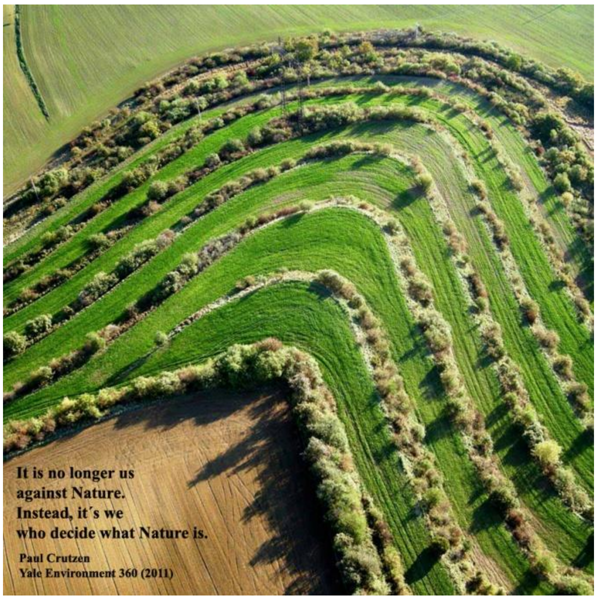
Development of Methods to Solve Transboundary Environmental Crises

IESP-Seminar

on

Sustainable Management of Natural and Engineered Landscapes



Humankind uses more and more land for its own purposes disregarding the eminent importance of land as a natural resource. We use land for settlements, industrial plants, roads and airports. We also use land – dry and wet - for the production of food, fiber and fuel. How far are we permitted to proceed in pushing-back ecosystems as the ultimate basis of life on Earth? During the seminar four outstanding scientists – Wolfram Mauser and three Stockholm Water Prize laureates - shed light in a development which gradually approaches the limits of civilization. It was, however, not the aim of the lecturers to paint a horror scenario. Instead, solutions were presented possessing the capacity to build up an effective coexistence of nature and civilization. Building on ecological principles, the lecturers present a global model which show that implementation of the proposed changes will lead to a win-win situation. Apparently, we can learn from nature how to develop a society that can flourish within the limits to growth with better conditions for prosperity and well-being.

The seminar was held in the faculty club at the TUM-Institute for Advanced Study. 33 scholars attended the lecture series, and participated in the discussion. In the following, the essence of the lectures are briefly summarized.

Lecturer

Dr. Sven Eric Jorgensen
Professor emeritus in environmental chemistry at the University of Copenhagen

Prof. Dr. Wolfram Mauser
Chair of Geography and Remote Sensing, Ludwig Maximilians University, Munich

Prof. William J. Mitsch, PhD
Director of the Everglades Wetland Research Park, Florida Gulf Coast University, Naples, USA

Dr. Peter A. Wilderer
Professor emeritus of excellence, Technical University of Munich

Participants

Dr. Thomas Baumann; Mr. Ahmed Belouazni; Mr. Rudi Fellner; Prof. Peter Fiener; Dr. Helmut Fuhrer; David Furtado; Prof. Martin Grambow; Prof. Wolfgang Haber; Dr. Andreas Hofmann; Mr. Yashwin Iddya; Willi Kiefel; Mr. Bernhard Loock; Verena Maurer; Markus Meyer; Ms. Nina Mitiaieva; Kim Pawelka; Dr. Uta Raeder; Ms. Elena Rozorvina; Mr. Dariusz Rzepecki; Ms. Annisa Satwika; Ms. Kristina Schwarzer; Ms. Ekaterina Solovyeva; Gabi Toepsch; Shuang Yang; Mr. Mojtaba Zeraatpisheh

Key Messages

Modification of landscape requires thoughtfulness; replacing nature by technology (engineering landscapes) is a no-go option.

A sizeable increase in our wetland resources around the world is necessary to solve the intrinsic environmental service of wetlands, with the strategic purpose of minimizing the excess amount of phosphorus, nitrogen, and carbon in our rural landscapes.

Today's unsustainable high intensity agriculture needs be transformed into a 21st century's sustainable information agriculture in order to preserve the ecological base of life on Earth, earn a sustained living for the rural communities and enable development of the rural societies.

It is important to write the history of the future of agriculture to explore how not to fail at the start of the anthropocene.

It is worth remembering that Nature originated and perfected the use the 3Rs: Reduce, Reuse, and Recycle.

The time is mature to leave today's policy, which is focused on short-sighted economic considerations in favor of a better environmental management, of a significant increase in the level of education, and in favor of a better solidarity and equality in society.

It is imperative to massively reduce deforestation.

Instead of expanding agricultural areas at the expense of nature, we better should increase the agricultural production by increasing the harvest yields.

There are great economic and cultural potentials in the developing countries, which would flourish if the developed countries would support more and better education.

Summary of the lectures

Sustainability, Nature and Engineered Landscapes

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Sustainable development is a process aimed at avoidance of any collapse. The participants of an internet workshop organized by IESP some months ago agreed upon this statement. Moreover, the participants agreed that continuous adaptation to changing ambient conditions is a promising approach towards collapse prevention (Bloesch et al. 2015). In nature, this process of adaption is obviously self-regulated. Over 2.4 billion years it led to the preservation of life on Earth despite of major climatic changes caused by variations of solar radiation, by impacts of celestial objects and outbreak of volcanoes. Self-regulation is not the major domain of modern anthropogenic systems, however. It is widely replaced by control based on scientific knowledge, and by the pursuit for power and profit. Moreover, time plays a very different role in natural and anthropogenic systems. In nature, adaptation processes are often very slow, whereas humankinds are impatient and obsessed for speedy progress.

Do we already know enough to be able to replace natural self-regulation by cognitive control? Let us take climate control as an example. There, the *terminus technicus* is “geo-engineering”. The question is whether landscape engineering is an option to control the regional or even the global water cycle in order to support rain-fed agriculture, and the growing number of people on Earth with food. In this context, it appears to be worthwhile to get back to the biotic pump concept presented by Victor Gorshkov and Anastassia Makarieva. According to their findings, transport of humidity from the sea to inland regions is facilitated by forest ecosystems (Makarieva et al. 2013). The mechanisms involved in this process includes evapo-transpiration, escape of water vapor into the atmosphere above the canopy, decrease of the water vapor partial pressure due to condensation, transport of water vapor molecules from regions of higher water vapor partial pressure (presumably from air pockets closer to the origin of humidity, i.e., closer to the sea). Clear cutting of forests, particularly of coastal forest interrupts the water vapor transport process. The result is drought, subsequently desertification and collapse of human societies because of the lack of food production at the local scale.

Abdication of destruction of forest ecosystems seems to be a sustainable solution of the problem. If the forest ecosystem is already gone, afforestation is to be considered as a must. However, trees grow slowly, and the re-establishment of forest ecosystems is even slower. Here comes the impatience of human beings into play. Can we speed up the process of atmospheric humidity transport by technology copying the biotic pump concept (bio-mimicry)? The solution could be to build-up an artificial forest of structures emitting ions (Corona effect). The idea is that negative ions would charge aerosols driving condensation processes in the lower atmosphere similar to the processes above the canopy of natural forests (Wilderer et. al. 2011).

Oh my! Are we ready to accept replacement of Nature by engineered landscapes of this kind? It is not only the beauty of a forest ecosystem, which would get lost. Besides the huge amount of energy necessary to operate such a system, it is not imaginable that a “robot forest” would deliver services comparable to natural forests. We, scientists and engineers, carry an enormous responsibility for the preservation of the Earth system that has demonstrated its sustainability over the past billions of years. In §6 of the Zugspitze-Declaration of 2008 (Wilderer et al., 2013) it was stated: “*Climate engineering is the deliberate, planned, large-scale intervention in the climate system. Such initiatives with potential global effects need rigorous risk and legal assessment, and authorization by a process of international consensus to which all nations are supposed to participate. Climate engineering must never be seen as an alternative to the necessity to solve the global crisis at its roots.*” In short: It is inacceptable to gamble with nature, neither on the small nor on the global scale.

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Phosphorus and Nitrogen and Carbon, OH MY!

The role of wetlands in mitigating pollutants in our landscape and globe

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The world is faced with unprecedented threats to our aquatic ecosystems from excessive nutrients, caused by agricultural and urban runoff and discharges. Fully 750 aquatic ecosystems suffer from degraded ecosystem services with impairments described as hypoxia, dead zones, and harmful algal blooms, most due to pollution caused by excessive nitrogen and phosphorus.

In addition, we have increased the atmospheric pool of carbon by 40% since industrial times leading to several impacts related to climate change. In the meantime, it has been estimated that, on a global scale, we have lost half of our original wetlands to our current extent of 8 to 12 million km^2, most of that loss in the 20^{th} century.

I am proposing here a sizeable increase in our wetland resources around the world, solving the diminishing wetland problem, with the strategic purpose of minimizing the excess phosphorus, nitrogen, and carbon in our rural landscapes in a sustainable fashion. Examples include attempts to minimize phosphorus inflows to the Florida Everglades with wetlands to quite low concentrations and a proposal to restore the Black Swamp in NW Ohio to minimize eutrophication of Lake Erie in the Laurentian Great Lakes.

Nitrogen retention by wetlands and riparian forests in Midwestern USA has been proposed for 15 years as a solution to the seasonal hypoxia in the northern portion of the Gulf of Mexico.

Finally, the case of wetlands being carbon sinks through carbon sequestration needs to be taken into account in the context of mitigating human-caused increases of CO_2 in the atmosphere, with the full understanding that greenhouse gas CH_4 emissions typical of most wetland ecosystems.

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Sustainable Management of Agricultural Land

The role of wetlands in mitigating pollutants in our landscape and globe

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Producing food is at the center of the human-environment-relations: it is the largest industry under the open sky, provides biomaterials, food, clothing (e.g., cotton), energy (e.g., firewood, energy crops) and raw material (e.g., starch). It is by far the largest user of natural resources in the form of land, genetic resources, soils and water. Food production is the global mega-employer and forms the glue of rural societies. Sustainable future agriculture is therefore central to preserve the ecological base (soil, water, atmosphere, intact ecosystems and biodiversity), earn a sustained living for the rural communities and enable development of the rural societies.

Global megatrends like population increase, urbanization, industrialization and changing life styles will double demand for agricultural products by 2050 from the 2005 level (Alexandratos, N. and J. Bruinsma (2012)). Sustainable management of agricultural land therefore faces a threefold challenge: 1) double production to meet demand, 2) exploit the existing yield potentials worldwide in a sustainable way and 3) avoid cropland expansion to protect natural ecosystems and biodiversity.

In orders to meet these challenges today's unsustainable high intensity agriculture should be developed into a 21st century's sustainable information agriculture. It will allow converting data streams from sophisticated remote sensing satellites into detailed crop development. The information for each point on each agricultural field on the Globe will collect data from intelligent sensor networks. It will use complex crop growth simulations to interpret the satellite and network observations and determine sustainable levels of fertilization and crop protection and will use the internet to inform each farmer and farming machinery on how to individually treat each piece of land and each plant in a most sustainable way. The purpose is to minimize environmental impacts and the use of resources like soil, water and fertilizer and at the same time maximize yields. This will result in sustainable intensification of agricultural production in most parts of the world and will extensify very high intensity production regions.

Simulations show that lifting existing potentials of sustainable intensification can satisfy 2050 demand without expanding today's cropland (Mauser et al.(2015)),. Information agriculture has the potential to provide the necessary technologies. Both research issues and questions remain, which have to be analyzed carefully. A central research question is how to keep the promise of sustainable extensification and intensification by knowing what the limits of sustainable management of farmland are at each point in time and at each location on the Globe. Beyond these techno-ecological research issues there remain central ethical questions: Will the algorithms make the decisions? How to keep information privacy and integrity for both humans and nature? Will companies own the information? What perception of nature and environment can 8 billion megacity people have? If our models and observation networks completely include natural and man-made systems how will we treat the remaining natural environment, biodiversity etc.? Who is reponsible?

In order to approach these questions we propose to write a history of the future of agriculture in which we try to explain:

- how information agriculture completely integrated nature into human societies (each plant, each field, each drop of water, each animal, each human)
- how models created a virtual world which made visible the state of the Earth system, the living conditions, identities and potentials of all living beings (human, animal or plant),
- how this made feeding 9.5 billion possible in a sustainable way,
- how and why we failed to share this virtual world equitably among all citizens of the planet and convert information from a commodity into a public good,
- how globally-operating private entities were able to monopolize knowledge and information, appropriate nature, lever out nation states and use the virtual world to redefine both natural species and the identities, shopping desires and life scripts of all human inhabitants on the Globe.

The purpose of this history of the future of agriculture is to explore how not to fail at the start of the anthropocene.

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Flourishing within the Limits to Growth by following nature's way

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Humans are confronted with a series of very serious problems: poverty, increased inequalities among countries and people, refugees, regional conflicts and civil wars, global climate change, faster and faster exploitation of the global non-renewable and renewable resources, rapid land use change and urbanization, and increased emissions of harmful chemicals into the environment. History has shown us that we cannot solve these problems using traditional methods based on short-sighted economic growth. Additionally, we know from natural laws that continuous growth in a finite environment is not possible at all. How can we ensure sustainable development for society on Earth? It would be possible by imitating the system that understand how to render the long-term development sustainable: to learn from nature and follow nature's way. Nature shifts from quantitative biomass growth when the resources become limiting to qualitative development by increasing resource use efficiency in terms of both improved network connectivity and information on process regulation and feedbacks. The two main ecosystem functions, flow of energy and transfer of nutrients, are accomplished by renewable energy and complete recycling of the needed elements. Nature also originated and perfected the use the 3Rs: Reduce, Reuse, and Recycle.

A global model was employed to test what it entails to apply the properties of nature on our society (Jorgensen et al. 2015). The model applies correlations based on global statistics. In particular, it considers how the development will change if

1) A revenue-neutral, resource-based Pigovian tax is increased significantly and along with commensurate tax reduction to enhance recycling and application of renewable energy.
2) We increase investment in education, innovation, and research significantly to raise the level of understanding by the population and to develop new progressive ideas to address our global problems. UN statistics have shown that it is the best investment a country can do. Yet, many invest far too little in education, innovation, and research.
3) We increase pollution abatement considerably to reduce its negative impacts on our health, nature, and production.
4) We increase aid from the developed to the developing countries to 0.8 % of GNP which would enhance the cooperation among countries, reduce poverty and the size of thepopulation growth and thereby also the number of refugees. In this context, it is important that the aid is given as support to education, health care, and family planning and not at all as military aid.

The model calculations show that it is possible to obtain a win-win situation, where both industrialized and developing nations can achieve a better standard of living – the developing countries mostly quantitatively and the developed countries mostly qualitatively. The calculations are compared with scenarios based on "business as usual" practices which include current levels of a) Pigovian (green) tax, b) investment in education, innovation and research, c) pollution abatement, and d) aid to the developing countries. The business as usual scenario shows a major collapse around the year 2060, which is in accordance to the Limits to Growth results from 1972 and the follow-up-publications from the Club of Rome.

Furthermore, the model demonstrates calculations of ecological footprints and sustainability by assessing our consumption and loss of work energy due to our use of resources and destruction of nature. These calculations lead to the following conclusions:

5) Do not increase agricultural areas at the expense of nature, but rather increase the agricultural production by increasing the harvest yields. There are great possibilities in the developing countries, particularly if the developed countries would support more and better education in the developing countries.
6) Natural areas have to be maintained because we are very dependent on the ecosystem services that the ecosystems offer us. We often forget that we get a lot of free, yet indispensable, services from nature. We must massively reduce deforestation.
7) There are several possibilities to shift from quantitative growth to qualitative development, but they are only utilized modestly. We need to use these possibilities much more, for instance by use of the three R's.
8) It is imperative to shift to renewable energy to reduce global warming. It will cost a major investment now, but will be much more cost effective then doing nothing over the long-term.
9) The time is mature that we leave today's policy focused entirely on short-sighted economic considerations and start to discuss how we can make better environmental management, increase the level of education and research, and ensure a better solidarity and equality in society. We have in this context to develop another measure of our welfare than the GNP/capita because it gives an inaccurate picture of our development direction.
10) It is necessary globally to reduce the possibilities for economic speculations, exorbitant profits, and gambling on the stock market. Abatement of corruption is urgently needed, too, to avoid new economic crises as the one that started in 2007/2008.

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Impressions