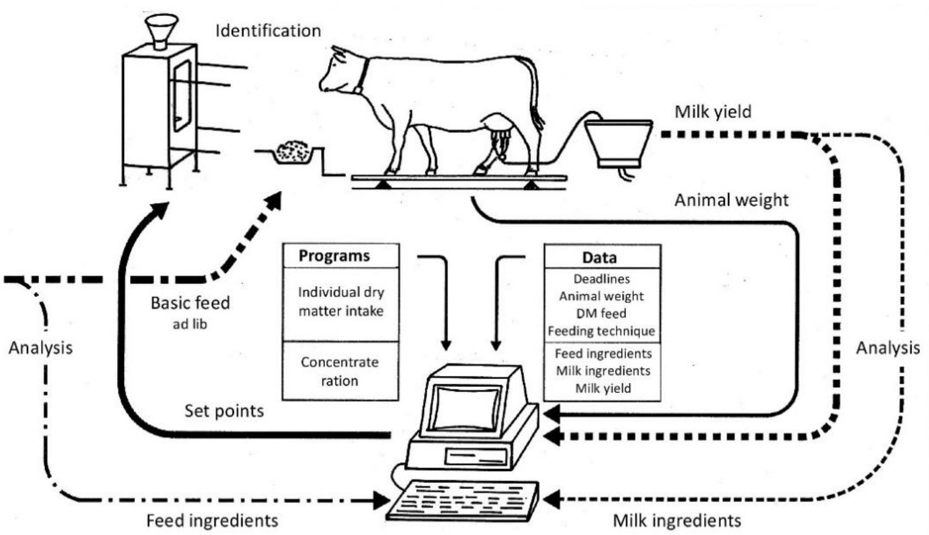

Fig. 1: Electronic control loop in precision livestock farming
(htps://mediatum.ub.tum.de/?id=1728215)

The amount of concentrated feed was linked to milk yield and animal weight and an initial electronically controlled regulation system was set up. If the body weight changes with regard to milk yield, the required amount of concentrate must be adjusted and/or health monitoring initiated while the basic feed quality remains the same [5, 6]. As early as 1985, the development of robotic milking technology meant that the cow was also able to decide on her own milk yield, thus guaranteeing individual animal behavior, as with the natural suckling process by the calves [7].

The fact that all these technologies are generating ever more and ever more precise animal-specific data opens up a wide range of new possibilities for individualized nutrient supply and health monitoring. Socially, it relieves the farmer of his previous manual routine work with new possibilities in the social environment of the family and society.

Precision Farming

Comparable to dairy farming with the yield milk output, in arable farming the yield of the cultivated crops and thus the N-fertilization as a yield generator is the most important target value of the management. It is understandable, therefore, that deficiencies visible in the growth were considered by an increased amount of nitrogen, in order to ultimately ensure a homogeneous high yield on a field plot.

Because in the manual-mechanical system a field plot represented a treatment unit, a uniform application was carried out there on the basis of the subplots with the lowest yield contained therein. In most cases, this led to overfertilization. Here also, electronics made it possible for the first time to use advanced distribution technology for fertilizers and crop protection products that were more closely adapted to natural conditions. With "plus/minus switching", it was now possible to react locally to the "greening of the plants" detected by the driver's eye [8]. If the plants were too light, the dosage was increased, if they were too dark, the dosage was reduced. In purely economic terms, it was thus possible to reduce the use of resources, while the continued pursuit of a homogeneously high yield did not yet reduce the environmental impact. However, this also allowed the ecological component to be taken into account if the driver knew from the experience of previous harvests that lower yields were always achieved in less fertile parts of the field despite high fertilization and that fertilization would therefore only cause costs and environmental pollution.

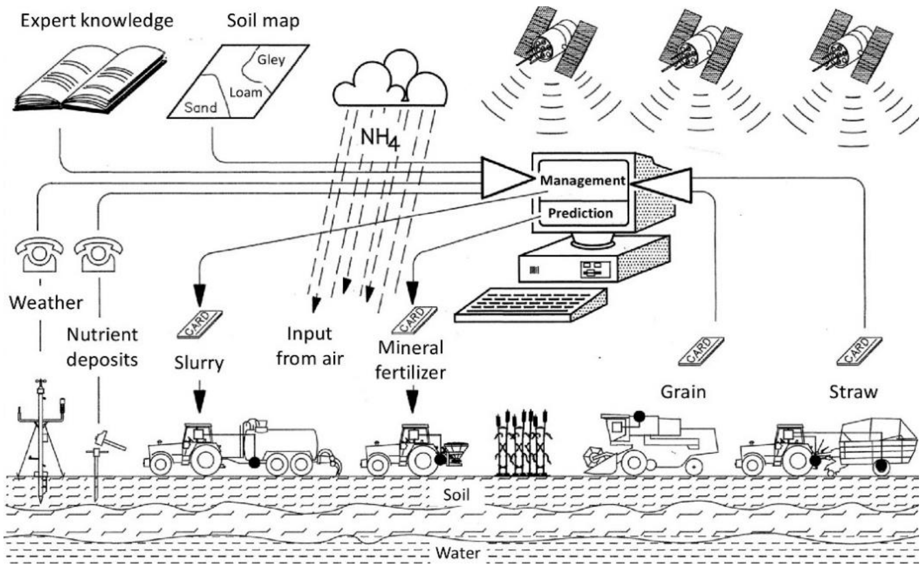

Fig. 2: Electronics in the "Environmentally oriented fertilization" control loop (htps://mediatum.ub.tum.de/?id=1728216)

And in comparison, to dairy farming, local yield determination in the combine harvester [9] provided a further building block for an ecologically oriented control loop (Fig. 2). GPS provided the location of the machine every second, while an installed yield sensor recorded the crop flow [10]. From this data, local yield maps were created for the first time, which documented the variability within parcels of land with regard to local conditions [11, 12].

In addition, near-infrared spectroscopy (NIR) was able to record the "greenness" of the plant population online during fertilization [13], which resulted in a completely new fertilization strategy in the "map overlay system" with the required application quantities derived from fertilization trials with the growth conditions recorded on site and the historical yield data [14,15, 16]. With further refined algorithms, it became possible to pursue strategies related to the individual field section in order to reduce oversupply from the past and ultimately to dose the amount of fertilizer applied in such a way that it was almost completely reflected in the resulting yield.

Ultimately, however, this yield and environment-oriented system could only be implemented because standardization of electronic communication between farm management, tractor and implement was created by Germany and some neighboring countries as early as the mid-1980s [17, 18, 19]. This globally accepted ISO standard made it possible to implement the now possible, environmentally-oriented crop management with machines from different manufacturers according to the wishes and preferences of the individual farmer. And this standard also enables the integration of additional sensors and other information, such as from satellite monitoring, refined soil analysis technologies and weather data, without any major problems.

Refined plant protection methods have also been developed based on similar approaches. There, in addition to the greenness of the plant population, great emphasis is now placed on individual plant recognition [20]. This could enable a local restriction of pesticide applications, which, based on the damage threshold principle, would result in a previously unimaginable plant diversity in the field without having to accept a significant reduction in yield. Satellite data and, above all, information from the use of drones for crop monitoring will also result in further environmentally friendly enhancements and improvements.

And finally, these technically and electronically advanced systems will lead to specific field robots [21]. In initial approaches, these will focus on the elimination of herbicides and attempt to enable largely undisturbed crop growth using traditional hoeing technology without manual assistance. The extent to which drones can be used to generate supplements or other systems is currently an open question. The same applies to initial approaches to autonomous field management.

Technology and data in tomorrow's land use

Through their development to date, both examples demonstrate the same systematic approaches to greater animal welfare with greater freedom for individual animals on the one hand, and to less environmentally damaging arable farming through the use of site-specific crop management through to individual plant management on the other. Both are based on new or adapted sensors that are integrated into the advanced systems through the use of electronics.

Precision livestock farming and precision farming are thus developing into technically driven types of land use which, despite the continued need for yield generation and yield security, are increasingly able to take nature and the environment into account and integrate them.

More and more precise data is becoming available, which enables economic, ecological and social added value through advanced algorithms. Artificial intelligence can be expected to make a further important contribution to ensuring that various cultural concerns, such as keeping the landscape open or a change in eating habits, are also taken into account.

Looking even further ahead, the technology will be capable to provide a complete shift away from current land use. Plant cultivation could then be realized in vertical farming systems with a permanently high energy supply under completely controlled conditions. With an exclusively vegan diet, there would also be no need for livestock farming in its current form. Ruminants will then have to keep the landscape open and urbanized society will have to find a broadly accepted way to maintain their position in the food chain.

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From Homo destructor to Homo constructor

Review of a book by Werner Bätzing

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In 2023, the C. H. Beck publishing house published a book in which Werner Bätzing explains with profound expertise that the destruction of the environment already began with the appearance of Homo sapiens, albeit on a limited scale. Werner Bätzing is an expert on issues relating to the Alpine region and rural life who is not only known to geographers. With his 463-page, almost encyclopedic Magnum Opus, he has created a work that is a "must" to read and to internalize for responsible and environmentally conscious representatives from governments, businesses, science, administration, planning offices and NGOs. Not because Bätzing finally proclaims the truth about the right way to deal with or heal the disturbed human-environment relationship, but because he offers two important aspects: on the one hand, an almost infinite and often new background and contextual knowledge about the historical arc from the origin of mankind to the present day across many epochs. He also conveys many very individual or even idiosyncratic explanations and opinions that are sure to provoke contradiction. However, contradiction is only useful once you have understood Bätzing's excellent explanations. Bätzing's argumentation always reveals his comprehensive education and training in philosophy, didactics, science, theology, craftsmanship and literature.

When you approach this enormous book, you are first of all surprised at the courage the author has shown in summarizing the history from the origin of mankind to the present day. In addition, methodical preliminary considerations are recorded in 9 chapters in great detail, didactically excellent, and peppered with many cross-references, e.g. to Jan Assmann's Axis Times. One learns a great deal and would wish almost every teacher to use this book in the classroom. But what should be of particular interest to readers of this book is his stance on the enormous environmental and climate change and the proposals he develops from this in chapter 10. He clears up with the common prescriptions of the end-of-pipe policy, as well as opposing the popular idea that it is enough to set aside a certain percentage of land for nature conservation. Why not? Because this would only increase the harmful intensification pressure on the remaining areas.

We cannot go back to the more stable and environmentally friendly hunter-gatherer or egalitarian farming societies, but we should adopt or take to heart the basic survival principles from these eras: Community instead of individuality, which was too strongly promoted by the Enlightenment, communal values and guiding principles of moderation and an active shaping (not adaptation) of nature influenced by this provided these eras and those that followed, right up to industrial society, with a certain degree of stability. The break only came with the globally borderless and unchanged growth-oriented service society, which is therefore also particularly harmful to the environment. Bätzing´s comments: "*It is up to the humanity itself! by assuming that the entire world is at his immediate disposal and that he can perfect all his possibilities to infinity, he becomes a homo destructor and turns his vibrant, diverse and attractive living environment into a purely functional, sterile and hostile world that simultaneously destroys all the natural foundations of its existence.*"

As a member of the post-war generation, I am very concerned that environmental destruction became particularly excessive from the 1950s onwards, i.e. that our current prosperity was bought at a high price from this time onwards.

Can we go on like this, the reader asks himself after reading this book? Probably not, because Bätzing goes even further by risking the reproach of Cassandra: "*Humanity is conducting a gigantic real-life experiment with the entire Earth, the outcome of which is completely uncertain and in which there is no responsible experimenter who will stop the experiment if it becomes problematic*." As we have painfully witnessed for years, the United Nations is too weak to take corrective action. Bätzing even suspects that, given this vabanque game, a large part of the earth will probably be uninhabitable for humans within the next 30 years.

The senior citizens of the post-war generation, especially the baby boomers, and the younger generation (probably including the Friday for Future movement, or the climate activists) must now join forces to save what can be saved. What sociologist Heinz Bude says in his new book "Farewell to the Boomers" fits in with this: "*In the end, the boomers have had it good so far. They have made good use of the transition from the industrial modernity of the economic miracle to the consumer and self-*

fulfillment society, albeit at the outrageous price of a huge consumption of nature. In doing so, it has also curtailed the future for children and grandchildren, creating a situation in which envy of the past can take hold instead of hope for the future. The boomers still have something to work off and make up for".

Bätzing does not believe in a slow transformation or sudden revolution, nor does he believe in patent remedies, technocratic solutions or even eco-romanticism. He refers to great thinkers such as Darwin, Marx and Freud and opposes too much rational thinking instead of accepting that mankind is a being whose needs go far beyond rational and "reasonable" objectives. He focuses on activity rather than adaptation, on the individual case and not on generally applicable principles, on the right measure as the guiding principle of self-limitation and on the ecological reproduction of cultural landscapes practiced in rural societies.

In summary, Bätzing makes some practical suggestions that are already familiar to land development experts in the book "Das Landleben" ("Life in the Countryside"), some of which appear to be feasible only to a limited extent.

Conclusion: The book triggers an intellectual (because it is technically insightful) and moral (because everyone shares responsibility) appeal to the reader to think about how he or she can make a constructive, realizable contribution as a homo constructor and not as a homo destructor in citizen and responsibility communities in the individual village, urban renewal and land development processes!

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Discussion

Questions by Peter Wilderer: Holger Magel's review begins by pointing out that mankind's destructive behavior is a tradition that is firmly rooted in Homo sapiens. Mankind's striving for power, greed for profit and self-centeredness were and are stronger than the religious and philosophical reminders to take responsibility for the whole. So where do we get the confidence to transform destructive into constructive action under today's constraints? Is the reason for our failure because we believed we could force changes in behavior with central regulation from above? Wouldn't it be worth turning the tables and countering the "top-down" with a "bottom-up" strategy? Holger Magel explicitly refers to the principle of subsidiarity in his review. This would mean limiting the power of governmental institutions and corporations and shifting responsibilities to the local level. What would have to happen for such a shift to be consensual?

Holger Magel's answer: The fact that centralized regulation from above does not work is something we have seen enough of, and not just in Germany. One example is the social distancing regulations that had to be implemented during the Covid pandemic, which led to determined resistance from some citizens due to a lack of understanding the reasons. The advocates of "green" grassroots democracy also had to realize that their suggestive claim: "We're ready, aren't you?" did not catch on. The electorate felt blindsided.

I also don't believe that religious or other normative values are of much use to the majority of our population, which has long since become secular. The god-kings quoted by Bätzing no longer exist. We can regret that, but we can no longer change it.

I agree more with the experts in village and rural areas, who know that it is only possible to achieve goals with the people and not against them. A viable consensus can only be found if the people themselves are actively involved in their personal and collective, e.g. village, future. The local population recognizes better than the central government what needs to be done in their environment without losing traditions and endangering the future of their children and grandchildren. In many cases, people lose their insecurity and fear of the future through this active, reflective examination of yesterday, today and tomorrow. They are aware of their circumstances!

Thus, it is not about "taking people with", as politicians wrongly like to say, but about activating and empowering people, about actively thinking for themselves and imagining the future to create guiding principles together. All this without coercion from above, but voluntarily. We call this "wanting to participate, letting people participate, being able to participate". It's about empowerment, enabling, and participation, i.e. this triad, which has been successfully practiced in Bavarian Village renewal projects for decades and is taught, learned and trained at least in three Bavarian rural training centers such as in Thierhaupten, Plankstetten and Klosterlangheim.

Is it any wonder that communities have become sustainable and climate-friendly model communities when they act across communities as part of integrated rural development? Examples of this in Bavaria include communities such as Wildpoldsried, Weyarn and the highly innovative Kirchanschöring, where citizens' councils have been established for the first time. There, a future has begun where the cultural self-limitation and finding the right balance called for by Bätzing are no longer foreign words. They have all long been self-sufficient in renewable energy, have laid modern fiber optic cables and have integrated sustainability and local supply into all processes of living, building and living together. However, this is only possible if we succeed in taking citizens seriously as active partners (and often also as experts) and not as subjects in need of help.

From this perspective, it is also clear that some experts and politicians who aim to limit land consumption quantitatively by law cannot succeed. Only a jointly established and discussed model process on the qualitative and quantitative handling of the limited resources of "land" and "soil" can lead to the goal. It has long been a truism that the more tangible and comprehensible the clearer they are, the better such processes of active citizens taking responsibility work. Hartmut Rosa would call this the village or regional resonance space.

The bottom-up principle, best suited to this, is of central importance for the much-cited transformation but does not exclude overarching guidelines and a regulatory framework. To act as a homo constructor for the hoped-for and necessary change in people's minds, top-down guidelines must not take the place of local decisions or stifle them. They should have a serving effect in the sense of subsidiary help for self-help, i.e. in the sense of a promise of state support, funding and advice (for example by rural service).

I fear that the fundamental importance of local civic responsibility and civil society for the Great Transformation is not sufficiently recognized in many areas of our lives in politics, business, science and administration. All too often it is a case of ruling from above. However, this is precisely the characteristic of authoritarian states and is unacceptable in our civil society, which is unfortunately once again at risk. Together with Alois Glück, I published two books on this subject 20 years ago: "Neue Wege in der Kommunalpolitik. A new civic and social culture for an active civil society" and, together with Thomas Röbke, "Neue Netze des bürgerschaftlichen Engagements. Strengthening families through voluntary initiatives". It is worth picking up these publications again and again if we want a transformation, a transformation with and not against the citizens!

From Domination to Co-Evolution -
It is not technology that endangers the earth system but our handling of it!

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Since the beginning of the 90s of the last centuries I have been intensively engaged in the research topic of Global Change which emerged at that time. This topic developed to explain and sustainably shape the observed "Great Acceleration" especially after World War II. Integrative, interdisciplinary research on Global Change includes the linkage of inter alia population growth, increasing resource use, climate change, and water scarcity as an expression of human impacts on the Earth system. Interdisciplinary and inclusive global research programs (e.g. Future Earth) followed. They produced e.g. the concepts of the Anthropocene, the "planetary boundaries", the SDGs and many others. For many years I was involved in research, research consulting, policy consulting and implementation of research results with stakeholders in leading positions in Germany and internationally (e.g. GLOWA-Danube project, chair of National Committee for Global Change Research (DFG+BMBF), chair of ESA-Earth Science Advisory Board, supervisory board UFZ, etc.). Besides my own research, I was able to contribute decisively to the launch of new research initiatives on the topic of "global change" for young scientists at BMBF, EU and ESA.

Since my retirement in 2021 and my move to industry, I have been a partner and chief scientist of the company VISTA GmbH, a 51% owner of BayWa, in Munich. VISTA successfully pursues its goal of reducing the environmental footprint of agriculture through digital information technologies locally to globally, thus contributing to sustainable agriculture.

Thoughts on the early assessment of the consequences of technical interventions in nature

Humans have been influencing their environment and thus the Earth system for thousands of years. Their first imprints, traces and evidence of time are fundamentally different from all that elephants, mammoths or iguanas have left us. They are tools, self-portraits, representations of food games, fire, and clan. They deal with the environment in a new way, testify to the attempt to master it, to the will to understand and shape it, and to cave walls as common self-reflection surfaces.

There is little evidence that we Anthropocene humans are any different from prehistoric humans. Thoughts on the early assessment of the consequences of technical interventions in nature and its self-regulation must therefore start first and foremost with man, his roots and his nature, and not with the nature he challenges.

What was demanded of man in terms of an attitude towards nature was rather manageable at the beginning of his development. Hunting and with it the understanding of the prey, the neighboring topography, the interaction of the hunters, was a precondition of survival. Here orientation, coordination, communication, and social bonding in small clans proved themselves; all things with which man was generously endowed. It was also here that the first techniques emerged, which, out of an understanding of purpose and characteristics, changed and used what was already there in order to ensure survival more successfully. If the hunting grounds were empty, one moved on an Earth, which appeared to be boundless.

The invention of agriculture was based on the realization that one can live from cultivated plants. The decision to cultivate plants on a large scale had drastic consequences. It was to lead, after a few millennia, i.e. rapidly, to the technical use of almost all suitable land on Earth to produce direct and indirect food, thus greatly reducing biodiversity, releasing the carbon of agricultural soils into the atmosphere, and so on. The scale of this interference with nature and its lack of sustainability exceeds anything that has been thought of in the field of geoengineering today. On the other hand, almost all of us would not exist today without the introduction of agriculture, not to mention the further technological development that built on the cultural success of agriculture.

Were there conscious decisions in favor of agriculture at the beginning of the development, based on an early assessment of the consequences of technical interventions in nature? Probably not, but we do not know. I find it rather unlikely that at that time in Mesopotamia or in South America or in China a council of wise men and women sat together, sifted through the available knowledge on the pros and cons of the introduction of agriculture and then voted with a majority of, say, 10 to 2 for the introduction of agriculture, well informed about the possible consequences.

With their knowledge, could they have rejected the introduction of agriculture at that time? Hardly! Compared to the long-term consequences, the short-term advantages seemed far too tempting, especially for individuals among them: the reduction of hunger, the hardships of hunting with an increasing population and tribal feuds and wars over ever scarcer hunting grounds.

Should they, with their knowledge, have refused to enter agriculture at that time? Rather yes! The result would have been a very painful but not impossible limitation of the number of inhabitants and the occupation of Earth to a sustainable level, peace talks between the tribes and a very rich tradition of man as hunter-gatherer until today.

Why is this view of the introduction of agriculture disturbing in the context of an early assessment of the consequences of technical interventions in nature? One could justify it by saying, firstly, that they had no chance to see the consequences and, secondly, that there was no alternative to agriculture, because people had no other choice. Renunciation as an alternative to the appropriation of agricultural technology and trust in the self-regulation of nature was, however, just as conceivable and possible as it is sometimes demanded today. We can also confidently assume that there were already people then who, in order to maintain the status quo, were critical of the displacement of wildlife by agriculture, for example, in the sense of parts of today's biodiversity discourse, and who fought against the introduction of agriculture. Both justifications are thus questioned in my view. However, both lines of justification can be found in a similar form in the currently heated discourse on social transformation towards sustainability.

What if we know (as in the case of climate change and its consequences) and if alternatives exist (decarbonization of civilization); if we know the consequences of technical interventions in nature? Answers depend very much on the context of perception. What technical options may we take,

a) to save the world from the imminent collapse of the Earth system postulated by parts of science, triggered by man. The answer must definitely be: all that work! It is about our life and death!

b) to preserve the world as we (the living) know it (e.g. attempts of regional mitigation of climate change). The answer, in my view, should be: beware! This is not about our life and death! It is most likely about sectoral or geographic particular interests rather than the big picture.

In this discussion, the nature of the technical solution itself has been completely neglected so far. Nor does it seem to me to be the central problem. Technical impact assessments often exist well before the technology itself is deployed, and it often turns out that someone who develops or plans a technology (atomic bomb, irrigation, internal combustion engine) also has a good, perhaps the best, understanding of its consequences. The Soviet agricultural engineers who planned the irrigation systems for cotton cultivation on the Sir-Darya in the early 20th century were well aware that in the long run, their operation would lead to the disappearance of the Aral Sea. Nevertheless, they were built! The nuclear physicists were well aware of the effect of released radioactivity on living organisms. Nevertheless, the atomic bomb was finally used! So, it is not so much the impact assessment that is lacking, but its evaluation and rigorous consideration in the respective decision.

The most comprehensive impact assessment of technical solutions is a necessary prerequisite for a responsible replacement of the self-regulation of natural systems in the Anthropocene. However, it is not yet a responsible replacement for the self-regulation of natural systems. Rather, I ask myself what meaning this postulated self-regulation of natural systems can still have in the Anthropocene with its nature largely molded by humans. The self-regulation of natural systems is only marginally responsible for man and his civilization, it regulates nature. If we solely trust in the self-regulation of natural systems for the survival of our civilization, we would have to revise decisions, e.g. for agriculture. This, however, seems impossible and senseless to us, since it would negate our civilization.

On the other hand, our civilization and its technologies are also based on the natural foundations that Earth provides. No technical system that I can think of will be able to maintain civilizations (e.g. our non-sustainable one) without interaction with nature, let alone against its self-regulating mechanisms over a longer period of time. The power fantasy of replacing nature's self-regulation with civilization in the Anthropocene is thus fraught with danger. We, in the Anthropocene, should not look for a replacement for the self-regulation of natural systems by technology, but for a responsible complement to it, in order to selfishly ensure the preservation of our civilization within the nature of the planet.

Suggestions on how to achieve sustainable resilience of technical solutions

In my view, proposals for achieving sustainable resilience of technical systems can best be achieved if they are understood and developed as a responsible complement to nature's self-regulation. In my further remarks, I therefore deliberately remain general, since sustainable resilience (of whatever) cannot be achieved by enumerating individual points. One antinomy seems central to me:

On the one hand, I believe we can confidently ascribe nature to a lack of interest in us and our civilization. Also, nature's self-regulation does not appear to be directed toward a purpose. In contrast, technology, as a result of civilizational activities, is usually deeply purpose-driven and, above all, usually driven by sectoral and/or geographical particular interests (money, power, conquest, defense, etc.).

Would a technical solution thus be sustainably resilient after it has been freed from all particular interests and serves a purpose that has been recognized by our world civilization as compatible with nature after careful consideration? It would thus be owned by mankind, free of intellectual property and patents, and its use accessible to all. It would serve the further development of the entire civilization and the protection of our bases of life within an intact nature of the planet. It would be applied, promoted and further developed by the wealthy for the benefit of all, even those who cannot afford it. It would be in the interest of mankind and would not only serve the interests of individuals (regional, sectoral or generational). From my point of view, it would be worthwhile to evaluate existing technical solutions according to these criteria. The result would probably be a different kind of technology, e.g. in agriculture, mobility or medicine.

From my point of view, first, shy approaches can be seen e.g. in the perception of patent rights for AIDS drugs or in the discussion about conscious and free transfer of technical know-how for the production of renewable energy to developing and emerging countries.

Discussion

Question from Peter Wilderer: In their articles, Wolfram Mauser and Martin Grambow refer to so-called geoengineering, a topic that made waves at the beginning of the 21st century. As it is more than doubtful that the 1.5-degree limit announced by the global community can be adhered to, "geoengineering" is flaring up again as a possible rescue measure.

My question is: at what spatial dimension can we speak of geoengineering? Are we talking about measures that affect the entire globe, or does a local influence already count as the starting point for geoengineering? So would the artificial over-rainfall of a piece of forest already be an indication of geoengineering?

Answer from Wolfram Mauser: Geoengineering has achieved a "resurrection" in the context of the discussions at COP28. The oil-producing countries are resisting a decision to phase out fossil fuels. They argue that there is no need to phase out fossil fuels, as CO_2 can be removed from the atmosphere and stored in the future (CCS). They are therefore hoping for a technology that may be available in the future and may even be cheap, which, when applied globally, will solve a global problem. This future-oriented and "naive" discussion about CCS is, of course, highly problematic in my view.

In my opinion, this COP28 discussion has a lot to do with geoengineering, because it is about the application of a technology that

1. addresses a global problem that affects everyone,

2. a technology is to be applied on a global scale to solve the problem.

I believe these criteria are sufficient to characterize geoengineering. According to this definition, there is no scale for geoengineering, only an intention.

From my point of view, questions should rather be asked like this:

Is research on geoengineering that takes place in a patch of forest already geoengineering? Rather no!

Would the manipulation of the atmospheric water cycle to remedy droughts wherever there is a lack of water be geoengineering? In my view, yes!

Can the "artificial" over-rainfall of a piece of forest in itself provide an answer to the question of whether this geoengineering works? From my point of view and justifiably rather no!

Note from Peter Wilderer: In order to disentangle the various references to the term "geoengineering", I suggest using the term "ecoengineering" to refer to locally effective human intervention in nature.

As we know, "geo" stands for "earth" as a whole. Thus, a typical example of geoengineering would be the installation of an umbrella at the Lagrange point to regulate the earth's temperature. "Eco" is derived from the ancient Greek word for "house", and thus has a reference to the local habitat. A typical example of ecoengineering would be the planting of monocultures in a field, the clearing of woodland to create farmland or the artificial irrigation of a forest or field.

In any case, geoengineering and ecoengineering have potentially positive as well as negative effects. Both geoengineering and ecoengineering require a rigorous risk assessment before deciding on a practical application.

My conclusion from this discussion is:

Geoengineering is a term that refers to the planned intervention in the earth system (see article by Martin Grambow

Geoengineering does not have a spatial dimension, but it does have a temporal dimension.

Geoengineering is not to be understood as the privilege of engineers. The term refers to planned measures of influence that are taken by each person as well as by the organs of human society to affect the future.

In the biotic part of the earth system, reactions to external and internal influences are genetically encoded and controlled.

In contrast, reactions to interventions in parts or all of the earth system are triggered by the will of actors.

The principle of responsibility, as described in detail by Hans Jonas in his book of the same name, plays a decisive role in achieving sustainable success.

In summary, it can be said that biotic self-regulation cannot be a model for anthropogenic systems. At best, biotic self-regulation can serve as a benchmark for sustainable, responsible action.

Answer from Wolfram Mauser: Whether I can agree with this conclusion remains to be seen

Natural Wastewater Treatment Systems for Domestic Sewage

A message from India

Introduction

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In the course of civilization's progress, unchecked population increase, improved living standards and economic progress have led to enormous freshwater consumption, for which about 70-80% is associated with private households (Mahapatra et al., 2022). Currently, about 380 billion m^3 of municipal wastewater is released yearly worldwide, which is expected to increase by 24% by 2030 and 51% by 2050 (Qadir et al., 2020). According to UN-Water (2017), the percentage of untreated wastewater released into the environment was 30%, 62%, 72%, and 92% for high-income, upper-middle-income, and low- and middle-income countries, respectively. For example, only 13.5% of wastewater in India is adequately treated (Chowdhury et al., 2022).

Direct discharge of domestic wastewater into water bodies reduces available dissolved oxygen (DO), causes eutrophication, and degrades ecosystem quality. Considering the need for sustainable development, it is important to explore natural wastewater treatment systems/technologies (NWWTSTs) for remediation and recovery of resources (e.g., N, P, energy) from domestic wastewater, which is the focus of this chapter. These are engineered systems that give a wide scope to natural self-regulation. Accordingly, natural wastewater treatment systems/technologies can also be called ecological hybrid systems.

Selected natural wastewater treatment systems/technologies for domestic wastewater treatment.

Various natural wastewater treatment systems/technologies are described by Ramakrishnan et al. (2016). Selected natural wastewater treatment systems/technologies are discussed below, including wastewater stabilization ponds (WSPs), constructed wetlands (CWs), vermifiltration/macrophyte-assisted vermifiltration (VF/MAVF), and plant-based aquatic systems.

Wastewater Stabilization Ponds.

They can be broadly classified as aerobic ponds, anaerobic ponds, facultative ponds, and maturation ponds (Mahapatra et al., 2022). Hasan et al. (2019) used a WSP for wastewater treatment and found > 90% and 50% removal of biological oxygen demand (BOD) and TN, respectively. De Assis et al. (2020) achieved the removal of 59%, 77%, and 16% of chemical oxygen demand (COD), ammonium N (NH4+-N), and total P (TP), respectively, using a high-flow aerobic WSP to treat domestic wastewater.

Constructed wetlands

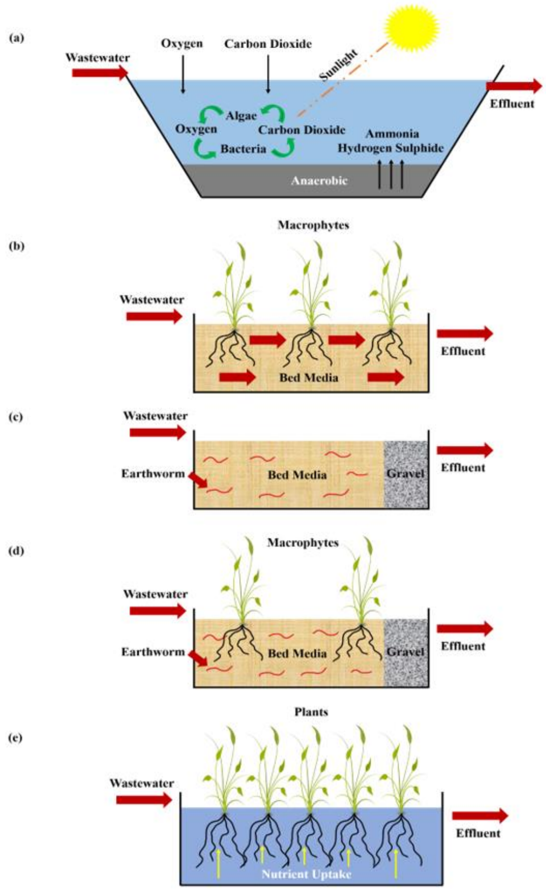
They can be broadly classified into four types: Free Water Surface Wastewater Treatment Plants (FWS WWTPs), Horizontal Subsurface Flow Wastewater Treatment Plants (HSSF WWTPs), Vertical Subsurface Flow Wastewater Treatment Plants (VSSF WWTPs), and Hybrid Wastewater Treatment Plants (HCWs) (Ramakrishnan et al., 2016). The main pollutant removal pathways in WWTPs are adsorption, microbial degradation, and plant uptake. In VSSF WWTPs, better effluent distribution provides an aerobic environment within the system, facilitating aerobic degradation of organic matter. In HSSF treatment plants, on the other hand, anaerobic biodegradation of organic matter predominates. HSSFs ensure enhanced removal of pollutants due to improved redox conditions (Chowdhury et al., 2022). Rahi et al. (2020) used two pilot-scale VSSF-CWs and found that the vegetated VSSF-CWs provided 86%, 85.9%, 82.1%, 59.6%, and 65.5% of COD, BOD, NH4+-N, PO43-P, and TSS removal, respectively, while the same values for the non-vegetated VSSF-CWs were 80%, 80.9%, 74.9%, 36%, and 56.4%, respectively.

Macrophyte-assisted vermifiltration.

These are soil biofilters in which the joint action of earthworms and microbes involves the removal of pollutants from wastewater. Earthworms perform a range of burrowing activities, including ingesting larger particles in the wastewater, crushing the ingested particles, digesting the crushed particles using gut microbes, and excreting them as castings enriched with nutrients, enzymes, and microbes (Chowdhury et al., 2023). Sometimes macrophytes and earthworms are integrated into a single filtration unit known as a macrophyte-assisted worm filter to further improve the treatment efficiency of a worm filter. Arora et al. (2016) used a vermifilter of *Eisenia fetida* earthworms to treat domestic wastewater and achieved > 85.5%, 77.8%, 90%, and 82.2% removal of BOD, COD, NH4+-N, and TSS, respectively. Chowdhury & Bhunia (2021) used a two-stage macrophyte-assisted worm filter with Eisenia fetida earthworms and Canna indica macrophytes to treat domestic wastewater and found that the system provided 67-77%, 74.4-98.2% and 73-87% removal of COD, NH4+-N and TN, respectively.

Plant-based aquatic systems.

These are used for phytoremediation of wastewater, with Eichhornia crassipes (water hyacinth), Pistia stratiotes L. (water lettuce), and Lemna minor L. (duckweed) being the most commonly used macrophytes. The effluent can flow freely over an impermeable medium, and the nutrients contained in the effluent are absorbed by the roots of the macrophytes. In addition, the microbes living in the root zone of the macrophytes facilitate the degradation of the organic matter contained in the wastewater. Alade & Ojoawo (2009) studied the potential of water hyacinth for domestic wastewater treatment and obtained 48.9% and 46.2% removal of BOD and COD, respectively.



Schematic representations of the natural wastewater treatment systems: (a) WSP, (b) CW, (c) VF, (d) MAVF, and (e) Plant-based aquatic system.

Environmental sustainability of natural wastewater treatment systems/technologies.

Conservation of non-renewable resources, protection of air, water, and soil quality, protection of aquatic and terrestrial ecosystems, nutrient recovery, and reusability of treated wastewater determine the environmental sustainability of a given wastewater treatment technology (Chowdhury et al., 2022). The main advantage of natural wastewater treatment systems/technologies is that they are energy efficient and cost-effective. Abello-Passteni et al. (2020) found that up to 0.04 kg of fossil fuel is required to remove one kilogram of BOD in the conventional activated sludge process, while no fossil fuel is required in VF.

Natural wastewater treatment systems/technologies significantly reduce greenhouse gas emissions (e.g., nitrous oxide (N2O), methane (CH4), carbon dioxide (CO2), etc.) because the CO2 released there is biogenic in nature, with the global warming potential (GWP) of biogenic CO2 being one, while the GWP of CH4 and N2O are 25 and 298, respectively (Chowdhury et al., 2022). Mander et al. (2014) found that for domestic wastewater treatment, CH4 emissions from an FWS-CW and an HSSF-CW were 1.8 and 6.4 mg/m2-h, respectively, and N2O emissions were 0.031 and 0.42 mg/m2-h, respectively. Singh et al. (2017) reported that the release rate of greenhouse gases from conventional WWTPs with anaerobic sludge blanket process and activated sludge process were up to 1,317,375- and 71,696-tons CO2-eq/year, respectively. Lourenco & Nunes (2021) reported that replacing the conventional activated sludge process with VF technology resulted in a reduction of GWP from 264 kg CO2-eq to 183 kg CO2-eq and eutrophication potential from 20.7 kg PO43-eq to 7.51 kg PO43-eq.

In addition, natural wastewater treatment systems/technologies can be used to stabilize the sludge produced in conventional wastewater treatment plants. In VF, earthworms act as sludge stabilizers and excrete the stabilized sludge as worm dung, which can be used as soil fertilizer. Webster (2005) reported that replacing chemical fertilizers with worm compost resulted in a 23% increase in grape yield. Alade & Ojoawo (2009) found that the sludge produced by treating domestic wastewater with water hyacinth can be used directly as biofertilizers due to its nutrient enrichment. When organic fertilizers are applied, the nutrients (i.e., N and P) stored in them are mixed with the soil and are available for plant uptake, thereby promoting plant/crop growth. In this way, natural wastewater treatment systems/technologies facilitate the recovery of nutrients from domestic wastewater. Apart from sludge, treated wastewater from NWWTSTs is detoxified, has a clear appearance, and is enriched with dissolved oxygen and nutrients; therefore, it can be used for irrigation, horticulture, and other non-potable uses and supports the survival of aquatic life, thereby maintaining the balance of the aquatic ecosystem (Chowdhury et al., 2023).

Conclusions and recommendations.

Natural wastewater treatment systems/technologies have good potential to treat domestic wastewater by providing substantial removal of organic matter and nutrients. In addition, each of the systems presented minimizes the need for non-renewable resources, preserves air, water, and soil quality, promotes the maintenance of aquatic and land-based ecosystems, facilitates the recovery of nutrients from domestic wastewater, and produces nutrient-rich and detoxified wastewater that can be used for irrigation purposes, thereby meeting the criteria for environmental sustainability. However, some recommendations to further improve the sustainable resilience of natural wastewater treatment systems/technologies are provided below.

Although natural wastewater treatment systems/technologies provide considerable effectiveness in removing pollutants, in-depth research is needed to further improve the treatment efficiency of natural systems.

Natural wastewater treatment systems/technologies do not completely eliminate greenhouse gas emissions during their treatment processes. Therefore, in-depth research is essential to reduce greenhouse gas emissions from natural wastewater treatment systems/technologies.

N.B. This paper was designed under the leadership of Rao Surampalli by scientists from India and USA, namely: Sanket Chowdhury, Puspendu Bhunia, Tian Zhang.

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Discussion

Remarks of Peter Wilderer: The article by Rao Surampalli and his co-authors points out that the centralized wastewater treatment methods developed and widely used in industrialized countries cannot be considered a universal model for solving the world's sanitation problems.

Decades ago, the International Water Association (IWA) set up a working group (Specialist Group on Small Water and Wastewater Technologies) to identify wastewater treatment systems in contrast to large systems. The "natural wastewater treatment systems" described in this chapter are part of this topic. However, alternative wastewater treatment should be understood as part of an overarching system that includes facilities for drinking water supply in rural areas as well as the training of the specialists needed to responsibly operate such systems.

I want to draw your attention to a project in the Indian state of Tamil Nadu that has attracted worldwide attention. In the village of Odanthurai, 40 km from the city of Coimbatore, the women of the village, led by the daughter of the village elder, decided in 1996 to take the solution to the local water problems into their own hands. The village elder had provided his daughter with a academic education in microbiology. She and some of her fellow students gradually established the transportation of water from the river below the village using simple means.

A plant for the production of high-quality drinking water, a plant for natural wastewater treatment and a plant for the generation of electricity using biogas and wind power were built. Despite these achievements, the women insisted on the preservation of traditional village life. Read, for example, in: Inspiring self-powered village - Odanthurai (ecoideaz.com).

Response of Rao Surampalli: We learn from this that sustainably effective technical processes require a combination of local initiative, solid education, inventiveness, hands-on knowledge and entrepreneurship, all grounded in local traditions and culture. The solutions built on this ground solutions will look different in rural Lower Bavaria than in rural Tamil Nadu. The diversity of technical solutions is as important as the diversity of species in ecosystems.

Subsidiarity in practice using the example of the village of Odanthurai, India
Tradition meets modernity
Photo taken by Peter Wilderer

Strategic Thinking on Dealing with the Earth Crisis

Message from China

Evolution of the Earth Crisis

Dr. Yonghui Song
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Adjunct Prof. Tsinghua University
River Basin Water Management
Fellow of EASA

Compared to the 4.6-billion-year history of the earth and the 3.8-billion-year history of life, what Paul Josef Crutzen referred to as The Anthropocene is the history that began with the Industrial Revolution in the late 18th century. It is just in this short history that the interaction between humans and nature has greatly intensified, and as a result, we humans have ushered in increasing the change of the climate globally. We are striving to control the increase of extreme weather events by reducing greenhouse gas emissions. However, simultaneously the loss of biodiversity resulted in a 28% decrease in global biodiversity between 1970 and 2008. Natural crises are intensifying day by day on earth.

Coping strategies

In general, the intentions to overcome the global climate change could be divided into three categories:

1) Ignoring and inacting.
As William D. Nordhaus pointed out "The situation of global warming is just one of many historical cases where efforts to understand nature are undermined by human stubbornness." Some people and even governments ignore or do not recognize greenhouse gas effects because of uncertainties, and some governments even withdraw from The Paris Agreement at will.

2) Active geoengineering

There are several proposals to develop radiation management technologies such as stratospheric aerosol injection, ocean cloud whitening, and the installation of a set of mirrors in space. Costs and the uncertainty of these measures limit the possibility of their deployment. For instance, carbon dioxide removal technologies, afforestation, gaining bioenergy with carbon dioxide capture and storage (BECCS), blue carbon, etc., cause immense costs and risks, and are still being explored and worth exploring.

3) Philosophical and scientific response

Since the birth of humanity, efforts to understand the world and to handle the relationship between humans and nature have been the core content of philosophy. The ancient philosophy of China emphasizes the "unity of heaven and man". Confucianism, Taoism, and Buddhism have different interpretations, but their common point is that they view humans as a part of the universe and nature, achieving harmonious coexistence between humans and nature, and achieving the organic unity of humanistic spirit and scientific spirit.

Based on these concepts, all things in the universe have their own laws of operation, and the Earth system also has its own laws of operation. It is a correct approach to leverage the Earth's resilience to respond to external changes and fully utilize the Earth system's self-regulation ability. Respecting nature and the Earth does not mean doing nothing. On the contrary, it is necessary to actively understand the operational laws of the Earth and nature, and understand global changes and their effects through observation. We should actively develop technologies to reduce human impact on the Earth as much as possible. We are ultimately visitors to the Earth, so we should respect our host - the Earth, be humble and polite guests, and clean up our trash, wastewater, and exhaust gas. To help the Earth system better utilize its self-regulatory function, the "assistance" of artificial restoration is necessary, especially in restoring vegetation, restoring ecosystem functions, and protecting biodiversity.

Progresses addressing climate change and restoring ecosystems

Since 1988, the IPCC has continuously evaluated climate change and its potential impacts on society and the economy, as well as possible strategies for adapting to and mitigating climate change. In September 2015, the United Nations Summit adopted the 2030 Agenda for Sustainable Development, calling for urgent action to address climate change and its impacts. In November 2021, the contracting parties of The Paris Agreement finally completed the implementation rules, making green, low-carbon, and sustainable development a global consensus and direction of efforts. In order to cope with global climate change, restore damaged ecosystems, and protect biodiversity, efforts are being made globally: UN agencies such as UNEP and UNDP have carried out extensive work; ecological restoration projects are widely carried out in Africa, Europe, and the USA. China has set carbon peak targets by 2030 and carbon neutrality targets by 2060. After years of afforestation, China's forest coverage has exceeded

24%, which is a significant achievement for an ecologically fragile country. In terms of eliminating desertification, China's Saihanba Afforestation Community was named Champion of the Earth for inspiration and action in 2017 in honor of its work transforming degraded land into a lush paradise. It shows that adopting technologically, economically, and socially feasible technologies to restore the Earth's ecosystem, helping and awakening the Earth's self-regulatory ability, is a practical and feasible approach to addressing the Earth's crisis.

The achievements are commendable, but compared to the acceleration of global climate change, greater efforts need to be made. Faced with the global climate crisis, countries and regions with imbalanced economic and social development have different understandings and attitudes, inconsistent thoughts and actions, and thus weaken the ability of humans to respond to earth and regional crises.

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Discussion

Question of Ortwin Renn: *In his contribution, Yonghui Song makes it clear that we need to do more?* What would be your priorities here?

Response of Yonghui Song: Thanks to Professor Ortwin Renn for his question. Understanding the challenge and providing solutions are both important. I am willing to provide a concise answer:

1. promoting the harmonious coexistence of humans and nature: It is necessary to prioritize ecology, promote green development and create a world of harmonious coexistence between humans and nature. This is not only a scientific concept, but also a concept that policy makers should refer to.

2. promote the formation of a green development model: We must advocate green production and green living, and build an environmentally friendly development and way of life to respect the earth. This is something that should be supported by the industry, the financial world and the general public.

3. promote international and regional cooperation: The ecological edge effects that must be achieved through ecological restoration in ecologically sensitive developing countries and regions. They are greater in their impact, not only in relation to the region, but also to the entire planet.

4. strengthening communication: Cooperation between think tanks and international organizations such as the United Nations and relevant government agencies is important. Thinkers must make those in power and capital aware that building a world of harmonious coexistence between humans and nature is the most important thing.

5. action is important, not just words: Action speaks louder than words. We should not neglect small things. A trickle eventually becomes a river. Together we can promote a sustainable and self-regulating ecosystem on earth.

Resilience Thinking and the Importance of Adaptive Cycles

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Fellow of AAAS and EASA
2003 Stockholm Water Laureate

Ecological self-regulation is the ability of ecosystems to establish an original or new state of equilibrium in response to changes of boundary conditions (Gorshkov et al., 2000).

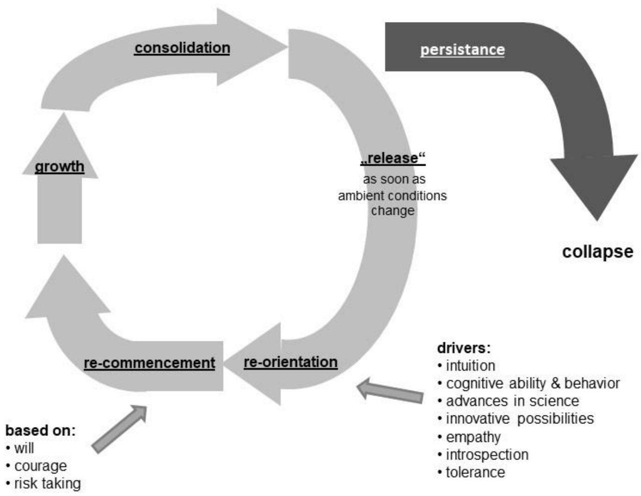
A distinction should be made between suddenly occurring or gradually progressing changes. An example of slowly changing boundary conditions is global climate change. Sudden changes occur in case of bush or forest fires, floods, or massive changes following reactor disasters such as the one in Chernobyl.

A prerequisite for the success of ecological self-regulation is the presence of a diversity of bacteria, plant, and animal species. As important are species that migrate from neighboring ecosystems. This provides a reservoir from which the ecosystem can draw to respond to changes in the local environment. In the course of the regulation process, the species that best cope with the new boundary conditions prevail. The ecological regulation process can last decades to centuries.

Explanation of the terms resilience thinking and adaptation cycles

Resilience Thinking is characterized by a circular sequence of actions. This is explained using as an example an economically active business enterprise:

- Ongoing observation of changes in the environment (climate, economy, society, politics).
- Evaluation of the observations and possible consequences in relation to one's own activities.
- Release of accustomed activities, if this is assessed as necessary.
- Recognizing and evaluating options.
- Decision-making and implementation.



Resilience Thinking (Walker and Salt, 2008) is a perpetual cyclic process, also referred to as an Adaptation Cycle (shown graphically in the image above).

Ultimately, resilience thinking leads to the state of resilience, i.e. the ability to continuously adapt to changes in the environment to remain efficient. The purpose of resilience thinking is similar to that of ecological self-regulation, with the difference that an autonomous process is replaced by knowledge-based, deliberate action.

Stepping out of the cycle by willfully insisting on the status quo can lead to a loss of resilience (as outlined in the picture on the right) and, in extreme cases, to system collapse (Diamond, 2005). Conversely, the decision to adapt to new challenges offers an opportunity for survival. A decision to adapt is driven by the perception of emerging risks and polycrises that are recognized as threatening the existence of the company. This provides an intellectual bridge to Ortwin Renn's contribution.

Breaking out of adaptation cycles can lead to collapse

A particularly blatant example of ignoring risks and polycrises is the bankruptcy of Lehman Brothers in 2008, an economic "monoculture". The same applies to the collapse of governmental monocultures. The collapse of the Roman Empire in the 5th century and the collapse of the Habsburg monarchy and the German Empire after the First World War may serve as other examples of this. In both cases, the claim of the emperors of the time to inherited rights, and the willful rejection of corrections in the handling of power were partly responsible for the collapse of the entire state system.

As in ecosystems, adaptive action in economic and state systems must relate to both holistic and regional conditions. We refer to such units collectively as ecotopes (i.e. economic living and working spaces). Ecotopes correspond to the biotopes in an ecosystem. The characteristics of an ecotope are the response to the local boundary conditions, which can vary greatly from case to case. Adaptive cycles can therefore only be effective if they are based on the particular characteristics of the local ecotopes. In contrast, the usual reverse approach from the whole to the parts is less effective. If the characteristics of the local subsystems are not taken into account, rules, regulations and laws issued by central institutions run the risk of being ineffective. They arouse resistance and, in borderline cases, lead to system collapse.

The global trend towards the centralization of companies (keyword: "merger endgame", Dean et al. 2003) and the merging of regions, countries and states into supranational state organizations (example: European Community) is difficult to achieve holistic resilience. It is essential that measures for local resilience are based on local knowledge and experience. In this respect, there is much to be learned from ecosystems and their methods.

Human intervention in large-scale ecological systems and their ability to self-regulate is particularly serious. For example, it is necessary to turn away from "modern" forests, which are predominantly populated with fast-growing trees. The favoring of spruce in Central European forests began in the late Middle Ages for purely economic reasons. The trigger at that time was Hanns Carl von Carlowitz, chief mining administrator of the Saxon Ore Mountains, with his book "Anweisung zur wilden Baumzucht" (Instructions on wild tree cultivation) published in 1713. It called for only as many trees to be felled in the forests per unit of time as would grow back in the same period. Ironically, Hanns Carl von Carlowitz has since been referred to as the founder of sustainability. Numerous examples prove that systems controlled by humans rarely deserve to be called "sustainable". The destruction of large spruce stands in Central Europe by the bark beetle and the loss of crop yields due to prolonged periods of drought support this thesis.

Investors and organizers with their innate egoism and their pursuit of profit are the cause of undesirable developments. Forest areas are being sacrificed in favor of land use for roads, settlements, airports, logistics centers and agricultural production of many profitable crops for export. The resulting sealing of soils contributes to a reduction in the recharge of groundwater. Due to the reduced holding capacity of the soil, flooding increases during heavy rainfall events and in droughts the following.

The clearing of forests, not only in the Amazon region but also in many other regions of the world, is accompanied by a loss of the at least temporary fixation of CO_2 in wood, soil and peatlands. Cutting down trees reduces the area of leaves and needles required for photosynthesis. It also reduces the emission of oxygen, a substance that, like water, is essential for the life of heterotrophic organisms including humans. The emission of water vapor into the air space above the canopy is reduced. This can have consequences for the terrestrial water cycle and for the climate (Makarieva A.M. and Gorshkov V.G. 2010; Makarieva A.M. et a. 2013).

The effects of subsidy policies, for example in the agricultural sector, should also be mentioned in this context. This suggests that the profiteers of subsidies gain a long-term economic advantage. In reality, opportunities are missed to adapt to changing market conditions. The cash flow from above often prevents long-term thinking and planning. Protests against the reduction of subsidies are understandable but ultimately irresponsible.

Training in the home countries is urgently needed

Effective concepts are needed to impart practical skills and knowledge about the complex relationships between cause and effect in nature, the economy and administration. In this way, a profound understanding of the necessity and advantages of adaptive cycles should be developed. The aim is to generate ethical and moral resilience.

On this basis and in recognition of the particularities of local ecological, economic and cultural characteristics, training programs are required that presumably are most efficient when they take place close to the trainees' place of origin. The current practice of teaching students in training centers of industrially developed countries entails the risk that knowledge will be acquired that is not or only marginally appropriate to the specific climatic, economic and cultural requirement at the home place of the students.

A rethink is also urgently needed in the application of technical solutions such as central sewage collection and treatment systems in developing countries. There are worldwide plenty of misleading examples of this, but there are also innovative initiatives that deserve attention and support.

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Synthesis

Biogenic self-regulation alone cannot serve as a model for the regulatory methods of human systems, as the prerequisites and processes are significantly different.

The self-regulation of biotic systems is genetically encoded in living organisms and communities, including their essential independent development, autopoiesis (Vogt). Furthermore, the regulation of human systems is based on decisions that are made deliberately to achieve self-imposed goals.

Over the past centuries, humankind has proven that the tireless pursuit of knowledge coupled with ingenuity has led to enormous progress in all areas of human life and activity. At the same time, the pursuit of power, hubris and ignorance have often thwarted these successes. If the function of biotic self-regulation is disregarded, damaged or even overridden by human influence, systemic risks (Ortwin Renn), setbacks and ultimately chaos arise. To understand the dynamics of self-regulation, the mathematical theory of complex systems has developed models to determine critical phase transitions. Computer simulation with AI enables early warning systems to recognize crises and ultimately chaos (Klaus Mainzer).

Nevertheless, the function of natural self-regulation processes has almost become the norm in the age of the Anthropocene. In this context, the term "Anthropocene" not only describes a period in the history of our planet. Martin Grambow also uses the term to subsume humanity's often selfish behavior towards nature. Global climate change and global warming are the result. However, understanding the processes that have led to the Anthropocene also opens up the opportunity to recognize which cultural techniques could be used to avert these critical developments.

To cope with such irreversible changes, it is urgently necessary to proactively protect the function of the remaining natural forests (Anastassia Makarieva). This is not just about the Amazon Forest. Natural forests, including boreal forests, wetlands and peatlands, play an important role in sustaining life in many different areas of the world. They ensure the availability of water, oxygen and biogenic raw materials. They are therefore relevant for the climate and economy, as well as for the sustainable development of inhabited areas. This assessment is supported by the US-American science journalist Erica Gies. She has influenced our consultations with her expertise. There is a consensus that the climatic changes and their consequences (droughts, heavy rainfall, storms, etc.) that can be observed all over the world are not only caused by hydrocarbon emissions. Human intervention and disruption of services provided by natural ecosystems are just as significant.

The question of how the disregard of biotic self-regulation processes can be compensated for by human action is addressed and attempted to be answered in several contributions to this anthology.

In his contribution, Markus Vogt explains the significance of the concept of sustainability as a return to the necessity of harmonizing the environmental, economic and social spheres through systemic thinking and synergetic networking (retinity). This claim is very difficult for representatives of various scientific disciplines, as can be seen from the example of economics. After all, the economy determines - or has a major influence on - many areas of our lives. The economy has also led to an enormous inequality of distribution, which contradicts intra- and intergenerational justice. It would therefore be particularly important for the majority of economists to give much greater consideration to sustainable development as a new paradigm in teaching and research.

Human influence on natural systems can only be exerted after a thorough assessment of possible risks and their interconnections under the primacy of responsible action (Ortwin Renn). With the keyword "responsibility", we are following on from the remarks made by Hans Jonas in his book "Prinzip Verantwortung" (Principle of Responsibility) as the basis for sustainable development.

In this context, we are also reminded of the often grotesque proposals that caused a stir at the beginning of this decade. One example is the installation of an umbrella at the Lagrange point between the sun and the earth to protect the earth from overheating. Such proposals were collectively referred to as "geoengineering". Discussions between Wolfram Mauser and Peter Wilderer led to critical reflections of this term.

According to this interpretation, "engineering" refers to planned action. The term "geo" refers to the populated surface of the earth. Geoengineering therefore refers to the planned intervention in the earth system. Such interventions are not reserved for engineers. Interventions relate to the actions of everyone, parts of human society, economically active individuals and organizations as well as governmental and non-governmental administrations.[15]

Responsible action begins on a small scale and ends with action on a global scale and not vice versa. The principle of subsidiarity, as laid down in the European Union's Treaty of Rome, also applies in a figurative sense to the sustainable interaction of human systems with the ecosystem.

The contributions by Alois Heissenhuber and Herman Auernhammer describe the current situation in the field of agriculture and forestry as well as the possibilities of taking steps towards sustainable development using modern knowledge and methods while maintaining the requirements for preserving the function of biotic self-regulation.

The contributions by Werner Lang and Brigitte Helmreich should also be seen in this light. This is about settlement planning that must not only take into account the needs of people, work and mobility. It is also important to develop and implement methods to preserve the needs of nature throughout the day. Brigitte Helmreich focuses on the topic of water in built-up areas, more specifically the sustainable use of rainwater as a contribution to groundwater recharge. In his article, Werner Lang demonstrates the importance of scientific methods for analyzing the environmental impact of buildings in the planning and implementation process for the realization of a sustainable building culture.

Rao Surampalli reports on developments that lead to orderly hygienic conditions in rural areas of India and in harmony with local economic and cultural conditions. The report on an initiative by women in a village in the south of India is particularly impressive. Using their own resources, they found and established solutions that combine traditional life with modern technical means while preserving the function of the environment.

Yonghui Song recalls China's ancient philosophy, which was based on the unity of heaven and man. All things in the universe have their functional laws. The earth system also has its functional laws. The aim today is also to use the earth's resilience to react appropriately to external changes and to fully exploit the earth system's ability to self-regulate. The importance of these basic principles is increasingly being recognized and implemented in real economic activity using modern knowledge.

Finally, in the contribution, Peter Wilderer argues that the constant and natural change of the earth's system requires a like-minded change in human behavior. Nature must not be treated as a museum. The idea of preserving the given, which is deeply rooted in human beings, is misleading. According to the concept of resilience, people, society, the economy and governmental administration are obliged to perceive changes using suitable methods and, after thorough evaluation, to implement them in responsible action. This creates a perpetual cycle of adaptation that leads to rational, responsibility-

[15] In this context, the question arises: should the concept of geoengineering be expanded to include "eco-based geoengineering", which by definition describes transnational, collective action with the aim of bringing about change on a regional, but also global scale? Examples of this already exist: collective plastic waste collection, reforestation, regeneration of wetlands, avoidance of critical trace substances or their purification in sewage treatment plants and, of course, renewable energy? A role model here would be the EU, whose ecosystem-based strategies are not only effective in the territory of the contracting states, but far beyond (Renewable Energy Directive, Supply Chain Directive, EU REACH Regulation, etc.).

based self-regulation. The following compilation of recommendations for action should be examined and evaluated based on this thesis.

Closing words

The content of these 85 pages of thought-provoking impulses represent a milestone on the way to an orderly, balanced world. The document includes the recommendations for action listed below and their feasibility. They show how important science is and what science can and must accomplish.

Prof. em. Dr. Wolfgang Haber
TUM Chair of Landscape Ecology (retired)
Chair of German Advisory Council on the Environment (retired)
1993 Award of the Federal Environmental Foundation

Recommendations for Action

It is recommended that the preservation of earthly life in all its local and global manifestations be given top priority.

The totality of life on earth encompasses more than just living beings in their socialization into biocenoses and ecosystems. An equally important component is the cultural life of mankind with its essential fields of activity such as the economy, industry, state and non-state organizational structures, science, art and religion. To this end, the fulfillment of human needs must be aligned with planetary boundaries.

In order to maintain and strengthen the functioning of the earth system, it is advisable to avoid anything that restricts or even overrides the ability of living organisms and biological communities (ecosystems) to regulate themselves.

Experience shows that species diversity and time are important prerequisites for the resilience of natural systems. In forestry, large-scale deforestation to gain land for agricultural use should be avoided. Land and sea use as well as land sealing due to new settlements and infrastructure must be limited to what is absolutely necessary.

To preserve life on earth, the promotion of diversity must be given top priority.

Diversity - not just biodiversity - is an important characteristic of nature worldwide (example: diversity of landscapes). In a figurative sense, this also applies to the design of the economy and society, to the design of coexistence in cities and to the design of governmental and non-governmental organizations. Anthropogenic diversity should be developed from local cultures, traditions and experiences and enriched, but not replaced, with modern methods, for example with methods of artificial intelligence. The aim of development should be to create resilient systems that are shaped not only by industry, but also by local societies. Existing and widespread monocultures in agriculture and forestry must be converted into extended crop rotations and plant communities.

It is recommended to recognize the climate-regulating function of Earth’s remaining natural ecosystems as a common planetary legacy and a cornerstone of human long-term existence.

Throughout history, human interaction with ecosystems has been dominated by local needs and visions. It is only with the development of modern science and technology and unprecedented global consciousness of humanity as a species and society that it became possible to begin quantifying the planetary significance of the ecosystems’ stabilizing impact on the environment and climate. These processes are incredibly complex and their understanding is increasingly challenging as the area occupied by natural ecosystems continues to shrink. International protection of these ecosystems and ambitious investigations to understand them, are key for preserving human identity both as a biological species and as a highly developed ethically and intellectually competent society.

To maintain natural self-regulation and as part of climate adaptation measures, it is recommended that the preservation and restoration of near-natural forests and the preservation and restoration of the near-natural water balance be promoted in all regions worldwide. Settlement areas must also become greener and more water-friendly.

Both the forest systems and the landscape water balance have a significant influence on life-giving precipitation, temperature regulation, soil formation and thus the entire biosphere. However, they have been optimized or even eliminated worldwide for certain economic uses through cultural engineering. Preservation and reconstruction are essential to restore regional and global stability. In land use, field structures that have been linear since the beginning of cultivation must be questioned and further developed with naturally adapted contour farming systems in conjunction with adapted and new technologies. This also includes the adaptation of large urban habitats to the conditions of the Anthropocene as water reservoirs, for better cooling and - together with the promotion of social housing - to improve the quality of life and work for all social classes

Interventions in the market are legitimate to maintain the fundamental functions of the earth system. This includes the renunciation of non-renewable energies. The emission of chemical substances must be reduced overall. Large-scale ecological measures such as forest conversion or stabilization of the water balance are always preferable to technical geoengineering.

The economy must quickly adapt to resource-saving and renewable energy production. To this end, technical and non-technical measures for more consistent technology must be developed, especially about the release of chemicals. Pure technical geoengineering is considered to be risky and can in no way replace the switch to an overall resilient and sustainable cultural technology. At best, temporary measures such as interventions for rain development can be used

In addition to phasing out the use of fossil fuels, it is recommended that major efforts be made to ensure the permanent supply of water, oxygen and healthy soil.

The history of the earth teaches us that living nature has been able to cope with extreme fluctuations in surface temperature. Without the availability of water and oxygen, however, terrestrial life cannot survive. It is therefore the task of mankind to decisively counteract the global temperature fluctuations caused by humans as well as the lack of water, atmospheric oxygen and living soil.

It is also recommended that more investment be made in research and development, both in empirical data collection and in mathematical computer simulations, as well as in education and training.

The method of adaptive cycles developed in resilience research should increasingly be seen as an opportunity to help with decisions and actions and be incorporated into the everyday lives of societies and decision-makers. These highly complex processes require careful data collection (big data), mathematical modeling and AI-supported computer simulations. These methods make it possible to act in a continuous cycle of observing and evaluating changes in the current environment. Targeted education should strengthen the willingness to discard the familiar if it does not prove successful and to dare to make a new start. Priority should be given to school education from kindergarten to secondary school.

In conclusion, it is recommended that all the recommendations listed here are consistently brought together in the popular call for transformation and that the economic and social dimensions are adapted to the guardrails of the ecological dimension.

Abbreviations

AAAS	American Association for the Advances of Science
AI	Artificial Intelligence (in German: KI: Künstliche Intelligenz)
BEA	Bavarian Elite Academy
BayWA	Bavarian goods brokerage of agricultural cooperatives
EASA	European Academy of Sciences and Arts an organization headquartered in Salzburg, Austria
DEI	Diversity, Equity, Inclusion
IAS	Institute for Advanced Study
IPCC	Intergovernmental Panel on Climate Change
IWA	International Water Association
IWF	International Water Foundation
IESP	Institute for the Preservation of Earth System Function a Non-Profit Organization of EASA, seated at Munich, Germany
SIWI	Stockholm International Water Institute
SEF	Senior Excellence Faculty
YPO	Young Professionals Organization
TUM	Technical University of Munich