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ECOLOGY AND SOCIETY. IMPACTED ECOSYSTEMS. PART I

EKOLOGIA I SPOŁECZEŃSTWO. WPŁYW NA EKOSYSTEMY. CZĘŚĆ I

Abstract: The Earth has existed for more than four billion years and has sustained life for three billion. Human beings have existed for just 200,000 years, yet our impact on the planet is so great that scientists around the world are calling for our period in the Earth's history to be named 'the Anthropocene' - the age of humans. The changes we are now making have exacted a heavy toll on the natural world around us, and now threaten the planet's ability to provide for us all. Problems of Ecology and Society in the new geological era as the Anthropocene - 'the age of humans' - are overviewed. The name is widely recognized as a useful classification of the period in which human activity has created and continues to generate deep and lasting effects on the Earth and its living systems. Examples of the interrelated effects of exponential population growth and massively expanding consumption of natural resources called Great Acceleration are given. Updated 'planetary dashboard' of environmental, economic and social indicators charts the trajectory of the Anthropocene are briefly summarized.

Keywords: Anthropocene, Great Acceleration

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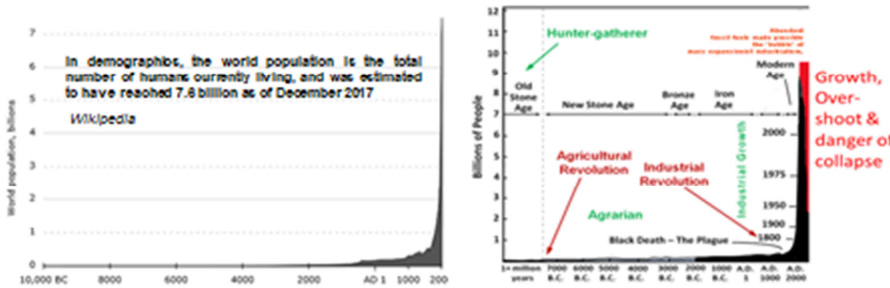
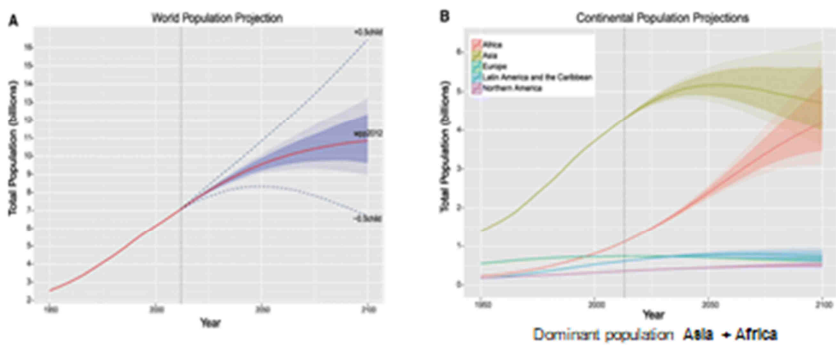
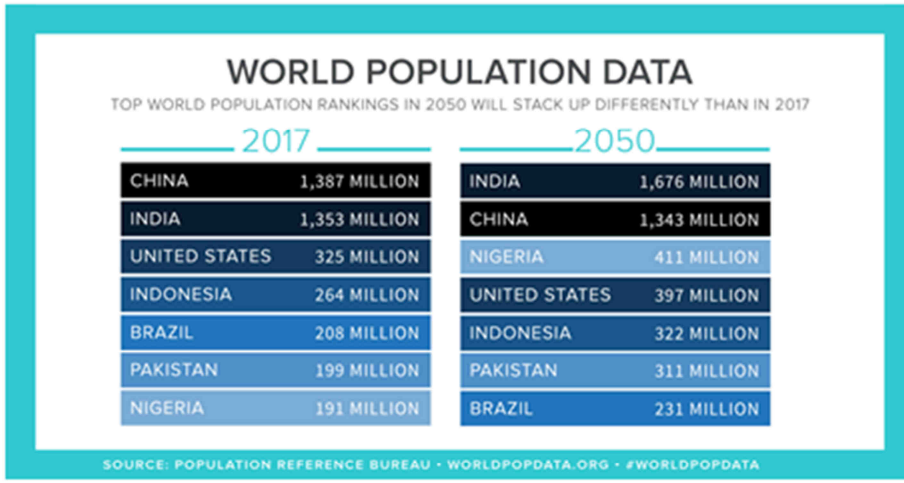


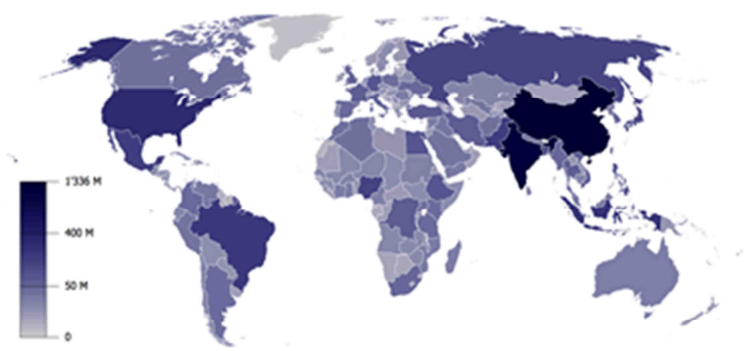
The Earth has existed for more than four billion years and has sustained life for three billion. Human beings have existed for just 200,000 years, yet our impact on the planet is so great that scientists around the world are calling for our period in the Earth's history to be named 'the Anthropocene' - the age of humans. The changes we are now making have exacted a heavy toll on the natural world around us, and now threaten the planet's ability to provide for us all.



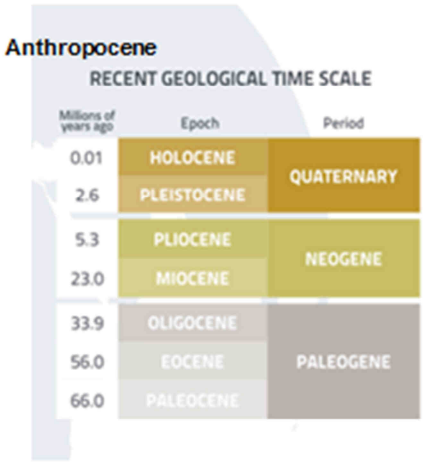
As follows from the world population projection, different scenario are discussed with most realistic by the year of 2100 of population growth close to 11 billions. Continental population projections evidence for tremendous differentiation between Asia+Africa and the rest of the world.



Population density by country



The world population is distributed unevenly over the Earth surface. Most of the world's human population lives on land (29% of the earth's surface) in South and East Asia and in-between latitudes 20 and 40 degrees north. Why? Because that's where the land is (the Southern Hemisphere is mostly ocean). Tectonic and climatic processes have concentrated minerals and habitable landforms in these land regions. Historically, good agricultural growing conditions and fertile soils gave rise to sustained population growth while too cold or too dry areas impeded population concentrations. Today, most people live in cities and towns because international commerce and trade can sustain these population concentrations, even in hot deserts and frozen shores.



When **Paul Crutzen*** first proposed the idea of the Anthropocene, he suggested it probably began as the Industrial Revolution kicked off around 1800.

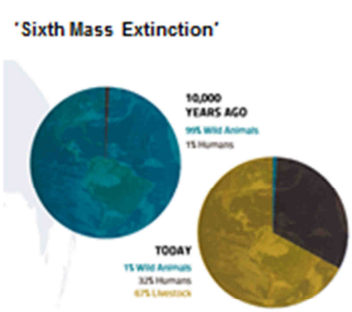
*"The Nobel Prize in Chemistry 1995 was awarded jointly to **Paul J. Crutzen**, Mario J. Molina and F. Sherwood Rowland, **for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.**"

Anthropocene, the current epoch in which humans and our societies have become a global geophysical force. The Anthropocene began around 1800 with the onset of industrialization, the central feature of which was the enormous expansion in the use of fossil fuels. We use atmospheric carbon dioxide concentration as a single, simple indicator to track the progression of the Anthropocene. From a preindustrial value of 270-275 ppm, atmospheric carbon dioxide had risen to about 310 ppm by 1950. Since then the human enterprise has experienced a remarkable explosion, the Great Acceleration, with significant consequences for Earth System functioning. Atmospheric CO_2 concentration has risen from 310 to 380 ppm since 1950, with about half of the total rise since the preindustrial era occurring in just the last 30 years. **The Great Acceleration is reaching criticality.** Whatever unfolds, the next few decades will surely be a tipping point in the evolution of the Anthropocene.

Interesting collection of papers is presented in the PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY, published in 2011, from conceptual and historical perspectives up to anthropogenic transformation of terrestrial biosphere.

Two upper pictures (photos) taken from the space demonstrate the Anthropocene at one glance: most populated areas are those where the electricity is present. Traces of most intense air traffic are obviously seen in the right picture. The third picture depict Asia and Europe as mostly populated areas of the world.

Since the beginning of the XIXth Century, by its own growing activities, Mankind opened a new geological epoch: the Anthropocene. The views above show and documentary shock you with a view of human impact on the planet.



The **Holocene extinction**, otherwise referred to as the '**Sixth extinction'** or **Anthropocene extinction**, is the ongoing extinction event of species during the present **Holocene epoch**, mainly as a result of human activity.

Before humans existed, the species extinction rate was (very roughly) one species per million species per year. Estimates for current species extinction rates range form 100 to 10,000 times that, but most hover close to 1,000 times prehuman levels (≈ 10% per century).

The impact of human activity upon our planet is now so profound and potentially long-lasting that the renaming of our geological era as the Anthropocene - 'the age of humans' - is being advocated by a growing body of scientists. In parallel, there is growing consensus that the Earth is undergoing the 'Sixth Mass Extinction', a permanent loss of multiple species caused not by natural phenomena but human activity.

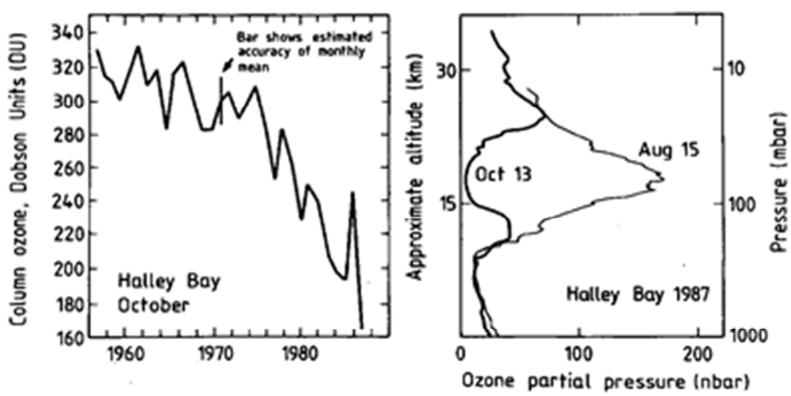
There is still debate about the causes of all mass extinctions. In general, large extinctions may result when a biosphere under long-term stress undergoes a short-term shock. An underlying mechanism appears to be present in the correlation of extinction and origination rates to diversity. High diversity leads to a persistent increase in extinction rate; low diversity to a persistent increase in origination rate. These presumably ecologically controlled relationships likely amplify smaller perturbations (asteroid impacts, etc.) to produce the global effects observed.

- During the past 3 centuries human population has increased tenfold to 7600 million and fourfold in the 20th century
- Cattle population increased to 1400 million (one cow/family); by a factor of 4 during the past century
- There are currently some 20 billion (20,000 million) of farm animals worldwide
- Urbanisation grew more than tenfold in the past century; almost half of the people live in cities and megacities
- Industrial output increased 40 times during the past century; energy use 16 times
- Almost 50 % of the land surface has been transformed by human action
- Fish catch increased 40 times
- The release of SO_2 (110 Tg/year) by coal and oil burning is at least twice the sum of all natural emissions; over land the increase has been 7 fold, causing acid rain, health effects, poor visibility, and climate changes due to sulfate aerosols
- Releases of NO to the atmosphere from fossil fuel and biomass burning is larger than its natural inputs, causing regional high surface ozone levels
- Several climatically important "greenhouse gases" have substantially increased in the atmosphere, eg. CO_2 by 40 %, CH_4 by more than 100 %.

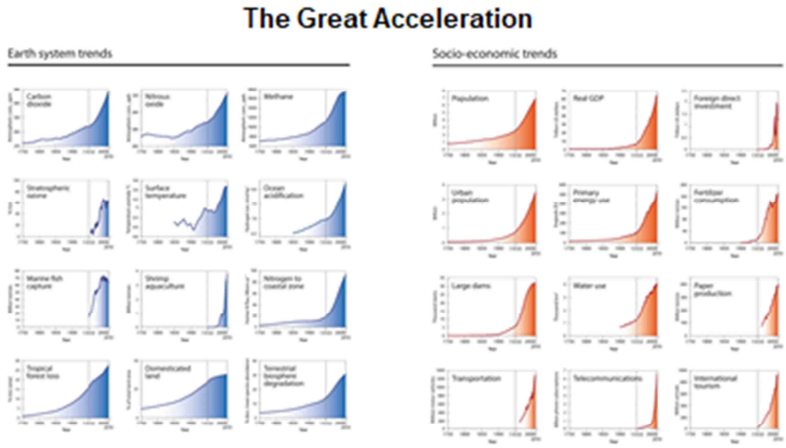
- Humanity is also responsible for the presence of many toxic substances in the environment and even some which are not toxic at all, but which have, nevertheless, led to the ozone hole
- Among the „greenhouse gases" are also the almost inert CFCs (chlorofluorocarbons, *Freons*) gases. However, their photochemical breakdown in the stratosphere gives rise to highly reactive chlorine and bromine gases (radicals), which destroy ozone by catalytic reactions. As a consequence, UV-B radiation from the sun increases, leading, for instance, to enhanced risk of skin cancer.

CFCs (Chlorofluorocarbons) are anthropogenic compounds with virtually no natural background. Their industrial production started in the 1930s and 1940s. Between this time and the 1990s, their atmospheric concentration increased, first quasi-exponentially, then quasi-linearly. In the late 1980s, the Montreal protocol led to a drastically reduction in CFC production. Consequently, the atmospheric concentrations of CFCs leveled off. Presently, the atmospheric concentrations of CFC11 and CFC 113 are decreasing significantly. That of CFC12 is in a plateau and will drop at a lower rate.

CFC production and use CFCs or chlorofluorocarbons are compounds that are essentially inert in the troposphere. The main compounds used as tracers in natural systems are CFC 11 (CCl_3F), CFC 12 (CCl_2F_2) and CFC 113 CCl_2F-$CClF_2$). All compounds have no known natural sources. In the early literature, CFC 11 and CFC 12 were also called chlorofluoromethanes due to their methane-type structure. The trade name of CFCs (DuPond) is Freon (F 11, F 12, F 113). CFCs are degraded in the stratosphere by photo dissociation. The resulting chlorine radicals contribute to the destruction of the ozone layer.



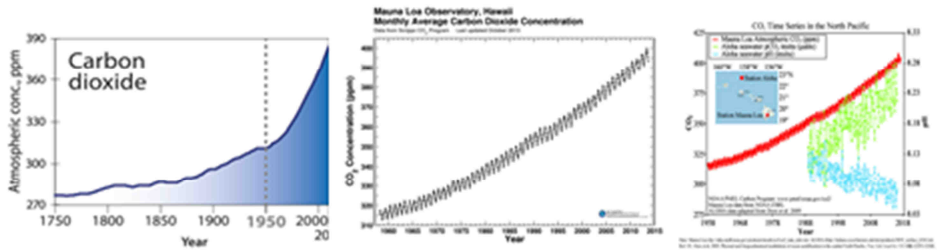
Fortunately, the CFC (chlorofluorocarbons, *Freons*) gases are no longer produced, but it will take 50 years or more to heal the ozone hole.



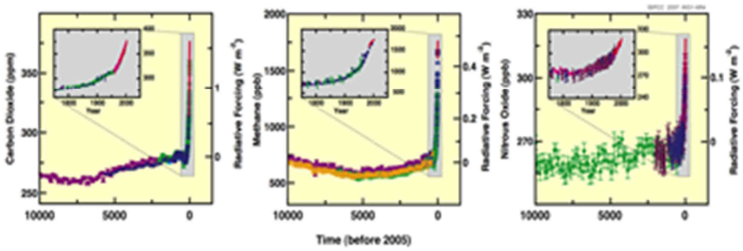
http://www.igbp.net/globalchange/greatacceleration.4.1b8ae20512db692f2a680001630.html

The **Great Acceleration** refers to the most recent period of the Anthropocene during which the rate of impact of human activity upon the Earth's geology and ecosystems is increasing significantly. While the Anthropocene commenced with Industrial Revolution if not long before, the Great Acceleration begins in the XXth century with the acceleration rate dramatically increasing after the Second World War. This concept has been further extended to refer to the rate of change in technology and society as a whole. In tracking the effects of human activity upon the Earth, a number of socioeconomic and earth system parameters are utilized including population, economics, water usage, food production, transportation, technology, green house gases, surface temperature, and natural resource usage. The Anthropocene is typically depicted as following the Holocene, to emphasize the central role of humankind in geology and ecology. Since 1950, these trends are increasing significantly if not exponentially.

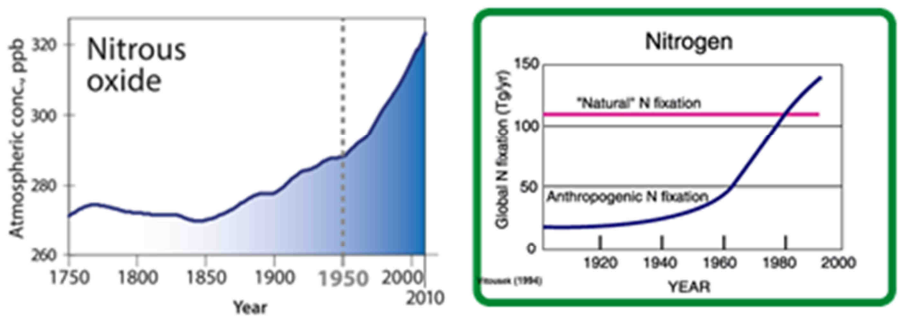
"**Great Acceleration**" graphs were originally designed and constructed as part of the synthesis project of the International Geosphere-Biosphere Programme (IGBP), undertaken during the 1999-2003 period. The synthesis aimed to pull together a decade of research in IGBP's core projects, and, importantly, generate a better understanding of the structure and functioning of the Earth System as a whole, more than just a description of the various parts of the Earth System around which IGBP's core projects were structured. The increasing human pressure on the Earth System was a key component of the synthesis. The project was inspired by the proposal in 2000 by **Paul Crutzen**, a Vice-Chair of IGBP, that the Earth had left the Holocene and entered a new geological epoch, the Anthropocene, driven by the impact of human activities on the Earth System (Crutzen, 2002; Crutzen and Stoermer, 2000). **Crutzen** suggested that the start date of the Anthropocene be placed near the end of the 18th century, about the time that the industrial revolution began, and noted that such a start date would coincide with the invention of the steam engine by James Watt in 1784.



Changes in Greenhouse Gases from ice-core and Modern Data

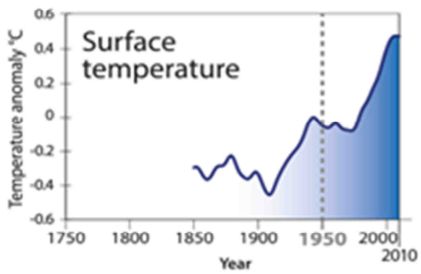


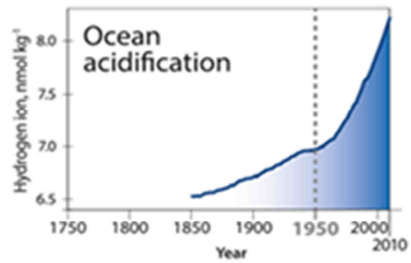
Carbon dioxide CO_2 as well as methane and nitrous oxide show their practically exponential growth with time.



Nitrous oxide, commonly known as laughing gas or nitrous, is a chemical compound, an oxide of nitrogen with the formula N_2O. At room temperature, it is a colorless non-flammable gas, with a slight metallic scent and taste. At elevated temperatures, nitrous oxide is a powerful oxidizer similar to molecular oxygen. Nitrous oxide occurs in small amounts in the atmosphere, but recently has been found to be a major scavenger of stratospheric ozone, with an impact comparable to that of CFCs. It is estimated that 30 % of the N_2O in the atmosphere is the result of human activity, chiefly agriculture.

Nutrient pollution in ground water can be harmful, even at low levels. Excess nitrogen in the atmosphere can produce pollutants such as ammonia and ozone, which can impair our ability to breathe, limit visibility and alter plant growth. When excess nitrogen comes back to earth from the atmosphere, it can harm the health of forests, soils and waterways.

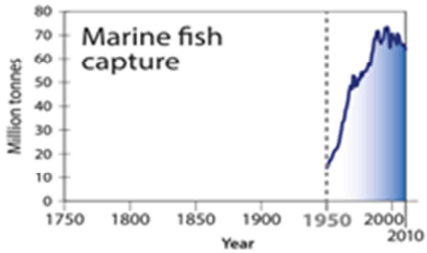


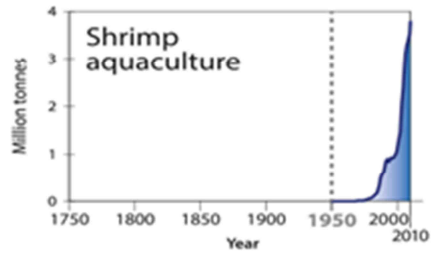


Grouth of surfface temperature
+
grown of energy

"dead end"

Acidity of ocean water increased by 0.1 pH units, hindering carbonate-secreting organisms building their skeletons.

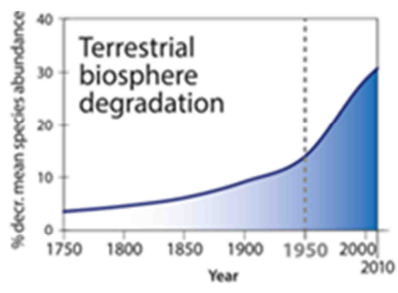


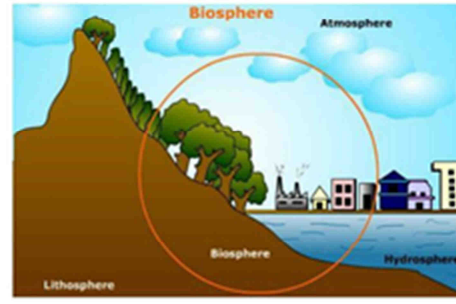


Since 1945, marine capture fisheries have developed significantly and have expanded rapidly in many developing countries. This development is mainly because of the following factors:

- the introduction of modern technologies and techniques for fishing such as the widely used monofilament nylon gill net;
- the increased motorization of fisheries boats;
- technical assistance rendered by donors and multilateral agencies such as FAO;
- inflow of capital investment for the required infrastructure;
- the discovery of new fishing grounds in offshore waters;
- the recognition of the fisheries contributions by governments and their common policy of strengthening the fisheries sector.

In the Black Sea, for example, variety of fish decreased from 60 to 6 species.



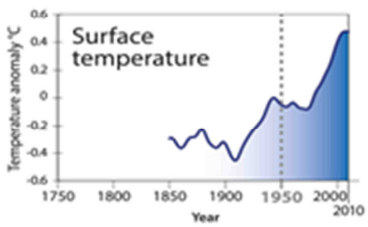


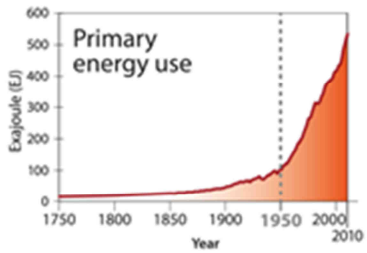
Terrestrial biosphere degradation began rapid increase in the mid of the XXth century. Thousands of species of animal, plant and microorganism are either extinct or dying out. Entire ecosystems are being destroyed. Some scientists say Earth is approaching mass extinction rates. In the past this has often been caused by a massive external event like the asteroid impact that wiped out the dinosaurs. This time, one species is responsible: humans. Humans have altered this planet permanently at levels equivalent to that of many past geological events that have justified major divisions of geological time. As we accept responsibility for the anthropogenic biosphere we have created and begin to practice the planetary stewardship we have earned in the Anthropocene, we can only hope that human systems will continue to evolve in their capacity to create and sustain the biosphere we want and need.

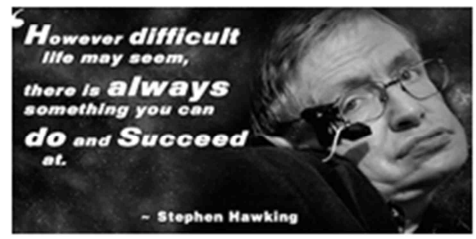
Stabilisation of atmospheric concentrations. Reductions in the human-made emission required to stabilise concentrations at current levels

Greenhouse gas	Reduction required
Carbon dioxide	> 60 %
Methane	achieved, but long term stabilisation is uncertain, for instance, by thawing of permafrost)
Nitrous oxide	70-80 %
CFC-11	achieved
CFC-12	achieved

Reduction in the human-made emissions of freons (CFC-11 and CFC-12) shows an example of positive effects, whereas reduction of other toxic substances is still need to be achieved.





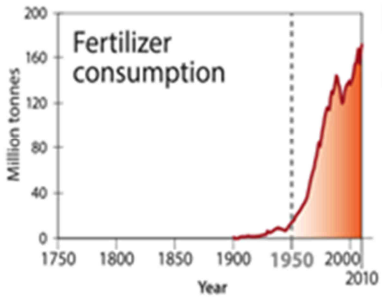


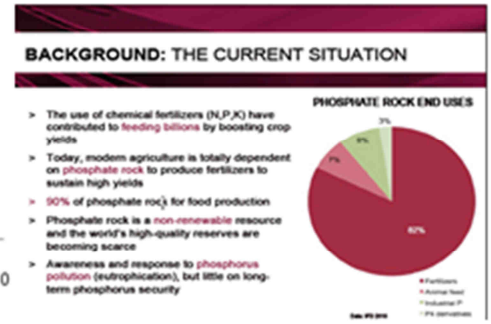
Stephen William Hawking
1942-2018

Growth of surface temperature
+
growth of energy consumption

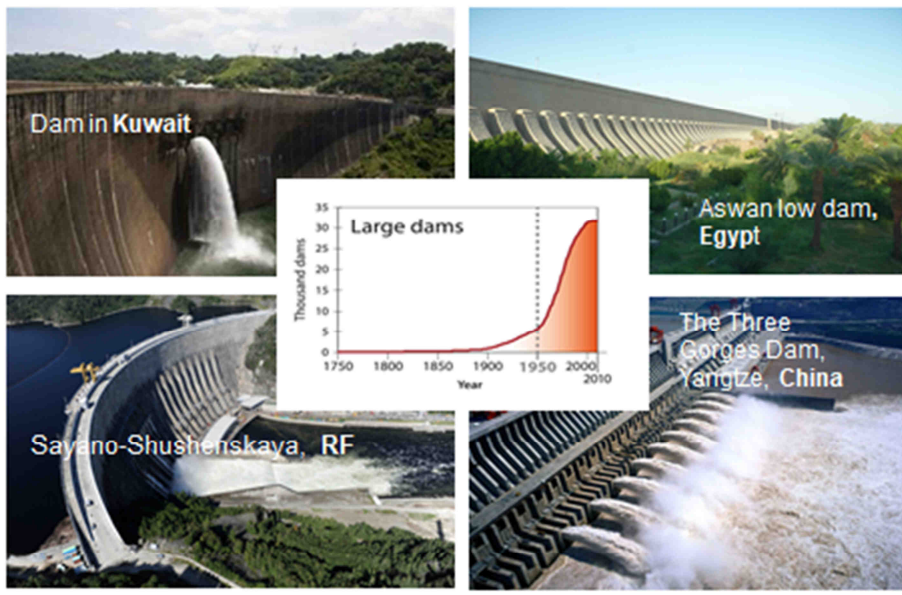
600-200 years of existence of life on Earth

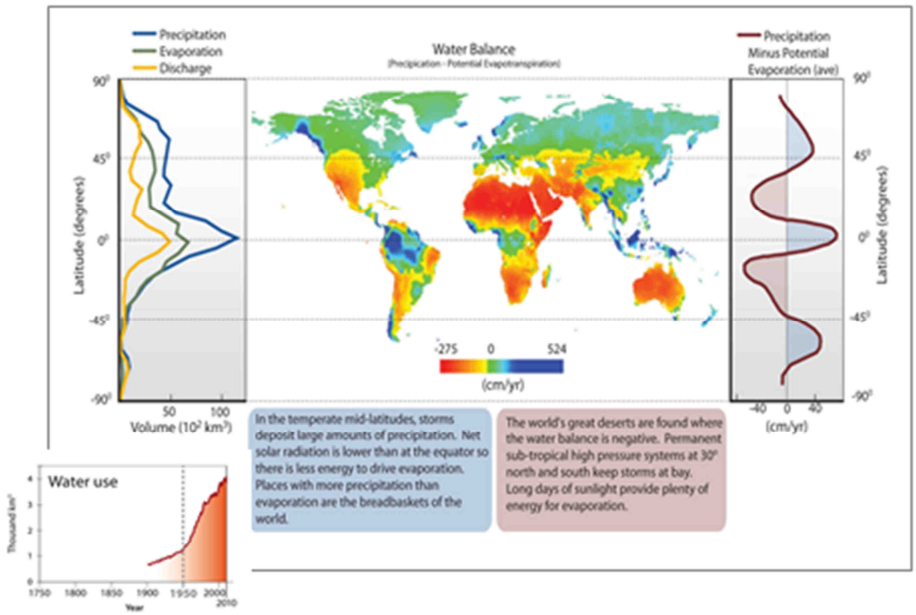
The Nitrogen and Phosphorous Problem



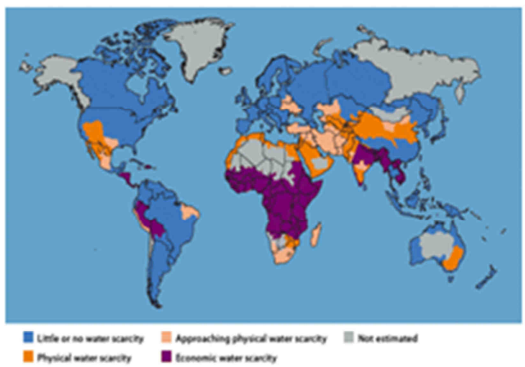


Nutrient pollution is one of most widespread, costly and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water. Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Nitrogen and phosphorus are nutrients that are natural parts of aquatic ecosystems. Nitrogen is also the most abundant element in the air we breathe. Nitrogen and phosphorus support the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water. Nutrient pollution has impacted many streams, rivers, lakes, bays and coastal waters for the past several decades, resulting in serious environmental and human health issues, and impacting the economy.





Water and Food in the Twenty-First Century



Over the past 100 years, freshwater consumption in the world has grown more than 7 times, which exceeds the consumption norms by about 10 times. As a result, the amount of fresh water per person decreased by 60 %.

Already at the beginning of the XXI century about 40 % of the population (about 2.5 billion people) of the Earth lived in conditions of very low water supply.

The number of inhabitants with a food deficit was about 0.85 billion before the 2008 crisis and was decreasing annually, but it increased abruptly after 2008 up to 1 billion inhabitants and is slowly decreasing now. Assuming a World average water consumption for food of 1300 m^3/year per capita in 2000, 1400 m^3/year in 2050, and **1500 m^3/year in 2100**, a volume of water of around 8200 km^3/year was needed in 2000, 13,000 km^3/year will be needed in 2050, and **16,500 km^3/year in 2100.**

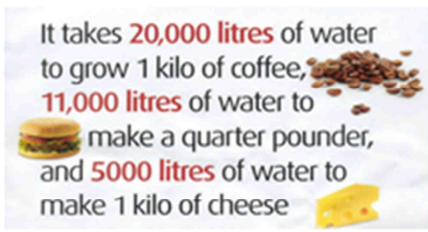
According to the forecast of the UN Secretary-General **Ban Ki-moon**, by 2030, half of the inhabitants of the earth will have nothing to drink. Therefore, all countries will have to spend 200 billion dollars annually for the desalination of ocean water, but the available energy resources can be sufficient only until 2047. Thus, at the moment, humanity stands at the line of an objective and mandatory review of the attitude to the use of available energy resources, to water, to protection water resources, their purity and rational use, to the **ecology of hydrobionts** in the decreasing volume of clean water and to understanding the problems of the hydrosphere as a whole.

In this context, **hydroecology is becoming one of the most important strategic scientific directions** in the world.

Since 2001, water and water resources have become a priority area for research by the UNESCO Natural Sciences Sector. According to UN experts, water will become a more important strategic resource in the 21st century than oil and gas, since a ton of clean water in parts of the regions (the Sahara desert and North Africa, the center of Australia, the Republic of South Africa, the Arabian Peninsula, Central Asia) is more expensive than oil.

Water use increased 9 fold during the past century to 800 m^3 per capita / year;
65 % for irrigation, 25 % industry, ~10 % households

1 kg meat → 16,000 liter of water
1 kg grain → 1000 liter of water



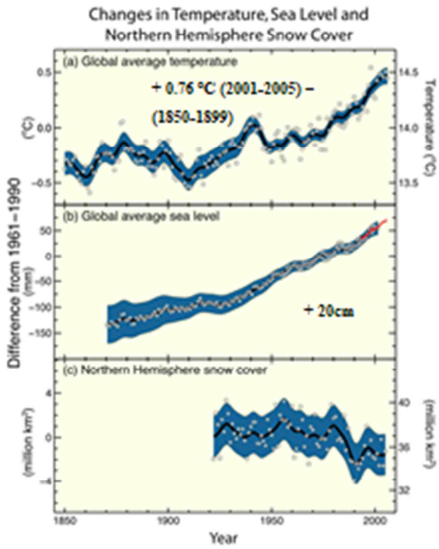
According to the **World Water Commission** (WCW), every modern person needs at least one daily 20-50 liters of water for drinking, cooking and personal hygiene, and for the production of food, but already nationwide, 2000-5000 liters are spent per person per day.

Socio-economic trends

Socioeconomic trends
www.igbp.net

Population
Real GDP
Foreign Direct Investment
Urban population
Primary energy use
Fertiliser consumption
Large dams
Water use
Paper production
Transportation
Telecommunications
International Tourism

Three last issues Transportation, Telecommunication and International tourist started their immense grown since 1950.



The Intergovernmental Panel on Climate Change (IPCC)

- Warming of the climate system is undeniable, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level
- Average global surface temperature rise 2.0-4.5 °C (1.1-6.4 °C) by 2100
- Sea level rises 19-58 cm by 2100; (S. Rahmstorff: 0.5-1.4 m by 2100)

- New studies indicate that the Arctic oceans ice cover is about 40 % thinner than 20-40 years ago
- There is dramatic climate change happening in the Arctic, about 2-3 times the pace for the whole globe
- Melting of permafrost, causing releases of CO_2 and CH_4
- **2008:** For first time commercial ships through northwest and northeast passages.

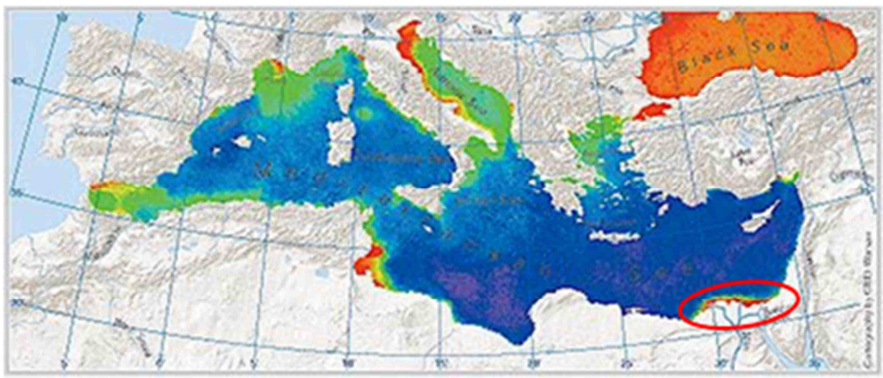
Wastes: Only 20-30 % of N fertilizer is taken up by plants.

Only about 50 % of food produced is consumed

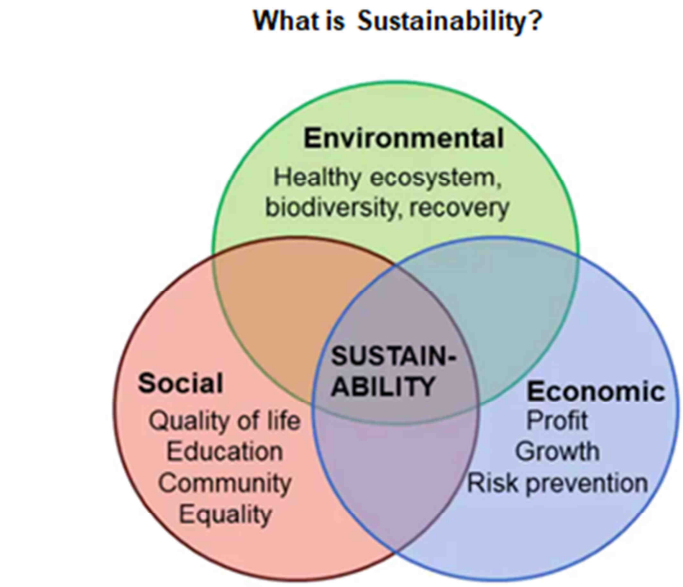
Future agriculture:

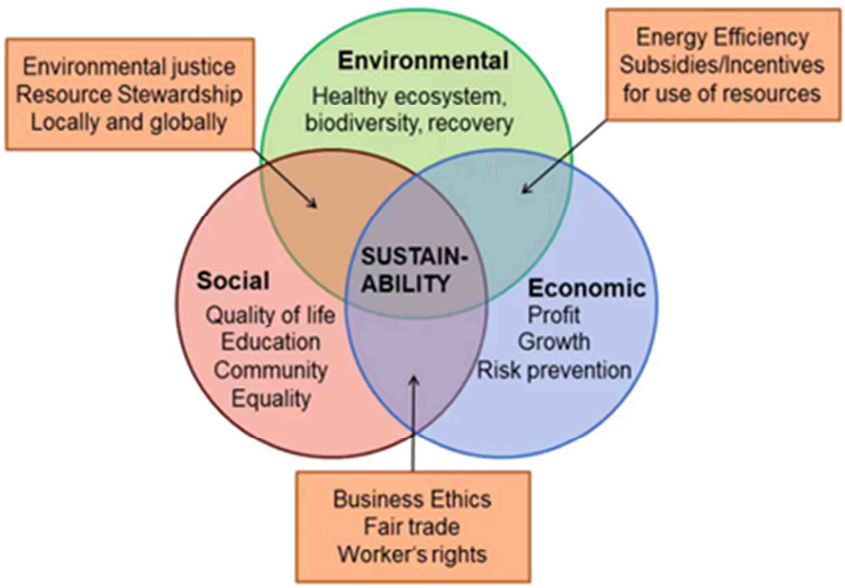
- Loss of agricultural soil through erosions is a serious problem.
- Even worse is the **loss of phosphorous**. Some studies indicate dangerous depletion in agricultural regions (tropics).
- From generation to generation, the effect of human activities is accumulating and even accelerating.
- Mankind only species that produces weapons of mass destruction (nuclear, chemical, biological).
- 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. This will require appropriate human behaviour at all scales.

The Mediterranean coastal waters affected by eutrophication, anthropogenic contamination of the Suez and Ismailia Canals and the Red Sea

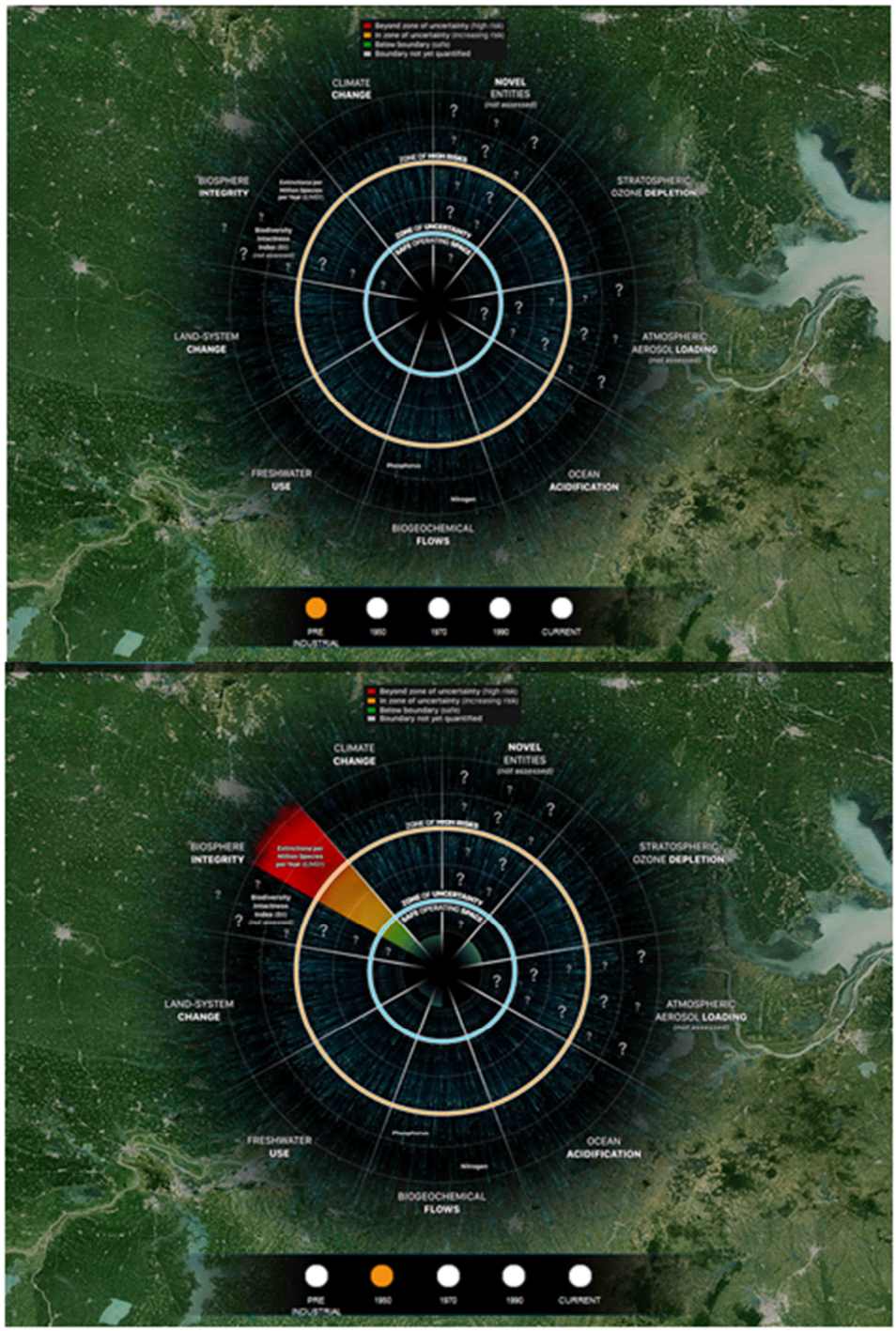


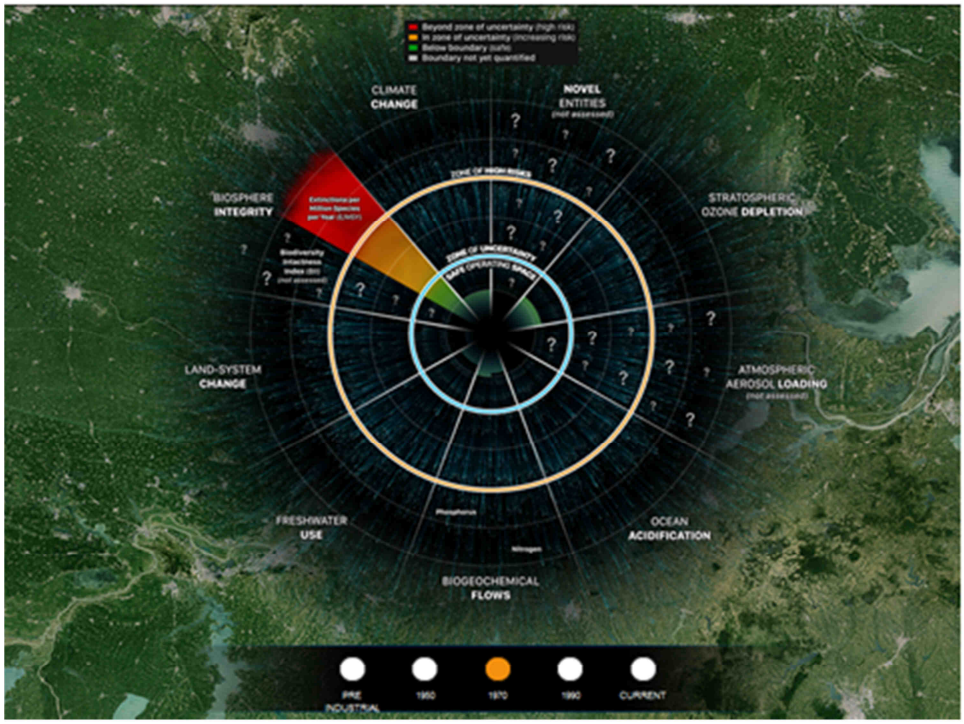
Dead zones in coastal areas have spread exponentially since the 1960s due to eutrophication fuelled by runoff of fertilizers and burning of fossil fuels. The area in red circle is the one where Sector of NAA and Applied research of FLNP JINR curries a study on water pollution by means of alga biomonitoring of the Mediterranean coastal waters near Alexandria, Egypt.

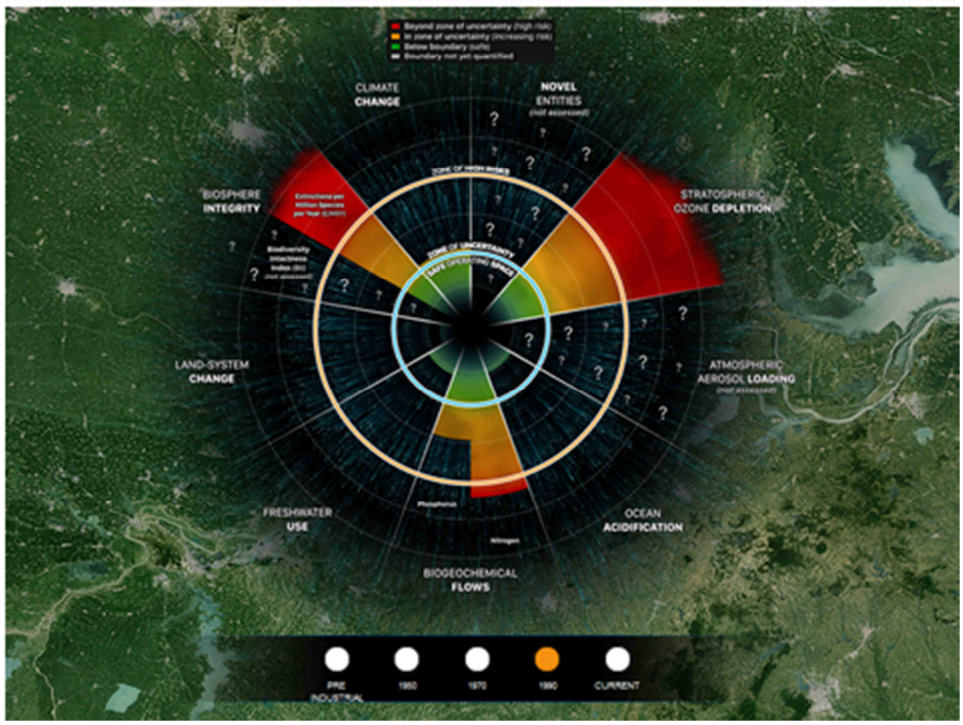

What is Sustainability?
Environmental
Healthy ecosystem,
biodiversity, recovery
Social
Quality of life
Education
Community
Equality
SUSTAIN-
ABILITY
Economic
Profit
Growth
Risk prevention


Environmental justice
Resource Stewardship
Locally and globally
Environmental
Healthy ecosystem,
biodiversity, recovery
Energy Efficiency
Subsidies/Incentives
for use of resources
Social
Quality of life
Education
Community
Equality
SUSTAIN-
ABILITY
Economic
Profit
Growth
Risk prevention
Business Ethics
Fair trade
Worker's rights

The Planetary Boundaries concept identifies **nine global priorities** relating to human-induced changes to the environment. The science shows that these nine processes and systems regulate the stability and resilience of the Earth System - **the interactions of land, ocean, atmosphere and life** that together provide conditions upon which our societies depend. Four of nine planetary boundaries have now been crossed as a result **of human activity: climate change, loss of biosphere integrity, land-system change, altered biogeochemical cycles (phosphorus and nitrogen)**. Two of these, climate change and biosphere integrity, are what the scientists call "**core boundaries**". Significantly altering either of these core boundaries would drive the Earth System into a new state. The next five pages contain information on anthropogenic impact in pre-industrial era, then in 1950, 1970, 1990 and, finally, at present time.


Beyond zone of uncertainty (high risk)
In zone of uncertainty (increasing risk)
Below boundary (safe)
Boundary not yet quantified
CLIMATE CHANGE
NOVEL ENTITIES
(not assessed)
BIOSPHERE INTEGRITY
STRATOSPHERIC OZONE DEPLETION
LAND-SYSTEM CHANGE
ATMOSPHERIC AEROSOL LOADING
FRESHWATER USE
OCEAN ACIDIFICATION
BIOGEOCHEMICAL FLOWS
PRE INDUSTRIAL
1950
1970
1990
CURRENT


Beyond zone of uncertainty (high risk)
In zone of uncertainty (increasing risk)
Below boundary (safe)
Boundary not yet quantified
CLIMATE CHANGE
NOVEL ENTITIES
(not assessed)
BIOSPHERE INTEGRITY
STRATOSPHERIC OZONE DEPLETION
LAND-SYSTEM CHANGE
ATMOSPHERIC AEROSOL LOADING
(not assessed)
FRESHWATER USE
OCEAN ACIDIFICATION
BIOGEOCHEMICAL FLOWS
ZONE OF HIGH RISK
ZONE OF UNCERTAINTY
SAFE OPERATING SPACE
PRE INDUSTRIAL
1950
1970
1990
CURRENT


Beyond zone of uncertainty (high risk)
In zone of uncertainty (increasing risk)
Below boundary (safe)
Boundary not yet quantified
CLIMATE CHANGE
NOVEL ENTITIES
(not assessed)
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STRATOSPHERIC OZONE DEPLETION
LAND-SYSTEM CHANGE
ATMOSPHERIC AEROSOL LOADING
(not assessed)
FRESHWATER USE
OCEAN ACIDIFICATION
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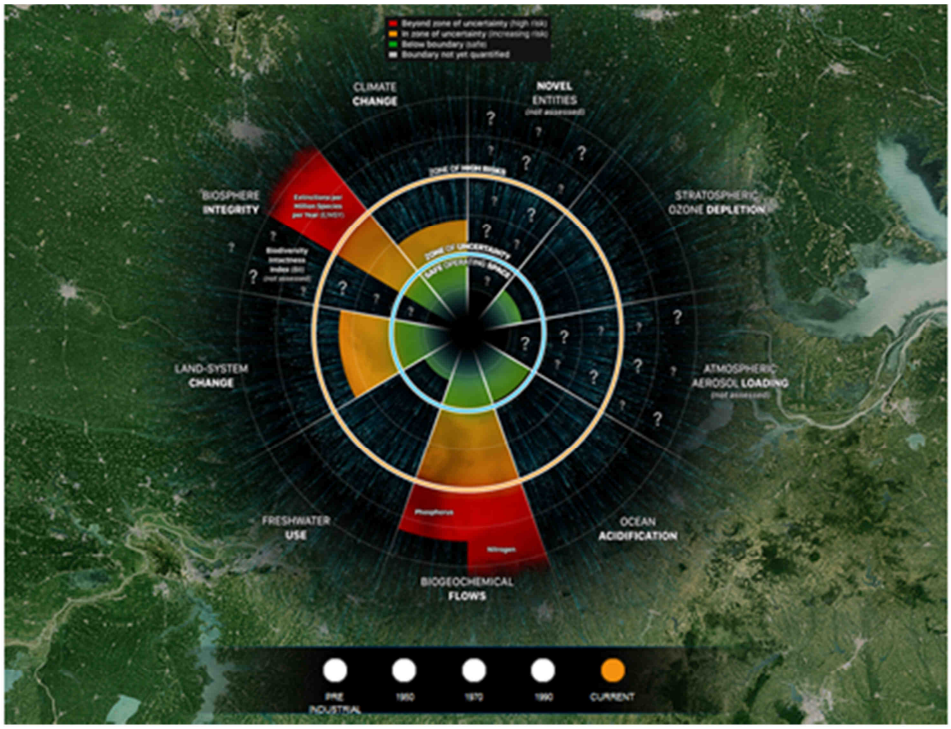
ZONE OF HIGH RISK
ZONE OF UNCERTAINTY
SAFE OPERATING SPACE
PRE INDUSTRIAL
1950
1970
1990
CURRENT



Living up to the Anthropocene means building a culture that grows with Earth's biological wealth instead of depleting it. In this new era, nature is us!

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EKOLOGIA I SPOŁECZEŃSTWO. WPŁYW NA EKOSYSTEMY. CZĘŚĆ I

Abstrakt: Ziemia istnieje od ponad czterech miliardów lat i podtrzymuje życie przez trzy miliardy. Istoty ludzkie istnieją od 200 000 lat, ale obecnie nasz wpływ na planetę jest tak wielki, że naukowcy na całym świecie przekonują, by ten okres w historii Ziemi nazwano „antropocenem" - epoką ludzi. Zmiany, które teraz wprowadzamy, spowodowały ogromne straty w naturalnym świecie wokół nas, a obecnie zagrażają zdolności planety do zapewnienia nam wszystkim życia. W artykule pokazano problemy ekologii i społeczeństwa w nowej epoce geologicznej - antropocenie - „wieku ludzi". Nazwa ta jest powszechnie uznawana za właściwą nazwę okresu, w którym działalność człowieka wpływała i nadal wpływa w istotny sposób na Ziemię i jej żywe systemy. Podano przykłady powiązanych ze sobą skutków wykładniczego wzrostu populacji i masowo rosnącej konsumpcji zasobów naturalnych, zwanej wielką akceleracją. Zaktualizowano „planetarną tablicę rozdzielczą" wskaźników środowiskowych, gospodarczych i społecznych, a następnie krótko podsumowano trajektorię antropocenu.

Słowa kluczowe: antropocen, wielka akceleracja