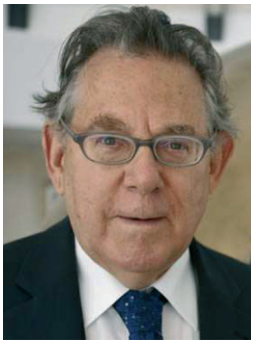
Prefaces



The Anthropocene: Geology by Mankind

Paul Crutzen, Nobel Laureate for Chemistry
Max Planck Institute for Chemistry
Department Atmospheric Chemistry

During 4,5 billion years of Earth history, after a long string of biological processes, only a million years ago, a single species 'homo sapiens' evolved, which grew increasingly capable of influencing the geology of our planet. That species is unique in the solar system and maybe beyond. A species, us, was created with a brain size of only some 1,300 g, which is capable of using and manipulating the Earth's environment in major ways from generation to generation in a catalytic fashion. Especially over the past hundred years, the human impact has become increasingly clear. Supported by great technological and medical advances and access to plentiful natural resources, the expansion of humankind, both in numbers and exploitation of the Earth's resources is astounding. Let us give a few examples.

- During the past 3 centuries human population increased tenfold to more than 6,000 million.
- This expansion was accompanied by a growth in cattle population to 1,400 million (about one cow per average size family). They produce methane gas.
- Urbanization has increased more than tenfold in the past century. About half of the human population lives in cities and megacities.
- Similarly large or larger were the increases in several other factors, such as world economy, of industries (40 times) and of energy use (16 times).
- More than half of all accessible fresh water is used by mankind.
- Fish catch increased 40 times.
- In a few generations humankind is exhausting the fossil fuels that were generated over hundreds of million of years.
- The release of sulphur dioxide, about hundred million tonnes per year, at least two times larger than the sum of all natural emissions, has led to acidification of precipitation, causing forest damage and fish death in biologically sensitive regions, such as Scandinavia and the north-east of North America. The situation in these regions has improved. However, in the meanwhile, the problem has got worse in East Asia.
- 30–50 per cent of the world's land surface has been transformed by humans; land under cropping has doubled during the past century at the expense of forests.
- More nitrogen is applied as synthetic fertilizer in agriculture than fixed naturally. Oversupply of nitrogen fertilizers have led to eutrophication of surface waters.
- Human activity has already increased species extinction rates by orders of magnitude.
- As a result of increasing fossil fuel burning, agricultural activities, deforestation, and intensive animal husbandry, several climatically important 'greenhouse' gases have substantially increased in the atmosphere over the past two centuries: CO_2 by more than 30 per cent and CH_4 by more than 100 per cent, causing the observed global average temperature increase by about 0.6 °C that has been observed during the past century.
- According to IPCC's 'business as usual scenario', global average temperatures are projected to rise by 2.0–4.5 °C during the current century and sea level is expected to rise by 9–88 cm, up to 50–140 cm.
- Humankind also releases many detrimental substances in the environment and even some, the chlorofluorocarbon gases ($CFCl_3$ and CF_2Cl_2), which are not directly toxic, but which destroy stratospheric O_3 and have led to the Antarctic 'ozone hole'. A global catastrophe has been averted through the Montreal Protocol and suc-

cessive amendments. Nevertheless, it will take more than half a century before the ozone layer may have recovered.

- Considering these and many other major and still growing impacts of human activities on earth and atmosphere, and at all scales, it thus is more than appropriate to emphasize the central role of humankind in the environment by using the term 'Anthropocene' for the current geological epoch. The impact of current human activities is projected to last and even expand over long periods. According to M. Loutre and A. Berger (2000), because of past and future anthropogenic emissions of CO_2, climate will depart significantly from natural behaviour over the next 50,000 years (no ice ages).
- To assign a more specific date to the onset of the 'Anthropocene' we propose the latter part of the 18^{th} century, when the global effects of human activities became clearly noticeable, by data retrieved from ice cores, which show the beginning of a growth in the atmospheric concentrations of several 'greenhouse gases', in particular CO_2 and CH_4. Such a starting date also coincides with James Watt's invention of the steam engine in 1784.
- Humankind will remain a major geological force for many millennia, maybe millions of years. To develop a worldwide accepted strategy leading to sustainability of ecosystems against human-induced stresses is one of the great challenges of humankind, requiring intensive research efforts and wise application of the knowledge thus acquired.

Hopefully, in the future, the 'Anthropocene' will not only be characterized by continued human plundering of the Earth's resources and dumping of excessive amounts of waste products in the environment, but also by vastly improved technology and management, wise use of the Earth's resources, and control of human and domestic animal population. For example, building on the success of the Montreal Protocol, we need something similar for climate, starting with COP 15 at Copenhagen. But maybe we run out of elements, such as phosphorus, and will experience a short Anthropocene.

Connecting Inconvenient Truths: Urgency of Nuclear Disarmament in a World of Pressing Problems[1]

Amb. Jayantha Dhanapala,
Former UN Under-Secretary General for Disarmament,
President, Pugwash Conferences on Science and World Affairs[2]

The fall of the Berlin Wall symbolized the end of the Cold War, a toxic legacy of which is the nuclear weapon. In 1989, Francis Fukuyama proclaimed the "the end of history" arguing "What we may be witnessing is not just the end of the Cold War or the passing of a particular period of post-war history, but the end of history as such: that is, the end point of mankind's ideological evolution and the universalization of Western liberal democracy as the final form of human government."

This neo-conservative dogma has propelled the world into a succession of calamities. The invasion of Afghanistan and Iraq, the bombing of its civilians, escalating global military expenditure of which the US share in 2008 was 41.5 per cent, the gulag of Guantánamo and the practice of torture and rendition, casino capitalism on Wall Street causing the greatest financial meltdown since the Great Depression of 1929, and the general rejection of multilateral cooperation as a means of finding durable global solutions to global problems are some of them.

With President Obama's policies a unique opportunity exists to reaffirm multilateralism. The 58th Pugwash Council statement of April 2009 stated that:

> the new international climate makes it possible for multilateral co-operative solutions to be negotiated for the critical issues affecting the global community. On nuclear disarmament and non-proliferation, weapons of mass destruction, terrorism, the international economic crisis, the urgent problem of climate change, the achievement of the *Millennium Development Goals* (MDGs), the strengthening of the rule of law, human rights, and other issues, the moment has arrived and we must seize the opportunity.[3]

But the international community is missing this opportunity. In November 2009, a FAO food security summit held to face the challenge of one billion hungry people in our world today declined to commit to the $ 44 billion needed as agricultural aid and failed to set a target date for the eradication of hunger. Underinvestment in agriculture – the source of livelihood for 70 per cent of the poor – will mean that in 2050 when the world's population reaches an estimated 9.1 billion, we will be in a worse situation than today.

The UN Climate Change Conference in Copenhagen failed to reach a binding agreement on greenhouse gas emissions between developed and developing countries with pledges of financial aid. In April 2010, the Obama Administration convened a World Nuclear Security Summit to ensure the safeguarding of the nuclear materials in the world and counter efforts of terrorist groups and the black market to exploit existing loopholes and weaknesses in the systems in place. In May 2010 the parties to the *Treaty for the Non-proliferation of Nuclear Weapons* (NPT) met in New York for its Eighth Review Conference forty years after the global non-proliferation regime entered into force.

Global interdependence has long been established, as the findings of the *Intergovernmental Panel on Climate Change* (IPCC 2007, 2007a, 2007b, 2007c) have shown. No state however powerful and wealthy can solve the problems facing its citizens without global cooperation that must be based in this cen-

1 This text is based on a speech at the Royal Society, London, 1 December 2009.

2 Pugwash Conferences and Joseph Rotblat were jointly awarded the Nobel Peace Prize in 1995 for their efforts to diminish the part played by nuclear arms in international politics and in the longer run to eliminate such arms.

3 See at: <http://www.pugwash.org/reports/pic/58/council-statement.htm>.

tury on the fundamental values of freedom, equality, solidarity, tolerance, and respect for nature and shared responsibility as lessons gleaned from the pages of history. The holistic approach to international peace and security that has now evolved compels us to recognize that there can be "no security without development; no development without security and no security or development without human rights" (Kofi Annan 2005). A convergence of national and human security (Ogata/Sen 2003) is also needed. We observe the interconnection among the problems facing our global community from nuclear weapon possession and proliferation, the risks of the peaceful uses of nuclear energy, the problems of climate change, the escalation of world military expenditure to levels exceeding those of the Cold War and the conflicts they fuel, the poverty of the 'bottom billion' (Collier 2007), international terrorism and the danger of non-state actors acquiring weapons of mass destruction, the widespread violation of human rights and other issues. The global chain connecting us all is as strong as its weakest link.

With the end of the Cold War we hope to end ideological or civilizational confrontation. New challenges facing the global community are terrorism, nationalism, and consumerism. Without global responses we are likely to endanger the future of our planet through nuclear annihilation or disastrous climate change or both.

The global reach of modern international terrorism with its complex network of funding, arms purchases and supplies, training and planning, is new, and 9/11 represents its epitome. It has resulted in a global consensus condemning terrorism in all its forms and manifestations, and a recognition that no cause justifies the use of terrorism. Thirteen international conventions were adopted to counter terrorism. Evidence of terrorist groups seeking weapons of mass destruction has emerged, and the network of clandestine nuclear proliferation activities of Dr. A. Q. Khan enhances the danger of nuclear terrorism. International cooperation is the key to combating terrorism.

That cooperation is undermined by nationalism. With supranational economic entities like the European Union and other regional and global international organizations, nation states were prematurely regarded as historical relics of the 1648 Treaty of Westphalia. Nationalist competition over territory and resources dominated international politics until World War II when the United Nations was established with the hope of eliminating "the scourge of war" and ushering in global cooperation for freedom, peace, development, and human rights. In the post-Cold War phase, nationalism is alive with multiple ethno-nationalist groups, all seeking to achieve statehood. It is also evident in the actions of large countries defending their national security interests. This trend cannot be underestimated. Dangers arise from the covert support for terrorism by some countries to groups elsewhere in support of irredentist claims or international rivalries. Encouragement of groups who have used or continue to use terrorist means by the grant of recognition or by arms supplies violates the global strategy against terrorism. It can also be self-destructive as terrorist groups created for one purpose mutate horribly to strike back even at their own creators.

Thus the Taliban, financed and run by the CIA against the Soviet invaders in Afghanistan, transformed themselves into the extremist force that harboured Bin Laden and incubated global terrorism against the USA and others. Within South Asia, Indira Gandhi's short-sighted policy of encouraging Bhindranwale as a counter to the Akali Dal's dominance in the Punjab led to Sikh terrorism and her own assassination. Examples abound but the lessons are not learned as surreptitious means are found to finance, arm, and otherwise support groups to destabilize neighbours or opponents in the perceived national interest. And so the unbridled nationalism of some countries is in conflict with the common interest of stamping out terrorism in terms of the UN strategy of 2006. We have to ensure that the legitimate pursuit of national security interests meshes with common and cooperative security and a norm-based structure that serves our interests.

Nationalism spurs nuclear weapon possession that is identified as an insurance policy for national security and as a symbol of global power status. But nuclear deterrence cannot be good for some and bad for others. Hence the clandestine WMD programmes of Saddam Hussein's Iraq which were discovered and destroyed by the UN and the IAEA acting under the authority of the Security Council; and North Korea's withdrawal from the NPT and subsequent nuclear tests. There was also popular jubilation when India and Pakistan conducted their nuclear tests in 1998 and became nuclear weapon states. Similarly, there were also strong nationalistic reactions of Iran over its enrichment of uranium at its Natanz and Fordo facilities belatedly reported to the IAEA.

Finally, consumerism has become an important driver of the global economy. With mass production,

consumerism is now a global phenomenon that lubricates markets and creates a demand for commodities and brands. The recent emergence of large economies in the South, particularly in China, India and Brazil, has led to a demand for energy and other commodities, entailing a rise in prices already distorted by agricultural subsidies in the USA, the European Union, and other developed countries. Economic nationalism drives protectionism, obstructing free and fair trade. Despite the stalemate over the Doha Round of the World Trade Organization, we need to move rapidly for equality in terms of trade, so allowing developing countries access to markets and to commodities that their people seek in an increasingly interdependent world. We cannot continue the use of fossil fuels to satisfy the consumer demands of the world. The reports of the IPCC (1990, 1995, 2001, 2007) argued that case. To ignore them would be a supreme, self-destructive folly.

The case against hydrocarbon has resulted in a 'nuclear renaissance'. Although Article IV of the NPT guarantees that non-nuclear weapon state parties will have an 'inalienable right' to the peaceful uses of nuclear energy, the world has suddenly woken up to the perils of this. It is less the threat of massive radiation leaks or accidents, like in Chernobyl (1986) and Three Mile Island (1979), to human lives and the environment but more the lack of credible firewalls between peaceful uses of nuclear energy and the development of nuclear weapons. The signing of the voluntary Additional Protocol of the *International Atomic Energy Agency* (IAEA) is no longer the confidence building measure. Many proposals for the multilateralization of the fuel cycle have been made. While some states will opt not to have their own enrichment facilities others will not want to be dependent on foreign supplies of nuclear fuel for their development needs. The dilemma could be resolved through innovative technology with proliferation-resistant reactors and the elimination of highly-enriched uranium. The discovery of other cheaper and safer sources of energy and greater investment in wind and solar power could also lower the demand for nuclear power.

The interconnectedness of these 'isms' is self evident. So also is their link with prevailing crises and the solutions. The first crisis is the possible use of the 8,392 nuclear weapons deployed by the nine nuclear weapon states (of their combined 23,300 warheads) either by accident or in accordance with their nuclear doctrines (SIPRI 2009: 16). President Obama (2009) said in Prague that

> one nuclear weapon exploded in one city – be it New York or Moscow, Islamabad or Mumbai, Tokyo or Tel Aviv, Paris or Prague – could kill hundreds of thousands of people. And no matter where it happens, there is no end to what the consequences might be – for our global safety, our security, our society, our economy, to our ultimate survival.[4]

Building on studies of a 'nuclear winter' (Crutzen/Birks 1982) caused by the use of nuclear weapons, more recent research has concluded[5] that even a minor nuclear war with 0.03 per cent of the current global arsenals will produce catastrophic climate change.

- Nuclear weapon proliferation arises largely from the strong demand for national security in a world of competing nationalisms where some nations are permitted to have these weapons and others are not. Neither the NPT nor the Nuclear Terrorism Convention together with UN Security Council Resolution 1540 which seeks to prevent terrorist groups acquiring weapons of mass destruction, can hold this demand in check as long as nuclear weapons are held by some states and vast amounts of enriched uranium and separated plutonium lie around.
- The second crisis confronting us is climate change caused by our global consumption patterns, the prevailing structure of international trade and our failure to invest in and cooperate in the search for new environmentally friendly sources of energy.

Both crises have the best chance of being resolved through a nuclear weapon free world – consistently espoused by Pugwash and more recently endorsed by George Schultz, Henry Kissinger, Sam Nunn, and Bill Perry.[6] This vision is being pursued by President

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4 The White House, Remarks by President Barack Obama, Hradèany Square, Prague, Czech Republic, 5th April 2009; at: <http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered/> (24 November 2009).

5 A. Robock, L. Oman, G. L. Stenchikov, O. B. Toon, C. Bardeen, and R. P. Turco: "Climatic consequences of regional nuclear conflicts"; at: <http://climate.envsci.rutgers.edu/pdf/acp-7-2003-2007.pdf>.

6 George P. Shultz, William J. Perry, Henry A. Kissinger, and Sam Nunn: "A World Free of Nuclear Weapons", in: *The Wall Street Journal*, 4 January 2007, A15, and see also George P. Shultz, , William J. Perry, Henry A. Kissinger, and Sam Nunn: "Toward a Nuclear Free World", in: *The Wall Street Journal*, 15 January 2008, 13; at: <http://online.wsj.com/article/SB120036422673589947.html?mod=opinion _main_commentaries> (24 November 2009).

Obama. Any delay in implementing nuclear disarmament and nuclear non-proliferation policies can be dangerous even though Obama himself hedges on a timetable for achieving his vision. The Obama-Medvedev Joint Statement of 1 April 2009[7] and Obama's Prague speech of 5 April 2009 set the goals[8] that are being implemented through

- the resumption of bilateral US-Russian negotiations for a follow-up to the *Strategic Arms Reduction Treaty* (START) that expired on 5 December 2009 with significant nuclear weapon reductions in both countries that own 95 per cent of nuclear weapons;
- the lifting of US impediments to the negotiation of a *Fissile Material Cut-off Treaty* (FMCT) in the Conference on Disarmament permitting other countries to reciprocate;
- the message by Obama to the parties to the NPT at their Preparatory Committee meeting in New York in May 2009 stressing the US commitment to the NPT;
- the statement of Secretary of State Hillary Clinton at the Article XIV Conference of the *Comprehensive Nuclear Test Ban Treaty* (CTBT) in New York, 24 September 2009;
- President Obama's statement on 24 September 2009 and the unanimous adoption of Resolution 1887 (2009) stressing more non-proliferation than nuclear disarmament;
- and the return to diplomacy resulting in fresh negotiations with Iran on the basis of IAEA proposals and the prospect of direct US-North Korean talks.

But obstructionist tactics are evident in the nuclear disarmament area both within the USA and with some NATO allies. As a confidence building measure President Obama has reversed the US ballistic missile defence plans in the Czech Republic and Poland. But the unfulfilled agenda is huge as is the task of setting the right conditions for a successful NPT Review Conference in May 2010. A new US Nuclear Posture Review must reflect the Obama vision accurately by abandoning nuclear first use and launch-on-warning capabilities deemphasizing the role of nuclear weapons in US defence strategy. The US senate must 'advise and consent' to both treaties: the new START and the CTBT. A well-organized campaign is needed and compromises must be reached to maintain his domestic and international support. The Nobel Peace Prize Committee has referred to Obama's "vision of a world free from nuclear arms (which) has powerfully stimulated disarmament and arms control negotiations".

West European leaders, especially within NATO, and of countries enjoying the shelter of the US nuclear umbrella must help persuade US Senators of the global importance of ratifying the new START and the CTBT. There is an international responsibility to protect the vision of Obama. In autumn 2009, the new German government has called for the elimination of US nuclear weapons from its soil. In the UK, Douglas Hurd, Malcolm Rifkind, David Owen, and George Robertson[9] supported this goal on 30 June 2008, as did the June 2009 report of the House of Commons Foreign Affairs Committee on "Global Security: Non-proliferation"[10] and the launch of the Top Level Group of UK Parliamentarians for Multilateral Nuclear Disarmament and Non-proliferation on 29 October 2009 who share the vision of a nuclear weapon free world.

However, until the UK government and the governments of other nuclear weapon states take more practical steps towards realizing this vision, a credibility gap will remain between the nuclear weapon states and non-nuclear weapon states within the NPT. Over six decades after Hiroshima and Nagasaki incremental steps towards a nuclear weapon free world makes the goal seem a mirage. The Global Zero group has set a target of 2030 for the completion of its phased verified programme for the total elimination of nuclear weapons. Reports of the *International Commis-*

7 The White House, Joint Statement by Dmitry A. Medvedev, President of the Russian Federation, and Barack Obama, President of the United States of America, Regarding Negotiations on Further Reductions in Strategic Offensive Arms; at: <http://www.whitehouse.gov/the_press_office/Joint-Statement-by-Dmitriy-A-Medvedev-and-Barack-Obama/>.

8 The White House, Remarks By President Barack Obama, Hradèany Square, Prague, Czech Republic, 5th April 2009; at: <http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered/> (24 November 2009).

9 Douglas Hurd, Malcolm Rifkind, David Owen and George Robertson: "Start worrying and learn to ditch the bomb. It won't be easy, but a world free of nuclear weapons is possible", in: *The Times*, 30 June 2008; at: <http://www.timesonline.co.uk/tol/comment/columnists/guest_contributors/article4237387.ece >.

10 UK, House of Commons Foreign Affairs Committee: "Global Security: Non-Proliferation – Foreign Affairs Committee"; at: <http://www.publications.parliament.uk/pa/cm200809/cmselect/cmfaff/222/22210.htm>.

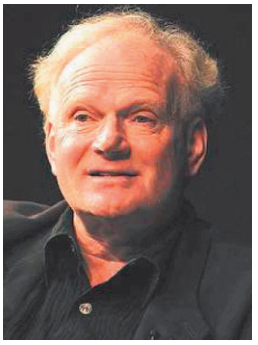
sion for Nuclear Non-proliferation and Disarmament (ICNND), co-chaired by the former Foreign Ministers of Australia and Japan, point to advocacy of a 'minimization' point of over 1,000 nuclear warheads by 2025, while President Obama says "perhaps not in my lifetime".

The simplest and most direct route would be to negotiate a verifiable Nuclear Weapon Convention to outlaw nuclear weapons as the world outlawed biological and chemical weapons. A draft Convention is before the UN, proposed by Malaysia and Costa Rica, and recommended by the Secretary-General in his 5-point plan of October 2008. It will contribute towards easing global tensions and resolving the burning issues of our times – nuclear weapons, climate change, terrorism, poverty, international finance, and human rights which intersect. With the elimination of nuclear weapons we have, in the words of UN Secretary-General Ban Ki-moon, "a global good of the highest public".

There is no greater task than achieving peace and security through disarmament. Einstein (1879–1955), the co-author of the Manifesto that continues to inspire Pugwash, once said,

> concern for man himself and his fate must always be the chief interest of all technical endeavours...in order that the creations of our minds shall be a blessing and not a curse to mankind. Never forget this in the midst of your diagrams and equations.

Scientists remain at the centre of weapon laboratories, the military industrial complexes, and energy consuming industries in all countries. National loyalties and protectionist pressures are strong in such situations and I can only quote the Russian playwright Anton Chekhov (1860–1904) who said, "Science cannot be national, in the same way that a multiplication table cannot be national. If a science becomes national it ceases to be a science." The common humanity of all scientists should act as a code of ethics to ensure nuclear disarmament and to arrest and reverse climate change. The Russell-Einstein Manifesto of 9 July 1955 said, "We appeal, as human beings, to human beings: Remember your humanity, and forget the rest." It is time to follow this advice before it is too late.



Living in and Coping with World Risk Society

Ulrich Beck

The narrative of global risk is a narrative of irony. This narrative deals with the involuntary satire, the optimistic futility, with which the highly developed institutions of modern society – science, state, business and military - attempt to anticipate what cannot be anticipated. Socrates has left us to make sense of the puzzling sentence: I know that I know nothing. The fatal irony, into which scientific-technical society plunges us, is, as a consequence of its perfection, much more radical: We don't know what it is we don't know - but from these dangers arise, which threaten mankind! The perfect example here is provided by the debate about the cooling agent CFC. About 45 years after the discovery of the CFC, the chemists Rowland and Molina (1974) put forward the hypothesis, that CFCs destroy the ozone layer of the stratosphere and as a result increased ultraviolet radiation would reach the earth. The chain of unforeseen secondary effects would lead to a significant increase of cancer all over the world. When coolants were invented no one could know or even suspect, that they would create such a danger.

The irony of risk is that rationality, that is, the experience of the past, encourages anticipation of the wrong kind of risk, the one we believe we can calculate and control, whereas the disaster arises from what we don't know and cannot calculate. The bitter varieties of this risk irony are virtually endless: climate change, mad cow decease, 9/11 terror attacks, global financial crises, swine flue virus and latest but not last, volcano ash clouds disrupting air traffic in Europe and elsewhere.

To the extent that risk is experienced as omnipresent, there are only three possible reactions: *Denial*, *apathy*, or *transformation*. The first is largely inscribed in modern culture, the second resembles postmodern nihilism, and the third is the 'cosmopolitan moment' of world risk society (Beck 1986, 1992, 2006, 2007, 2009). I would like to demonstrate that here in three steps (drawing on empirical research findings of the Munich Research Centre on 'Reflexive Modernization'):

1. Old dangers - new risks: What is new about world risk society?
2. Ruse of history: To what extent are global risks a global force in present and future world history, controllable by no one, but which also open up new opportunities of action for states, civil society actors etc.?
3. Consequences and perspectives: In order to understand the manufactured uncertainty, lack of safety and insecurity of world risk society is there a need for a paradigm shift in the social sciences?

Old Dangers - New Risks: What is New About World Risk Society?

Modern society has become a risk society in the sense that it is increasingly occupied with debating, preventing and managing risks that it itself has produced. That may well be, many will object, but it is indicative rather of a hysteria and politics of fear instigated and aggravated by the mass media. On the contrary, would not someone, looking at European societies from outside have to acknowledge that the risks which get us worked up, are luxury risks, more than anything else? After all, our world appears a lot safer than that, say, of the war-torn regions of Africa, Afghanistan or the Middle East. Are modern societies not distinguished precisely by the fact that to a large extent they have succeeded in bringing under control contingencies and uncertainties, for example with respect to accidents, violence and sickness?

As true as all such observations may be, they miss the most obvious point about risk: that is, the key distinction between risk and catastrophe. Risk does *not* mean catastrophe. Risk means the *anticipation* of catastrophe. Risks exist in a permanent state of virtuality, and only become 'topical' to the extent that they are anticipated. Without techniques of visualization, without symbolic forms, without mass media etc. risks are nothing at all. In other words, it is irrelevant, whether we live in a world which is in fact or in some sense 'objectively' safer than all other worlds; if destruction and disasters are anticipated, then that produces a compulsion to act.

The theory of 'world risk society' maintains that modern societies are shaped by new kinds of risks, that their foundations are shaken by the global anticipation of global catastrophes. Such perceptions of global risk are characterized by three features:

1. *De-localization*: Its causes and consequences are not limited to one geographical location or space, they are in principle omnipresent.
2. *Incalculableness*: Its consequences are in principle incalculable; at bottom it's a matter of 'hypothetical' risks, which, not least, are based on science-induced not-knowing and normative dissent.
3. *Non-compensatibility*: The security dream of first modernity was based on the scientific utopia of making the unsafe consequences and dangers of decisions ever more controllable; accidents could occur, as long and because they were considered compensatible. If the climate has changed irreversibly, if progress in human genetics makes irreversible interventions in human existence possible, if terrorist groups already have weapons of mass destruction available to them, then it's too late. Given this new quality of 'threats to humanity' – argues Francois Ewald (2002: 275) – the logic of compensation breaks down and is replaced by the principle of *precaution through prevention*. Not only is prevention taking precedence over compensation, we are also trying to anticipate and prevent risks whose existence has not been proven. Let me explain these points - de-localization, incalculableness, non-compensatibility – in greater detail.

The de-localization of incalculable interdependency risks takes place at three levels:

1. *spatial*: The new risks (e.g. climate change) do not respect nation state or any other borders;
2. *temporal*: The new risks have a long latency period (e.g. nuclear waste), so that their effect over time cannot be reliably determined and limited.
3. *Social*: Thanks to the complexity of the problems and the length of chains of effect, assignment of causes and consequences is no longer possible with any degree of reliability (e.g. financial crises).

The discovery of the incalculability of risk is closely connected to the discovery of the importance of not-knowing to risk calculation, and it's part of another kind of irony, that surprisingly this discovery of not-knowing occurred in a scholarly discipline, which today no longer wants to have anything to do with it: economics. It was Knight and Keynes, who early on insisted on a distinction between predictable and non-predictable or calculable and non-calculable forms of contingency. In a famous article in *The Quarterly Journal of Economics* Keynes (1937: 213–14) writes: "...by 'uncertain knowledge', let me explain, I do not mean merely to distinguish what is known from what is merely probable. The sense in which I am using the term is that in which the price of copper and the rate of interest twenty years hence, all the obsolescence of a new invention are uncertain. About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know..." However, Keynes' admonition to open up the field of economic decision-making to the unknown unknowns was entirely neglected in the subsequent development of mainstream economics (including mainstream Keynesian economics); and this denial of non-knowing has become a causal condition for the emergence of the global financial crisis in 2009.

The crucial point, however, is not only the discovery of the importance of non-knowing, but that simultaneously the knowledge, control and security claim of state and society was, indeed had to be, renewed, deepened, and expanded. The irony lies in the institutionalized security claim, to have to control something, even if one does not know, whether it exists! It are precisely unknown unknowns which provoke far-reaching conflicts over the definition and construction of political rules and responsibilities with the aim of preventing the worst. For the time being the last and most striking example of that are the volcano ash clouds in spring 2010: flights are back – ash is too!

If catastrophes are anticipated whose potential for destruction ultimately threatens everyone, then a risk calculation based on experience and rationality breaks down. Now all possible, more or less improbable scenarios have to be taken into consideration; to knowledge, therefore, drawn from experience and science there now also has to be added imagination, suspicion, fiction, fear (Ewald 2002: 273–301). The boundary between rationality and hysteria becomes blurred.

Given the right invested in them to avert dangers politicians, in particular, may easily be forced to proclaim a security, which they cannot honour. Because the *political* costs of omission are much higher than the political costs of overreaction. In future, therefore, it is not going to be easy, in the context of state promises of security and a mass media hungry for catastrophes, to actively limit and prevent a diabolical power game with the hysteria of not-knowing. I don't even dare think about deliberate attempts to instrumentalize this situation.

The Ruse of Risk: Global Risk is an Unpredictable and Impersonal Force in the Contemporary World

There is no better way than to start with an example: in 2005 Hurricane Katrina destroyed New Orleans. This was a horrifying act of nature, but one which simultaneously, as a global media event, involuntarily and unexpectedly developed an enlightenment function which broke all resistance. What no social movement, no political party, and certainly no sociological analysis (no matter how well grounded and brilliantly written) would have been able to achieve, happened within a few days: America and the world were confronted by global media pictures of the repressed *other* America, the largely racialized face of poverty. How can this relationship between risk and the creation of a global public be understood? In his 1927 book *The Public and its Problems*, John Dewey explained that not actions but *consequences* lie at the heart of politics. Although Dewey was certainly not thinking of global warming, BSE or terrorist attacks, his idea is perfectly applicable to world risk society. A global public discourse does *not* grow out of a consensus on decisions, but out of *dissent* over the *consequences* of decisions. Modern risk crises are constituted by just such controversies over consequences. Where some may see an overreaction to risk, it is also possible to see grounds for hope. Because such risk conflicts do indeed have an enlightenment function. They destabilize the existing order, but the same events can also look like a vital step towards the building of new institutions. Global risk has the power to tear away the facades of organized irresponsibility.

Egoism, autonomy, autopoesis, self-isolation, improbability of translation – these are key terms which, in sociological theory, but also in public and political debates, distinguish modern society. The communicative logic of global risk can be understood as the exact opposite principle. Risk is *the* involuntary, unintended compulsory medium of communication in a world of irreconcilable differences, in which everyone revolves around themselves. Hence a publicly perceived risk compels communication between those, who do not want to have anything to do with one another. It assigns obligations and costs to those who refuse them - and who often even have current law on their side. In other words: Risks cut through the self-absorption of cultures, languages, religions and systems as well as the national and international agenda of politics, they overturn their priorities and create contexts for action between camps, parties and quarrelling nations, which ignore and oppose one another.

I propose that a clear distinction be made between the philosophical and normative ideas of cosmopolitanism on the one hand and the 'impure' actual cosmopolitanization in the sociological sense on the other. The crucial point about this distinction is that cosmopolitanism cannot, for example, only become real deductively in a translation of the sublime principles of philosophy, but also and above all through the back doors of global risks, unseen, unintended, enforced. Down through history cosmopolitanism bore the taint of being elitist, idealistic, imperialist, capitalist; today, however, we see, that reality itself has become cosmopolitan. Cosmopolitanism does not mean - as it did for Immanuel Kant – an asset, a task, that is to order the world. Cosmopolitanism in world risk society opens our eyes to the uncontrollable liabilities, to something that happens to us, befalls us, but at the same time stimulates us to make border-transcending new beginnings. The insight, that in the dynamic of world risk society we are dealing with a cosmopolitanization under duress, robs 'impure' cosmopolitanism of much of its ethical attractiveness. If the cosmopolitan moment of world risk society is both at once: deformed and inevitable, then seemingly it is not an appropriate object for sociological and political reflections. But precisely that would be a serious mistake.

As important as all these arguments are, the decisive question is a different one: To what extent does the threat and shock of world risk society open up the horizon to *historic alternatives of political action*? For an answer see *Power in the Global Age* (Beck 2005). Here I can only outline the basic idea.

Two premises: (1) World risk society brings a new, historic key logic to the fore: No nation can cope with its problems alone. (2) A realistic political alternative in the global age is possible, which counteracts the loss to globalized capital of the commanding power

of state politics. The condition is, that globalization must be decoded not as economic fate, but as a strategic game for world power. A new global domestic politics that is already at work here and now, beyond the national-international distinction, has become a meta-power game, whose outcome is completely open-ended. It is a game in which boundaries, basic rules and basic distinctions are renegotiated - not only those between the national and the international spheres, but also those between global business and the state, transnational civil society movements, supranational organizations and national governments and societies.

The strategies of action, which global risks open up, overthrow the order of power, which has formed in the neo-liberal capital-state coalition: global risks *empower* states and civil society movements, because they reveal new sources of legitimation and options for action for these groups of actors; they *disempower* globalized capital on the other hand, because the consequences of investment decisions and externalizing risks in financial markets contribute to creating global risks, destabilizing markets, globally operating banks, and activating the power of the state as well as of that sleeping giant the consumer. Conversely, the goal of global civil society and its actors is to achieve a connection between civil society and the state, that is, to bring about a *cosmopolitan form of statehood*. The forms of alliances entered into by the neo-liberal state instrumentalize the state (and state-theory) in order to optimize and legitimize the interests of capital world wide. Conversely the idea of a cosmopolitan state in civil society form aims at imagining and realizing a robust diversity and a post-national order. The neo-liberal agenda surrounds itself with an aura of self-regulation and self-legitimation. Civil society's agenda, on the other hand, surrounds itself with the aura of human rights, global justice and struggles for a new grand narrative of radical-democratic globalization.

Why is this not wishful thinking, why is it an expression of a *cosmopolitan realpolitik*? The cosmopolitan perspective suggests that there is a hidden link between global risk and Immanuel Kant. It is precisely the stark realism of the *cosmopolitan imperative: either Kant or catastrophe! either cooperate or fail!* which is also cause for hope.

Consequences and Perspectives

It is evident, that the taken-for-granted nation-state frame of reference – what I call 'methodological nationalism' – prevents the social and political science from understanding and analyzing the dynamics and conflicts, ambivalences and ironies of world risk society. This is also true - at least in part - of the two major theoretical approaches and empirical schools of research, which deal with risk, on the one hand in the tradition of Mary Douglas, on the other in that of Michel Foucault. These traditions of thought and research have undoubtedly raised key questions and produced extremely interesting detailed results as far as understanding definitions of risk and risk policies is concerned, work which no one can dispense with and which will always remain an essential component of social science risk research. Their achievement and their evidence are to open up risk as a battle for the redefinition of state and scientific power.

An initial defect lies in regarding risk more or less or even exclusively as an ally, but failing to perceive it as an *unreliable* ally and not at all as a potential antagonist, as a force hostile both to nation state power as well as to global capital. Surprisingly the research traditions of Douglas and Foucault define their problem in such a way, that the battle over risk always comes down to the reproduction of the social and state order of power. Because the nation state, which attempts to deal with global risks in isolation, resembles a drunk man, who on a dark night is trying to find his lost wallet in the cone of light of a street lamp. To the question: Did you actually lose your wallet here, he replies, no, but in the light of the street lamp I can at least look for it.

In other words, global risks are producing 'failed or bankrupt states' - even in the West (last example Greece, but maybe in the near future also Italy or Great Britain or even the USA). The state-structure evolving under the conditions of world risk society could be characterized in terms of both inefficiency *and* post-democratic authority. A clear distinction, therefore, has to be made between rule and inefficiency. It is quite possible, that the end result could be the gloomy perspective, that we have totally ineffective and authoritarian state regimes (even in the context of the Western democracies). The irony here is this: manufactured uncertainty (knowledge), insecurity (welfare state) and lack of safety (violence) undermine *and* reaffirm state power beyond democratic legitimacy. Given the maddening conditions of world risk society, the older critical theory of Foucault is in

danger of becoming simultaneously affirmative and antiquated, along with large areas of sociology, which have concentrated on class dynamics in the welfare state. It underestimates and castrates the communicative cosmopolitan logic and irony of global risks; consequently the historic question, where politics has lost its wallet, that is, the question of an alternative modernity, is analytically excluded by the vain searching in the cone of light of the nation state street light.

Cosmopolitan social sciences, which face up to the challenges of global risks, must also, however, shed its political quietism: Society and its institutions are incapable of adequately conceptualizing risks, because they are caught up in the concepts of first nation state modernity, believing in scientific certainty and linear progress, which by now have become inappropriate. And it has to face the question: How can non-Western risk societies be understood by a sociology, which so far has taken it for granted, that its object - Western modernity - is at once both historically unique and universally valid?[1] How is it possible to decipher the internal link between risk and race, risk and enemy image, risk and exclusion?

1 See special issue on "Varieties of Second Modernity: Extra-European and European Perspectives", of: *British Journal of Sociology* 61(3), ed. by U. Beck and E. Grande, September 2010 (in print).

Population Prospects and the Challenges of Sustainability

Hania Zlotnik[1]

As the world prepares to cope with the challenges posed by environmental change, the implications of the rapid population growth that started almost a century ago and of future population trends cannot be ignored. Between the late 1920's and today, the population of the world has more than tripled, passing from 2 billion to nearly 7 billion. Except for a short hiatus caused by the Second World War, the growth rate of the world population accelerated between the 1920's and the late 1960's, passing from 0.5 per cent per year to 2.0 per cent per year. Such acceleration was the result of reductions in mortality, particularly among children. Starting in the 1970's, declining fertility in developing countries began to counteract the reduction of mortality to produce a declining global rate of population growth. Yet, despite the major reductions in fertility that the majority of countries have recorded, population growth still averages 1.2 per cent per year globally and is a high 2.4 per cent per year in sub-Saharan Africa and 2.3 per cent in the least developed countries (about two thirds of which are in sub-Saharan Africa).

Because of population momentum, even if the fertility of each country were to reach replacement[2] level tomorrow, the world population would still increase to 9 billion by 2050 and, in a scenario without further change in fertility and mortality, it would attain 10.1 billion by mid-century and still have a large potential for continued growth.

These population outcomes need to be borne in mind when considering the medium variant projection (UN 2009) produced by the United Nations Population Division, whose results are the most often used to indicate the likely size of the world population by mid-century. In the medium variant, mortality is projected to decrease in all countries and fertility levels in developing countries are projected to fall below replacement level, whereas the fertility of developed countries is expected to recuperate somewhat from the very low levels reached over the past decade. The result is a population of 9.1 billion in 2050, whose annual rate of change would have dropped to 0.3 per cent by then and would therefore be well on the way to stabilization. Nevertheless, this low growth rate is not equally shared by all development groups. Developed countries as a whole are projected to have a declining population in 2050. In sharp contrast, the population of the least developed countries will still be growing at a rate of 1.1 per cent annually and the rest of the developing world will have a population that is nearing the end of population growth, rising annually at a low rate of just 0.2 per cent.

According to the medium variant, nearly all the increases in population expected from now to 2050 will occur in developing countries. Out of the additional 2.2 billion people expected to live on Earth by 2050, 48 per cent will be added to the population of Asia and 43 per cent to that of Africa. The least developed countries, which account for just 12 per cent of the world population today, are projected to account for 36 per cent of the population growth expected from now to 2050 under the medium variant.

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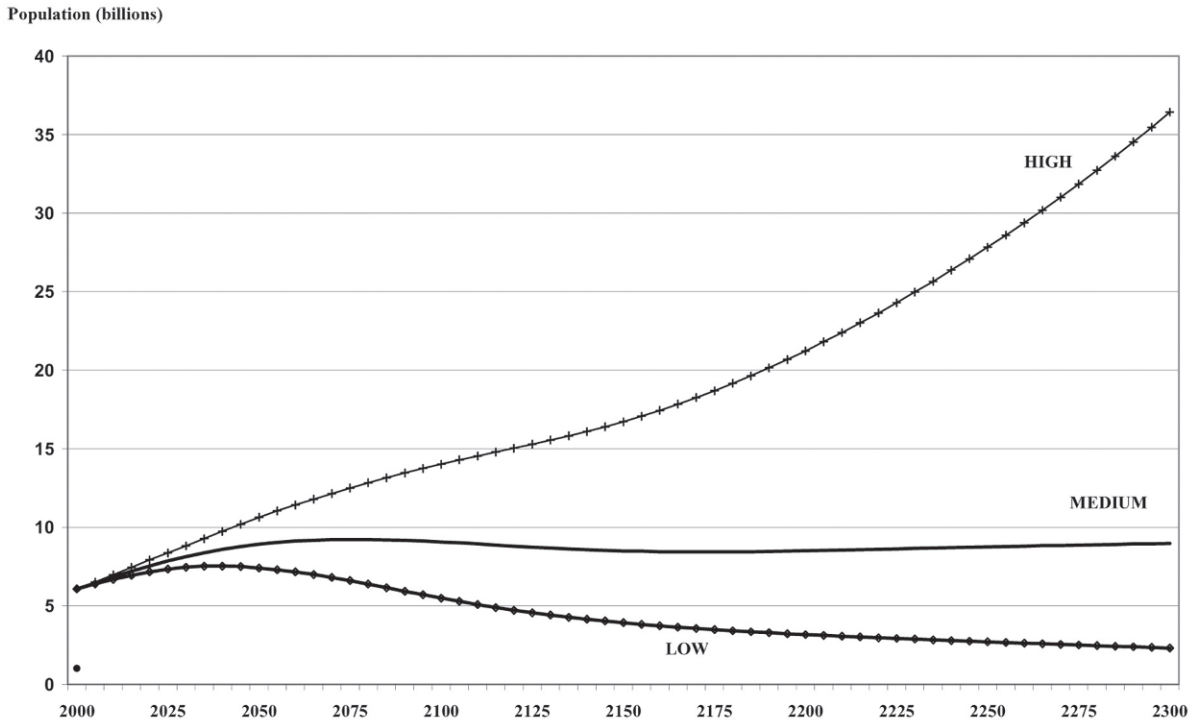
1 The views and opinions expressed in this essay are those of the author and do not necessarily represent those of the United Nations.

2 Replacement-level fertility is the number of children women should have on average to ensure that every woman is replaced by a daughter. Because some women die before they reach the age when they can reproduce and more boys are born than girls, replacement-level fertility is always above 2 children per woman and can be much higher in high-mortality countries. In the scenario whose results are cited here, replacement-level fertility is calculated exactly for each country according to its level of mortality.

Figure PE 4.1: World population according to different scenarios, 2000-2300. **Source:** UN (2004).



These trends present opportunities and challenges. The population reductions expected in developed countries as a whole can help moderate the impact that high standards of living have on the environment. Similarly, slowing population growth in the majority of developing countries can assist in counterbalancing the impact that accelerated economic growth will likely have on the forces leading to environmental change. Yet, even with slowing population growth, India alone will account for nearly 18 per cent of future population increases and, together with China, Indonesia and Brazil, in order of importance, will add 541 million inhabitants to Earth by 2050 or a quarter of the overall projected population increase.

In the least developed countries, the rapid population growth still expected to occur is likely to present more challenges than opportunities. Precisely the populations that are already most vulnerable to environmental change because of the limited capacity and resources they have to adapt are those most likely to see their numbers double over the next forty years. An Africa of 1 billion people today is very likely to become the home of 2 billion by 2050. The least developed countries, whose current population is 0.9 billion, are projected to have 1.7 billion inhabitants by mid-century.

The Sensitivity of Long-term Population Trends to Deviations from Zero Population Growth

In 2004, the United Nations Population Division produced long-range projections to 2300 to explore the impact that deviations from replacement-level fertility would have on the eventual size and distribution of populations (UN 2004). The medium scenario in that set of projections produced a world population of 8.9 billion in 2050 and a population that peaked at 9.2 billion in 2075, declined to 8.3 billion in 2175 and then increased slowly to reach again 9.0 billion in 2300. Underlying those changes in population size was a fertility path that kept every country at below replacement level for about 100 years and then returned fertility to replacement level[3] and maintained it there until 2300. The population did not quite stabilize over the projection period because mortality was projected to keep on declining, producing therefore a sustained but very slow population increase.

3 Replacement-level fertility for each country was calculated according to its level of mortality. If mortality is constant and net migration is nil, maintaining fertility at replacement level yields eventually an unchanging population with zero population growth.

Two different scenarios were produced to test the sensitivity of future population size to small but sustained deviations of fertility from replacement level. Thus, a low scenario, where fertility remained a quarter of a child below that in the medium scenario, yielded a 2300 population of just 2.3 billion, similar in size to the global population in 1950. In contrast, a high scenario where fertility remained a quarter of a child higher than in the medium scenario produced a 2300 population of 36.4 billion.

Even more telling was the scenario where fertility was maintained constant at the level it had in 1995–2000. Under that assumption, world population soared to 244 billion by 2150 and 134 trillion in 2300, indicating the unsustainable character of current fertility levels. Furthermore, all the projected population increase occurred in the developing world, whose population rose from 4.9 billion in 2000 to 134 trillion in 2300. Africa's population alone was projected to rise from 0.8 billion in 2000 to 115 trillion in 2300. In contrast, the population of developed countries as a whole was projected to be cut in half, from 1.2 billion in 2000 to 0.6 billion in 2300. This unlikely scenario served to highlight the stark regional differences that exist today in population trends and their implications for the future.

Although none of the scenarios produced as part of the long-term projections may actually come to pass, their implications are clear: positive deviations from zero population growth maintained over the long run are unlikely to be sustainable. So far, the major cause of the global deceleration of population growth has been the reduction of fertility, which dropped from nearly 5 children per woman in 1950–1955 to 2.6 in 2005–2010. The medium variant produced in 2008 projected that global fertility would be slightly below replacement level by 2045–2050, at 2.0 children per woman. To attain that level, fertility still needs to decline in many countries, including in the least developed countries, where fertility averages 4.4 children per woman, and in a number of other developing countries, especially those in South-central Asia, Western Asia and Northern Africa, where fertility still averages just under 3 children per woman, and in Central America, where it averages close to 2.5 children per woman. A number of measures can be taken to promote and facilitate the further reduction of fertility, including improving information and access to contraceptive methods (UN 2009a) and supporting the empowerment of women through education, equality of rights with men and women's increased participation in economic and social life.

The Increasing World Urbanization

With 50.5 per cent or 3.5 billion of the people on Earth living in cities in 2010 and urban populations growing, often at the expense of rural areas, the global population as a whole has become more urban than rural.[4] Yet, there are major disparities in the levels of urbanization among regions. Northern America, Latin America and the Caribbean, Europe and Oceania are highly urbanized, with proportions urban ranging from 70 per cent in Oceania to 82 per cent in Northern America. In sharp contrast, Africa and Asia remain mostly rural, with just 40 per cent and 42 per cent of their respective populations living in urban settlements in 2010.

A third of all urban inhabitants (1.1 billion) live in small urban localities with populations below 100,000. Another 0.6 billion live in urban centres with populations ranging between 100,000 and 500,000 inhabitants. In all, 52 per cent of the urban population lives in urban centres with fewer than half a million inhabitants. The rest live in 958 cities having more than half a million inhabitants each in 2010, only 53 of which have populations surpassing 5 million. These larger cities include 21 megacities, that is, cities with at least 10 million inhabitants, which altogether account for 9 per cent of the world urban population (324 million).

According to current projections, the level of urbanization of the highly-urbanized regions is expected to increase slowly, but a relatively rapid urbanization is projected in both Africa and Asia. Nevertheless, by 2050 both Africa and Asia are expected to be significantly less urbanized than the other regions, with 60 per cent and 65 per cent of their respective populations living in urban areas. All other regions, except Oceania, are projected to be more than 84 per cent urban in 2050.

In 2009, 140 out of the 230 countries or areas constituting the world were already more than half urban. Over the next four decades, 66 countries or areas are expected to reach that threshold for the first time. In 2050, only 24 countries or areas are expected to fall

4 This section draws heavily on the following United Nations publications: UN (2009b, 2010); and on "World Urbanization Prospects: The 2009 Revision", Press Release, New York, 25 March 2010; at: <http://esa.un.org/unpd/wup/Documents/WUP2009_Press-Release_Final_Rev1.pdf>. All UNPD documents are accessible at: <http://www.un.org/esa/population/>.

Figure PE 4.2: The world's cities above 1 million inhabitants. **Source:** UN, "World Urbanization Prospects: The 2009 Revision", Press Release, New York, 25 March 2010; at: <http://esa.un.org/unpd/wup/Documents/WUP2009_Press-Release_Final_Rev1.pdf>.

short from being half urban, including eight countries in Africa, another eight in Oceania and five in Asia.

Globally, the rural population is projected to start decreasing around 2020 and 0.56 billion fewer rural inhabitants are expected in 2050 than today, with the rural population projected to decline from 3.4 billion in 2010 to 2.9 billion in 2050. Asia, having the largest number of rural inhabitants, is expected to experience the most sizable reduction: from 2.4 billion in 2010 to 1.8 billion in 2050. In contrast, the rural population of Africa is expected to gain 147 million and to keep on rising until 2040. By 2050, Africa is expected to have 0.8 billion rural inhabitants.

The slowing pace of growth and outright decline of the rural population and the rising levels of urbanization are two sides of the same coin. Urbanization results from the restructuring of economies to become more productive and is an intrinsic part of the development process. Agriculture, the major economic activity in rural areas, is subject to diminishing returns if, over long periods, the number of agricultural workers grows more rapidly than the land available for production. When the urban productive sector can absorb the excess labour force in rural areas, both sectors benefit. Successful economies have all experienced an acceleration of urbanization. Today, countries having large proportions of the population living in rural areas are more likely to be among the least developed countries and to have lower levels of national income per capita. Conversely, higher levels of urbanization are associated with higher income levels.

Because the rural population is projected to decrease, the urban areas of the world are expected to absorb all the population growth expected over the next four decades while at the same time drawing in some of the rural population. Between 2010 and 2050, the world population is expected to increase by 2.2 billion, passing from 6.9 billion to 9.1 billion. At the same time, the population living in urban areas is projected to gain 2.8 billion, passing from 3.5 billion in 2010 to 6.3 billion 2050. Asia, which is home to the largest number of urban dwellers in the world (1.8 billion in 2010) is expected to see its urban population increase by 1.6 billion, to reach 3.4 billion. Africa, whose urban population is the fourth largest in the world in 2010, following those of Europe and Latin America and the Caribbean, is expected to see it rise by 0.8 billion, to reach 1.2 billion in 2050, when it will be the second largest after that of Asia.

The expected redistribution of the world's population between urban and rural settlements has important implications for both economic growth and environmental change. It is estimated that the 3.5 billion people living in cities today occupy 3 per cent of the Earth's land area, while the livelihoods of today's 3.4 billion rural dwellers depend mainly on cropland, which accounts for 12 per cent of the world's land area (UN 2009c). Burdening agricultural areas with the additional 2.2 billion people expected to live on Earth by 2050 would be unsustainable. Cities, where wealth, infrastructure and know-how are already concentrated, are in a better position to adapt to growing populations but to do so authorities at both the local

and the national levels must address the ills that often affect urban settlements, especially environmental contamination stemming from traffic congestion, the concentration of industry and inadequate waste disposal systems, as well as inequities arising from the persistent disparities among city dwellers, which mean that poor people bear the brunt of the negative aspects of urbanization. The expected rapid urbanization of low-income countries, particularly those in Africa and Asia, pose special challenges. Providing urban populations with access to services, including water and sanitation, transport and adequate housing, is necessary if their vulnerability to the extreme weather events associated with climate change is to be reduced. The concentration of population in cities generates the economies of scale that can justify improving planning for the provision of services in ways that are consistent with better protection of the environment.

As the world becomes increasingly urban, decisions taken today in cities across the world will shape the economic, social and environmental future of humankind. Properly managed, urbanization can help in combating poverty, inequality and environmental degradation, but action to capitalize on the opportunities it presents and to address the challenges it raises must be prompt and sustained (UN 2009c: 46–47).

Towards a Great Land-Use Transformation?

Christoph Müller, Hermann Lotze-Campen, Veronika Huber, Alexander Popp, Anastasia Svirejeva-Hopkins, Michael Krause and Hans Joachim Schellnhuber

The Climate Change Challenge and Land-use Mitigation Options

Climate change poses great threats to many compartments of the Earth System and, as a consequence, to human societies. There is growing scientific evidence that a rise of the global mean temperature by more than 2 °C (as compared to pre-industrial levels) would irreversibly harm many ecosystems and most likely exceed the adaptive capacities of many societies. In order to confine global warming to maximally 2 °C, major efforts to reduce emissions of greenhouse gases are required. These may even include 'negative emissions' of carbon dioxide to be achieved by the second half of this century: carbon dioxide may have to be actively removed from the atmosphere and deposited on land for many decades, centuries, or even millennia.

The transformation of the energy system, steering away from fossil fuels, will have to contribute the lion's share of emission reductions. However, land-use changes are currently responsible for one third of total greenhouse gas emissions, so improved land management and productivity increases on land under cultivation could significantly contribute to climate change mitigation since soils and forests store large amounts of carbon.

Several techniques that would allow for negative emissions are currently discussed: afforestation and the restoration of peat and wetlands would be the most easily accessible options. Other options such as technologies for *carbon capture and storage* (CCS) in the energy sector involve sequestration of carbon dioxide in geological formations underground. Carbon dioxide could be directly extracted from the atmosphere making use of chemical reactions turning the greenhouse gas into solid carbonates. The large-scale application of these technologies is however still in its infancy. The most promising mechanism to achieve negative emissions is to fuel power plants with biomass, extract carbon dioxide from the exhaust and sequester it underground. However, in order to draw down a really significant amount of carbon dioxide, enormous quantities of biomass would have to be processed this way.

Increasing Demands on Land and the Need for Adaptation

In many regions, most of the available resources of fresh water and fertile land are already being used excessively, either directly for the production of food, fibre, and timber, or indirectly as carbon sinks, for water and air purification, nature conservation, and many other ecosystem services. This scarcity of basic resources is amplified by a non-sustainable use, causing degradation of ecosystems and production potentials. Fifteen per cent of the global land surface (about 2 billion hectares) are currently considered as being degraded – due to overgrazing, deforestation, over-exploitation and non-sustainable agricultural practices.

Since the year 2000, global agricultural supply has not kept pace with an increasing demand for food and bioenergy. The food price spike in 2007–2008 and related food riots in more than 60 countries had many underlying causes, but increasing demand in large emerging economies and dwindling stocks were certainly part of them. High oil prices and subsidies for biofuels in rich countries urged farmers around the world to allocate land and other factor inputs to energy crops, thus reducing the production of staple food crops. Continuous droughts, e.g. in Australia, added more pressure on food markets. Finally, an underlying cause of stagnating productivity increase in

agriculture is a lack of funds for research and development.

In most countries, land prices insufficiently reflect the growing imbalance between demand and supply of fertile land. However, first conspicuous signs of land shortages have emerged. Large companies and even countries are already trying to stake their claims globally, a process known as 'land-grabbing'. In addition to buying food on the world market, several governments and large companies lease or buy land abroad, and ship the products back home. Advocates of these deals emphasize that poor countries may gain from access to new seeds and advanced farming practices. However, leasing land to financially powerful investors has also sparked conflict in the recent past. In Madagascar, public hostility to a deal that would have leased 1.3 million hectares to a South Korean company – half of the country's arable land – contributed to the overthrowing of the government. While foreign investors mostly secure land to improve food security in their home countries, an increasing number of projects involve growing biomass for fuel production. China has recently succeeded in leasing 2.8 million hectares in the Congo to construct the world's largest palm oil plantation.

Climate change is expected to increase these pressures and further reduce land productivity in many regions (chap. 1 by Brauch/Oswald Spring). The need for climate change adaptation is evident – already today. Most developing countries are located in the lower latitudes, they are dependent on agriculture, they will be strongly affected by climate impacts, and they have lower adaptive capacity (chap. 49 by Adeel; chap. 50 by Galil Hussein; chap. 51 by Arredondo/Huber-Sannwald; chap. 63 by Bikienga). People migrate from degraded to more fertile areas, from the countryside to cities, from regions that cannot provide sufficient resources to sustain people's livelihoods to more fortunate places. The war in Sudan, for example, has partly been blamed on the competition for water supplies and grazing lands. About 155 million people worldwide are known to be currently displaced by environmental conflicts and natural disasters (chap. 40 Guha-Sapir/Vos). This number could significantly grow under climate change as more people are expected to be affected by water shortages, sea level rise, deteriorating pasture land, and crop shortage.

Negative climate impacts on agriculture may be reduced through a range of adaptation measures. Adjustments in production technology and soil management, crop insurance schemes, modified agricultural policies, and diversified international trade flows can improve regional food availability and security of farm incomes. Creating more options for climate change adaptation and improving the adaptive capacity in the agricultural sector will be crucial for improving food security and rural development, and for preventing an increase in global inequality in living standards in the future (chap. 48 by Safriel; chap. 54 by García Lorca). However, at present, these improvements are often blocked by the lack of information, financial resources and good governance in the developing world.

The Earth's Carrying Capacity Conundrum

Mismatches between the demand and supply of land and its services already exist today. They could increase in the future not only due to climate change but also due to human population growth. Until the year 2100, human population is projected by the UN to grow up to 9–12 billion people, while already today about 1 billion people are undernourished. Changing lifestyles will further accelerate demand growth as people start to consume more goods that are produced with large amounts of energy, land, and water (such as meat) as soon as they can afford it.

The increasing competition for land and water resources between production sectors, ecosystem services, and regions raises the question of the Earth's carrying capacity for humans.[1] The first known attempt to answer the question of how many people the Earth can support was undertaken in the late 17th century. By extrapolating the population density of the Netherlands at that time to the global scale, Antonie van Leeuwenhoek in 1679 calculated a maximum human population of 13.4 billion people, which is astonishingly close to current UN projections of maximum world population.

Estimates of the human carrying capacities since then have varied substantially in a range of below 1 billion to more than 1 trillion people. Magnitudes reflect surprisingly well optimistic or pessimistic contemporary beliefs on the pace of technological progress and future development of energy supply. The broad range of possible lifestyles and accompanying usage

1 Ecologists define 'carrying capacity' as the population of a given species that can be supported indefinitely in a defined habitat without permanently damaging the ecosystem upon which it is dependent.

patterns of energy, land, and water complicate a direct assessment of the human carrying capacity. Estimating the human carrying capacity in any serious manner therefore requires first of all answers to a set of crucial sub-questions:

- Solar energy is theoretically infinitely abundant and could be harvested to fulfil all global energy needs. However, is it feasible given the current state of technology?
- It has been shown during the past 'Green Revolution' that agricultural productivity can be increased by 2 per cent per year for some time, but can this be sustained for another half a century into the future?
- How much land will be available for food production, while other land-use types for forestry, energy, infrastructure and settlements, and nature conservation also have to be taken into account?
- Agriculture accounts for 70 per cent of global freshwater use. How can agricultural water use be reduced in the future, in order to meet increasing demands from households and industry?

Defining a realistic set of assumptions on limits to technological change, energy generation, and the availability of land and water is a most difficult task. Consequently, it is more promising to undertake the *inverse* exercise and, instead of aiming at an estimate of the human carrying capacity, to ask the question: How much land, water, agricultural productivity increase, and financial resources are required to feed 9–12 billion people in a sustainable manner, i.e. without exhausting the planetary regeneration capacities?

With the given competition for the scarce resources of fertile land and water, higher production on currently used areas is a necessity. Assessments show, however, that average productivity of current cropland needs to be increased by 70 per cent by 2050 if only population growth and changing diets with rising income are considered. If further climate change impacts and increasing demand for bioenergy are taken into account, agricultural productivity may need to be increased by 150 per cent by 2050. This would be equivalent to an average annual growth rate of 2.3 per cent in land productivity over the next 40 years.

The historic development of agricultural productivity puts this challenge into perspective: The overall increase over the period 1961–2005 was approximately 1.4 per cent per year. These growth rates could be achieved because of large-scale application of artificially synthesized nitrogen (Haber-Bosch process) and chemical pest control, but also improvements in cropping methods, mechanization, and breeding. These technological advances allowed for agricultural production to keep pace with past population growth and diet changes, including rising consumption of animal products, which require higher inputs of nitrogen, water, and land per calorie produced than vegetal products. It is, however, questionable whether technological innovation and further intensification of agriculture will bring about the productivity rise needed to feed 9–12 billion people on a planet suffering from climate change and land degradation.

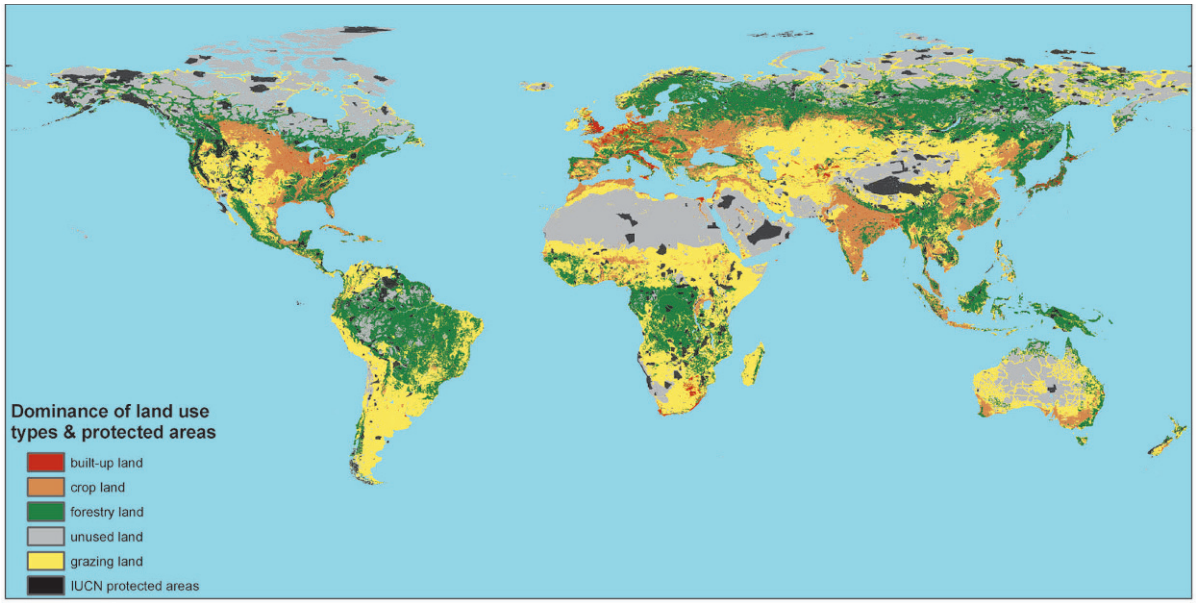
Water scarcity may be technically overcome by improved desalination. However, this depends on the availability of clean energy as well as on future cost reductions for desalination technologies. Aquaculture has the potential to provide an increasing share of world food supplies, but it is not without its own sustainability challenges regarding feed and nutrient management. In other words: It seems unlikely that improved management and technological change alone will suffice to counterbalance the increasing pressure on land and water resources.

The Great Land-use Transformation

Climate change and the scarcity of land and water resources are global-scale challenges to humankind and therefore require global-scale transformations in the energy and food systems. However, initiating and managing major socio-economic transitions is often impeded by path dependencies – or so-called "QWERTY phenomena": Q-W-E-R-T-Y are the first six letters on the upper left part of an English typing keyboard. As a matter of fact, this arrangement of symbols has become an iconic constituent of our technical culture. Interestingly, the arrangement of letters on modern computer keyboards is by no means optimized with respect to the frequencies of use defined by the language. Instead, the key configuration probably originates from some mechanical requirements for the first typewriters built in the 19th century. Similarly, societal processes are often locked, through historic pathways, into certain patterns, which are defined by past knowledge and technologies and which can only be changed through major investments and/or behavioural changes. New and potentially radical ideas and actions are needed to overcome these lock-in phenomena.

Current land-use patterns have developed over hundreds of years, largely reflecting heterogeneous

Figure PE 5.1: Global map showing current dominant land-use types: agriculture (including cropland, managed pasture land and rangeland), forestry, infrastructure and settlement, unused land, and nature conservation (protected areas as listed by the International Union for the Conservation of Nature, IUCN). Areas that are used for renewable energy generation are either included in the cropland category (in the case of bioenergy) or are not represented in the map (in the case of e.g. solar thermal power in the deserts and onshore/offshore wind energy production). **Source:** Data sets on global land-use types, i.e. built-up land, cropland, forestry land, unused land, and grazing land were provided by Erb, Gaube, Krausmann, Plutzar, Bondeau and Haberl (2007).[a]

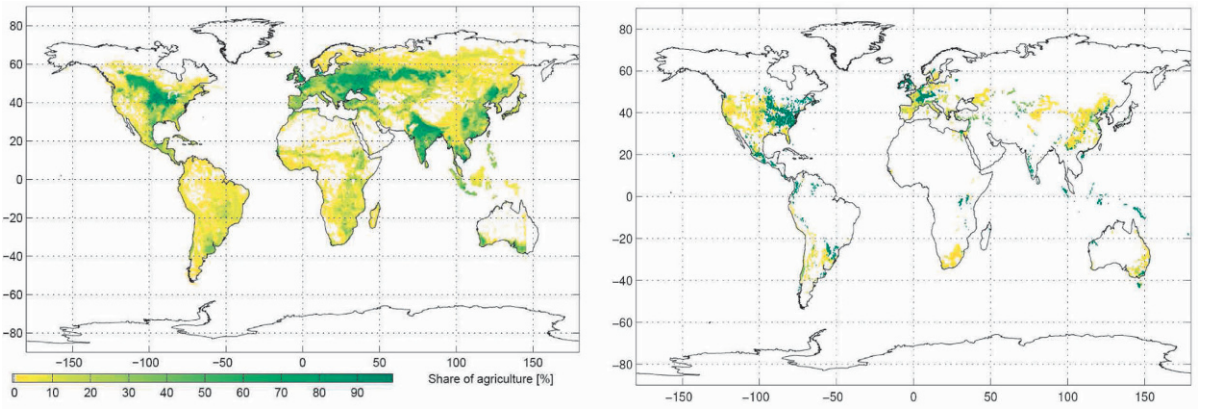


a. Currently protected areas and restricted management areas were captured by overlaying data sets on IUCN protected areas category I to VI, i.e. nature reserves and wilderness areas, national parks, natural monuments, habitat/species management areas, protected landscapes, and protected areas sustainable use of natural resources (UNEP-WCMC 2007). Data sets were integrated at a spatial resolution of 5 arc minutes, i.e. 8.3 km times 8.3 km at the equator. By rule, the land-use type bearing the maximum fraction per grid cell was defined as dominant. Built-up land which covers 10 per cent of the grid cell at a minimum was intuitively added in order to emphasize the presence of rural and urban built-up areas, industrial and transport facilities, as well as other urban areas. The IUCN protected area cover entered as a separate layer independent of the underlying land-use types. The map was produced by means of ArcGIS v. 9.2 and R v. 2.8.1.

distribution and growth of population density and productivity of the land. From a local perspective, land-use patterns have been well adapted and optimized given local resource and market conditions and constraints. However, the globalization of trade has made some parts of these local multi-purpose land-use mosaics obsolete. About 10 per cent of the total raw production of food, fibre, and forest products is traded around the world, and a much higher percentage could be allocated reasonably by the global market. Still, land-use patterns determined by history are largely persistent. This lock-in situation can be partly explained by transportation costs and the inertia of land-use patterns due to large investments required for land conversion. However, another factor is societies' and countries' desire to remain largely autonomous with respect to their most fundamental resources: food and water.

If humankind wants to manage the climate change challenge through a cooperative global strategy, such heterogeneous land-use patterns for agriculture, forestry, energy, infrastructure, and nature conservation (figure 1) may have to be questioned. If productivity cannot be increased to similar levels across the globe, due to a variety of bio-physical, social, institutional, and economic reasons, a larger share of production may have to be concentrated in the most productive areas instead. Studies show that optimal spatial allocation and specialization can, in theory, strongly reduce the area needed for agricultural production, literally leaving room for other purposes such as bioenergy production, afforestation for carbon storage, or nature conservation (figure 2).

Figure PE 5.2: Observed global agricultural land-use pattern of 1995 (left panel) versus globally optimized pattern that would allow feeding 12 billion people with 1995 dietary habits (right panel). Agricultural areas shown in right panel correspond to roughly one third of the area currently used for crop growing. **Source:** Figures were taken without modifications from Müller, Bondeau, Lotze-Campen, Cramer and Lucht (2006).[a]



a. Details on data used, underlying assumptions and optimization algorithm can be found in the publication.

The world's regions have heterogeneous potentials and different land-use categories also have very heterogeneous demands. Climate change will certainly require reallocating some of the land-use types on the planetary map simply for ensuring their functionality. There is an ongoing debate about advantages and disadvantages of segregating versus integrating nature conservation and agricultural production at the local scale. But the climate change challenge requires lifting this discussion also to the global scale. In the future, specific migration corridors may be needed which allow species to move with changing climate patterns. Agricultural areas will be abandoned if they are degraded or fall dry. Settlements may also have to be moved if droughts, heat waves, hurricanes, and floods occur more frequently, or if sea level rise threatens to inundate them.

As global land-use patterns will have to adapt to climate change, the potential for optimizing these patterns by matching the different land-use categories to the needs of heterogeneous potentials have to be considered. There are and will be regions that are especially appropriate for certain land-use types, e.g. because of their favourable climatic conditions or fertile soils. Urban areas, for example, often spread on fertile land even though they do not require them, outcompeting agricultural or forestry systems that do depend on fertile soils. The Sahara region, on the other hand, is of little use for agriculture, but is suitable for solar power harvesting, potentially combined with desalination of water along the coastlines. This, however, requires large investments to install the infrastructure for power generation and for electricity transport to the regions with high energy demand – such as Europe. Joint international efforts, like the recently launched DESERTEC project, could lead the way to the benefit of all. In the interest of climate mitigation, adaptation, and development, international efforts are needed to harmonize the spatial patterns of land use with the spatial patterns of potentials, beyond national boundaries and interests.

Global Agricultural Commons: A Proposal

'Global Agricultural Commons' may provide a way to overcome the inefficient use of land resources. Under such a scheme the most fertile areas of the planet would be declared a global public good (albeit still part of the national territories) and reserved for agricultural production. Wealthier regions increasingly expect countries like Brazil, Indonesia, and the Congo to refrain from large-scale deforestation or timber harvest and protect the global public goods and services that tropical rainforests provide to humankind. Could these countries in return expect other countries to put their productive agricultural systems to the most valuable and yet sustainable use to feed the world? Declaring the fertile soils of the Earth a common agricultural good would help to frame the supranational obligation to use them efficiently and sustainably.

The idea of conserving areas of international interest is not new: the UNESCO's 'Convention concerning the Protection of the World Cultural and Natural Heritage' and its *International Union for Nature*

Conservation (IUCN) already provide frameworks for the protection of areas of universal value. Intensive but sustainable exploitation of the agricultural production potential is, however, not yet considered a value that deserves internationally coordinated protection.

There are of course several restrictions to the idea of globally optimized land-use patterns and agricultural commons. First of all, the ecological side effects will have to be carefully evaluated. Land conversion often triggers undesired secondary effects, such as carbon emissions, degradation, or increased vulnerability to climate variability. Intensive agricultural management often comprises non-sustainable treatment of soils and water as well as spillover of nutrients and pesticides to neighbouring ecosystems and also causes emissions of nitrous oxide and methane, both being very potent greenhouse gases. These systems have high energy requirements for providing production inputs, like fertilizers, pesticides, and machinery. An optimized global land-use pattern will require more trade and transportation between the producing and the consuming regions.

There are, certainly, also many political obstacles, the most important being the lack of international trust. The supply of fundamental resources to sustain human livelihoods, like water, food, and energy, is usually considered a question of national autonomy. Not surprisingly, the most protectionist policies are prevalent in the agricultural and energy sectors. Relying on international trade for providing a larger share of domestic food supplies would require the development of strong and competitive non-agricultural sectors, which is an obstacle for many food-insecure countries.

Yet, in a world that faces the risk of dangerous climate change and the enormous challenge to guarantee a decent life for 9–12 billion people these political obstacles may have to be overcome. Planet Earth, a number of degrees Celsius warmer than today, is unlikely – if not by all means incapable – of carrying such a big human population. Rising up to the double challenge of climate change and population growth seems impossible without calling into question the current land-use pattern, which has emerged from a history that was more or less blind to considerations of global sustainability.