ENERGY, CLIMATE CHANGE AND GLOBAL FOOD SECURITY

Proceedings of a symposium arranged by the Danish National Group, Pugwash Conferences on Science and World Affairs; Center for Philosophy of Nature and Science Studies, University of Copenhagen; Swedish and Danish Branches, International Physicians Against Nuclear War; Mandela Center; SGI Denmark; Danish Peace Academy; International Network of Engineers and Scientists for Global Responsibility and the Danish Institute for International Studies

Summary

On Friday, December 4, just before the start of the United Nations Climate Summit in Copenhagen, SGI Denmark, the Danish National Pugwash Group and several other NGO's organized a symposium focusing on the severe food security problems that the world is likely to experience partway through the 21st century because of rising energy prices, growing populations and climate change.

The delegates assembling in Copenhagen are concerned with many problems, but of these, the threat of a global food crisis is one of the most worrying. At present a child dies from starvation every six seconds - five million children die from hunger every year. Over a billion people in today's world are chronically undernourished. There is a threat that unless prompt and well-informed action is taken by the international community, the tragic loss of life that is already being experienced will increase to unimaginable proportions.

As glaciers melt in the Himalayas, threatening the summer water supplies of India and China; as ocean levels rise, drowning the fertile rice-growing river deltas of Asia; as aridity begins to decrease the harvests of Africa, North America and Europe; as populations grow; as aquifers are overdrawn; as cropland is lost to desertification and urban growth; and as energy prices increase, the billion people who now are undernourished but still survive, might not survive. They might become the victims of a famine whose proportions could exceed anything that the world has previously experienced. The symposium discussed the steps that are necessary to avert such a tragedy.

The meeting was chaired by Mr. Jan Mller, President of SGI Denmark. Participants were welcomed by Dr. John Scales Avery, Chairman of the Danish Pugwash Group. The lecturers were: 1) Janet Larsen, who is Director of Research at Lester Brown's Earth Policy Institute; 2) Professor Mario Giampietro from the University of Barcelona, who is known for his studies of the large energy inputs to modern agriculture; 3) Professor Emeritus Klaus Illum of Ålborg University, who has for many years written eloquently about energy-related problems; 4) Professor Jürgen Scheffran of the University of Hamburg, who is an expert on the social consequences of a severe food crisis;

and 5) Senior Scientist Steven Starr of the University of Missouri, who spoke about the severe impact on global agriculture of even a limited nuclear war.

The speakers concluded that the threat of severe future food shortages can only be avoided by prompt and well-informed policy changes. These include

- stabilization of populations
- stabilization of climate
- stabilization of aquafers
- conservation of soils
- protection of cropland
- restriction of the use of grain for motor fuels
- investment in agriculture and agricultural research
- establisment of a global food bank

Janet Larsen pointed out that individuals can help in three areas of life: 1) In the home - energy-saving light bulbs, insulation; 2) Transportation - bicycles, public transport; 3) Personal diet - less meat. Individuals can also become more politically active and demand that their politicians address the problems.

For a detailed discussion of these issues, Janet Larsen recommended Lester Brown's recent book, "Plan B, 4.0", which may be downloaded free of charge from the website of the Earth Policy Institute. John Avery's book "Crisis 21; Civilization's Crisis in the 21st Century" deals with many of the problems discussed at the symposium, and it may be downloaded free of charge from http://diku.dk/ avery/csbk.pdf, or obtained as a paperback from www.lulu.com/john189. Prof. Mario Giampietro's books dealing with energy and agriculture are available from Barnes and Noble, and many of his papers can be found on the Internet. Details relating to Steven Starr's lecture can be found on www.nucleardarkness.org.


Janet Larsen
USA
MARIO
GIAMPIETRO
(SPAIN)
KLAUS
ILLUM
(DENMARK)

Plan B for Stabilizing Climate and Ensuring Food Security

Janet Larsen, Director of Research, Earth Policy Institute, Washington, DC, USA

Based on Earth Policy Institute research, much of it in *Plan B 4.0: Mobilizing to Save Civilization* (New York: W.W. Norton & Company, 2009) by Lester R. Brown, as presented by Janet Larsen at the Symposium on Energy, Climate Change and Global Food Security held at the Ørsted Institute, University of Copenhagen, Denmark, 4 December 2009. For references, data sets, and other information from Earth Policy Institute, please visit www.earthpolicy.org.

People around the world have a variety of reasons to be concerned about climate change. For small, low-lying nations the principal threat is sea level rise. Increasing wildfires and heat waves are what preoccupy people in Australia and the Mediterranean countries. For Eastern Asia and the Caribbean, the stronger storms that accompany higher temperatures pose an obvious risk. Climate change is about all these things and much more, but in a fundamental sense, a changing climate threatens food security for us all. In a globalized food economy, where food prices are largely determined by the basic relationship between supply and demand, a production shortfall in any one region can raise food prices, and thus hunger, everywhere.

Agriculture has existed for some 11,000 years, during a period of remarkable climate stability. Yet since the Industrial Revolution, humans have been burning fossil fuels and destroying forests at increasing rates, emitting heat-trapping gases to the atmosphere that in recent decade have begun to raise global temperatures. Without a sharp reduction in greenhouse gas emissions, we will enter a new climate regime outside the bounds in which civilization has developed. Whether the world's harvests can sustain the threats posed by rising temperatures, heat waves, melting glaciers, and higher seas remains to be seen.

The Food Security Backdrop

The world is in a precarious situation on the food front, even before we experience the most dangerous impacts of climate change. This was illustrated dramatically by the food price spike from late 2006 to 2008. Staple food prices climbed in short order to record highs, provoking unrest in dozens of countries around the world. It started in Mexico in 2007, with the infamous "tortilla riots." Later in Indonesia, over 10,000 people took to the streets to protest rising prices of tempeh, the soybean-based food staple. In Thailand, farmers were forced to guard their ripening rice fields at night with shotguns lest someone come to steal their harvest out from under them. In Egypt soldiers were conscripted to bake bread, which was then sold at highly subsidized prices. Fights would sometimes break out as people waited in the snaking bread lines. In Haiti, unrest over soaring food prices contributed to the toppling of the government. Around the world, families, many of whom now live in cities, became trapped between low incomes and the fast-rising food prices.

Wheat Prices (CBOT) ***Source: futures.tradingcharts.com***

Rice Prices (CBOT) ***Source: futures.tradingcharts.com***

Figures 1 & 2. The rise in world grain prices.

Governments responded to the sharp rise in food prices in several ways. First, in attempts to keep domestic food prices down, some key exporters like Argentina, Russia, and Vietnam imposed grain export restrictions. Second, some countries tried to secure bilateral agreements to import food for their people. Following this route, the Philippines signed an agreement to buy 1.5 million tons of rice from Vietnam each year for the next three years. Other such agreements included Egypt approaching Russia for wheat imports, and Yemen looking for the same from Australia. Yet in a sellers' market, supplies could not be assured.

The third type of response is entirely new. In the last few years, a growing list of countries has bought or leased land in other countries to farm staple foods for shipment back home. One of the early "farming abroad" negotiations came when Libya approached the Ukraine for 100,000 hectares to farm wheat. South Korean company Daewoo made headlines when the political furor sparked by its attempt to secure 1 million hectares in Madagascar helped bring a change of government, which then led to the cancellation of the agreement.

Similar protests erupted when farmers in the Philippines found out that their government was communicating with China about leasing an area equal to 10 percent of Filipino riceland. This negotiation was also called off, but many more are proceeding. China has acquired land or plans to do so in a number of countries, including Australia, Brazil, Kazakhstan, Mozambique, Myanmar, and Zambia. One of the largest "farming abroad" agreements has been Chinese firm ZTE International securing rights for 2.8 million hectares in the Democratic Republic of Congo, which it plans to use for growing oil palm that can be used as cooking oil or as a biofuel.

Other governments working out deals in multiple countries include South Korea, which is leasing land for wheat in the Sudan, the largest World Food Programme recipient. Saudi Arabia is farming in a number of countries, including Ethiopia, another food aid beneficiary. There is no question that these host countries need investment and capital, but it is unclear whether any of these agreements will bring them overall benefits, particularly those that are already struggling to feed their own people.

Long Term Trends Put Pressure on Farmers to Feed a Growing Population

The world has seen food prices rise sharply in the past, but almost always because of weather-related crop failures. We only had to wait until the next harvest for prices to return to "normal" levels. What made this most recent food price spike unique was that it was not the product of a temporary harvest shortfall, like a failure in the Indian monsoon. Instead it was the culmination of trends that are making it more difficult to increase the supply of food, paired with those that are raising demand. It took the greatest economic crisis since the Great Depression to bring down food prices from their record highs, but prices still remain well-above their long term averages.

On the supply side, the world has very little unused arable land and very few yield-raising techniques that have not already been employed. The grain crop gets larger almost every year, but the yield gains have been shrinking. Overplowing, overgrazing, and deforestation have eroded soils. In many places, underground aquifers that supply irrigation water have been overpumped, causing wells to go dry and leaving little prospect for expanding irrigation.

On the demand side, each year there are 79 million more people at the global dinner table. Some 3 billion people around the world desire to move up the food chain and eat more grain-intensive livestock products, like meat, milk, and eggs.

Traditionally human demand on the land was for food, feed (for animals), and fiber. The most-recent driver of demand is a fourth "f": fuel. In a misguided attempt to reduce dependence on foreign oil, Americans now have some 200 ethanol distilleries around the country converting food into fuel. Prior to the big ethanol push in the United States, which took full force shortly after gasoline prices spiked in the wake of Hurricane Katrina in late 2005, the annual growth in world grain demand was about 20 million tons. Ethanol doubled that additional annual demand to close to 40 million tons. In 2009 over 100 million tons of U.S. grain, more than a quarter of the total crop, was turned into to fuel for cars.

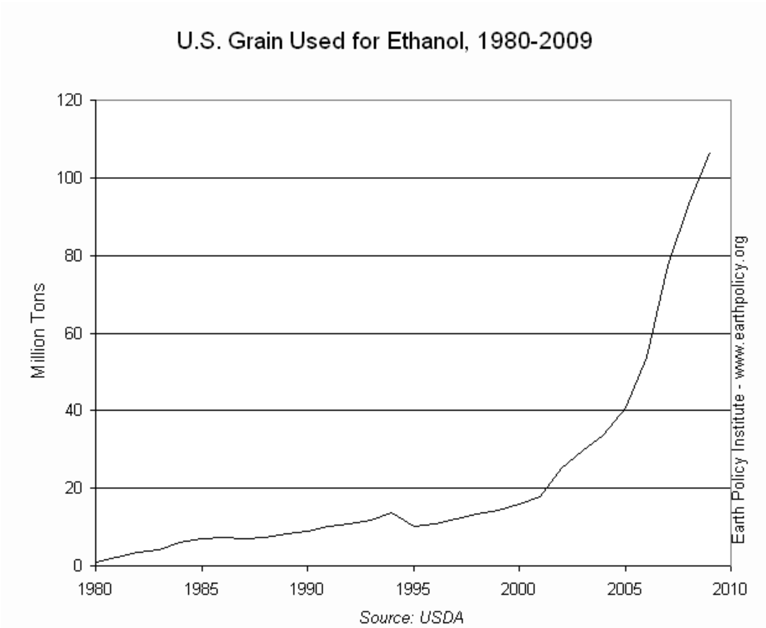

Figure 3. More than a quarter of the 2009 U.S. grain crop was fed to cars.

From an agricultural perspective, the automotive appetite is insatiable. Even if the United States were to take its entire grain crop and turn it into ethanol, the country would satisfy at most 18 percent of its gasoline demand. The grain required to fill an SUV tank with ethanol just one time is enough to feed a person for an entire year. The grain used for ethanol production in the United States in 2009 could feed 330 million people for a year at average world consumption levels. In the competition for food between cars and people, the wealthier owners of the world's 940 million automobiles are winning out over the 2 billion poorest on the planet.

The United Nations Food and Agriculture Organization estimates that because of the recent food price spike the number of hungry people in the world jumped to over 1 billion in 2009. The world had been making progress in reducing hunger since the late 1960s, with the number of undernourished people falling to 825 million in the mid-1990s. But since then, hunger has spread and is likely to continue to do so unless fundamental food supply and demand trends are addressed.

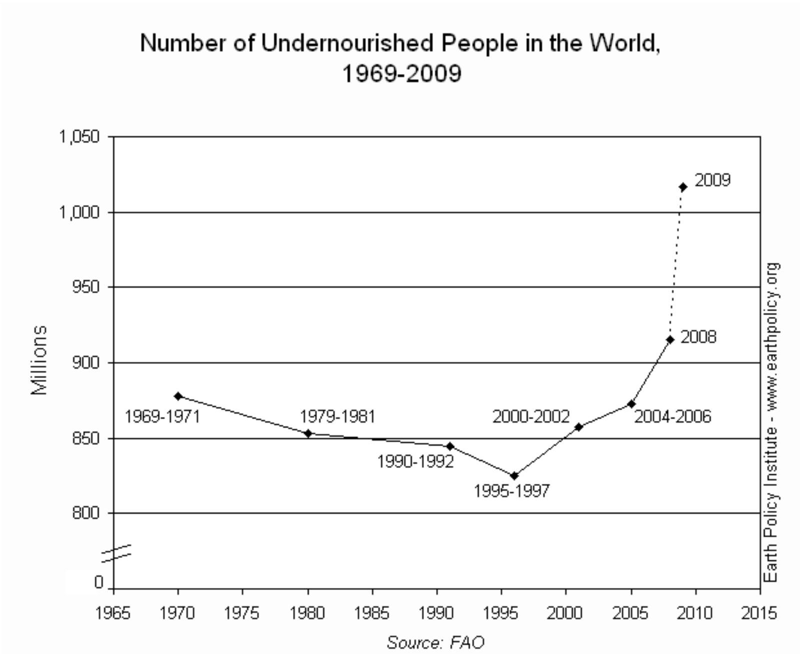

Figure 4. For the first time the number of hungry people topped 1 billion in 2009.

Future Threats: Peak Oil, Water Shortages, and Climate Change

As these statistics demonstrate, the world food situation is tight, even before the world has begun to experience the worst effects of peaking world oil production, water shortages, and climate change. When world oil production begins to decline, whether we are there now or even if it is delayed another 10 or 15 years, our energy-intensive food production and distribution system will certainly be put to the test.

While our underground repositories of "easy" oil are becoming harder to tap, our underground water supplies are also being stressed to the limits. Half the world's people live in countries where water tables are falling. This includes the world's three largest food producers: China, India, and the United States. World Bank numbers suggest that the food supply of some 175 million Indians is irrigated with water drawn from overpumped aquifers. This means that once those wells go dry, 175 million people will be in trouble. In China, some 130 million people are likely in the same boat.

Climate change is projected to increase water scarcity in many areas, as longer droughts and heat waves hit many parts of the world. Precipitation events are expected to veer to the extremes, bringing more droughts in some areas, but more flooding in others. Either way, farmers get hit.

A warmer globe also brings the loss of ice. As glaciers and ice caps melt, and as the oceans warm, sea level rises. The extent of Arctic sea ice has hit record lows in recent summers. This does not raise sea level directly because sea ice is already floating, but as the exposed darker waters absorb more heat from the sun, regional warming provokes the melting of ice sheets on nearby Greenland. Greenland glaciers have been melting at astounding rates, outpacing scientists' predictions. Altogether Greenland contains enough ice to raise seas by 7 meters (23 feet). At the South Pole, melting on the West Antarctic Ice Sheet, which contains enough ice to raise seas by 5 meters (16 feet), is accelerating. The ice sheet has lost some of its buttressing ice shelves in recent years, allowing glaciers to flow more quickly to the sea.

By the end of this century, without dramatic climate pollution reductions, sea level is expected to rise by up to 2 meters. Higher seas threaten many of the world's major cities, including London, Shanghai, Alexandria, Kolkata, Washington, and New York. Beyond the chaos that could result from millions of rising sea level migrants, higher oceans pose a particular risk to rice production. A 1-meter rise in sea level, well within the range of possibility for this century, would inundate half the riceland of Bangladesh, a country of 160 million people, and a third or more of the Mekong Delta, responsible for half the rice harvest of Vietnam (the world's second largest rice exporter).

As Asia's harvests are threatened by inundation by rising seas, they are also at risk from the loss of irrigation water as glaciers dwindle. In China, glaciologists estimate that two-thirds of country's glaciers could be gone by mid-century if the accelerated melting continues. Recent reports from the Himalayas reveal that many glaciers there are melting, as well. I recently had the pleasure of meeting Apa Sherpa from Nepal who holds the world record for summiting Mount Everest. During his 19 ascents and a lifetime in the mountains he has seen major changes. Expedition teams used to heat up ice and snow to get water for drinking and cooking. Now oftentimes water flows freely.

All the major rivers of Asia—including the Indus, Ganges, Mekong, Brahmaputra, Yellow, and Yangtze—are fed in part by glacial runoff. As the glaciers in the Himalayas and on the Tibetan plateau melt, these rivers could lose much of their dry season flow. The food prospects of well over 1 billion people in Asia depend on the mountaintop glacier "reservoirs in the sky" whose meltwater sustains irrigation.

Another effect of higher temperatures is falling crop yields. The rule of thumb emerging among scientists is that each 1 degree Celsius rise in temperature above the optimum during a plant's growing season shrinks yields by 10 percent. Chinese scientists recently warned that without actions to curb global warming, crop yields there would shrink by a third or more in the second half of this century. A study published in November by the U.K. Meteorological Office portends losses for other quintessential food cultures: In Italy, yields of the durum wheat used to make pasta are predicted to fall starting in 2020. The Italian crop could disappear entirely by the end of the century as desert-like conditions cross the Mediterranean. The researchers predicted similar devastation for fruits and vegetables in Spain, potatoes and wheat in Poland, and grapes for wines and champagnes in France.

Looking back through history at previous civilizations that have collapsed, like the Sumerians, Mayans, or Easter Islanders, we see that a shortfall in the food supply was often the weak link. Is it possible that food could be the weak link for today's global civilization? In recent years the group of countries vulnerable to state failure—places like Somalia and Haiti and Yemen—has grown. Countries where governments are too weak to govern can become havens for terrorists, wellsprings for diseases like polio, or fonts for drugs. This deterioration of order already has some spillover effects, but thus far has been mostly localized. However, if in the future more governments struggle to ensure food supplies for their citizens, the risks mount for a failing state cascade, where such problems spill out far beyond national borders and become completely unmanageable.

The Response: Plan B

With the trends of deterioration outpacing the trends of progress and our food supply in jeopardy, it is clear that business as usual is not working. When Plan A fails, what do we have to turn to? Plan B. Plan B has four main components: One, stabilize population; two, eradicate poverty; three, restore the earth's ecosystems; and four, stabilize climate. These goals are all interconnected. Action on all fronts is required to succeed.

Here I will go into some detail on the climate component. More information on all parts of Plan B is discussed in *Plan B 4.0: Mobilizing to Save Civilization*, by Lester R. Brown, which is available for free downloading at www.earthpolicy.org.

Stabilizing Climate: Cutting Carbon Emissions 80 Percent by 2020

When deciding on the Plan B climate goals, Earth Policy Institute did not ask what would be easy or politically feasible. Instead we asked the question: "What is *necessary* to prevent dangerous climate change?"

The Plan B climate action strategy works in three areas—energy efficiency, renewable energy, and forestry and soils—to cut world net carbon emissions 80 percent by 2020.

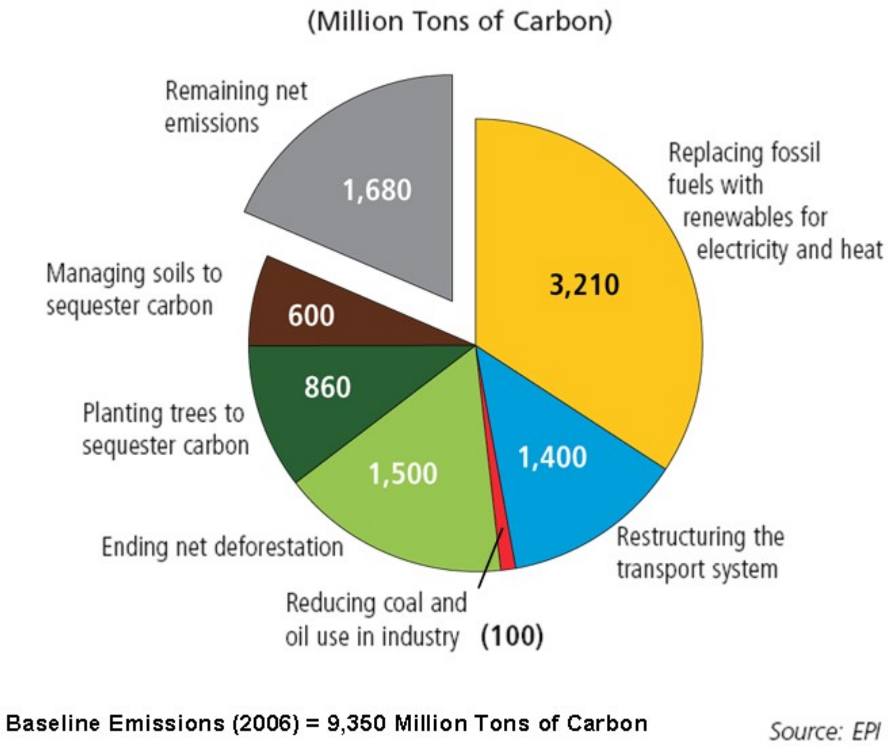

Figure 5. Plan B Carbon Dioxide Emissions Reduction Goals for 2020

Cutting net carbon emissions 80 percent by 2020 could prevent atmospheric carbon dioxide concentrations from exceeding 400 parts per million. This then sets the stage for reducing carbon concentrations. Already the world is at 387 ppm, yet a growing number of scientists, like NASA's James Hansen and Intergovernmental Panel on Climate Change head Rajendra Pachauri, are saying that we need to return to 350 ppm to avoid the most dangerous effects of global warming.

Using Energy More Efficiently

On efficiency, we reach for the lowest hanging fruit and figure out how we can use energy more wisely, saving energy and money. It may sound cliché to say that we need to change our light bulbs (I often say that changing our politicians is far more crucial in the fight to arrest climate change), but light bulbs are no laughing matter. If you add up the energy savings from changing to more-efficient lighting in all the world's homes, businesses, and industry, we find we can lower global electricity use by 12 percent, enough to close more than 700 of the world's 2,700 coal-fired power plants. For households, this largely involves changing from inefficient incandescent bulbs to compact fluorescents that use one quarter the energy. Once the cost of highly efficient LEDs, which use just 10 percent the electricity of a comparable incandescent bulb, falls enough to make them more widely affordable, the efficiency savings can be even greater.

Switching to more-efficient household appliances, like refrigerators, computers, televisions, and washing machines, can achieve similar savings. The model to follow is Japan, where the Top Runner Program uses the most efficient technologies on the market to set the new standards for future production. In industry, taking best practices and applying them across steel, cement, and chemical manufacture will reap the biggest gains.

The largest energy efficiency potential is in the transportation sector. Redesigning cities for people rather than cars, and stepping up public transportation options and pedestrian and cycling infrastructure are high priorities, both for reducing energy use and for making cities more livable.

All together, the Plan B efficiency measures allow us to hold world energy demand flat to 2020.

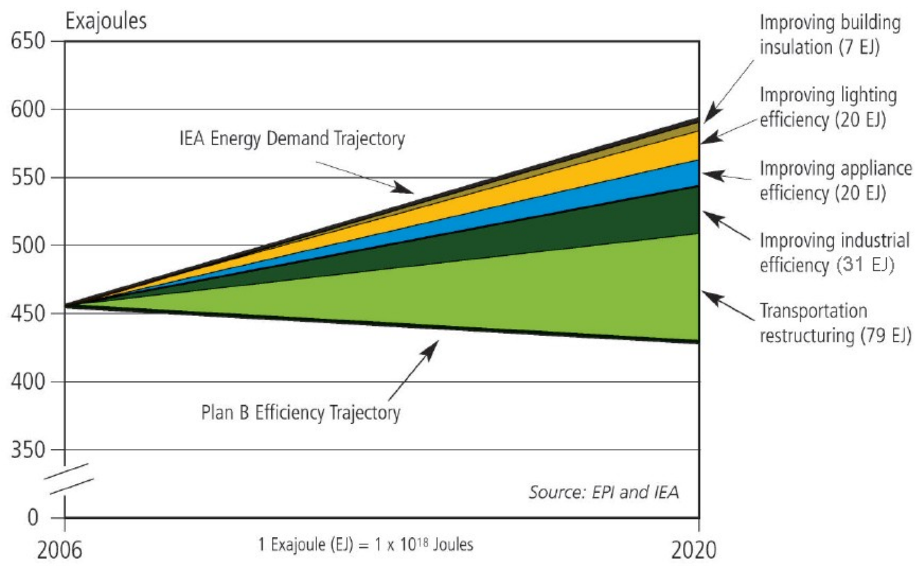

Figure 6. Plan B Energy Efficiency Measures Compared to IEA Projections

An Energy Revolution

The next step is to cut carbon emissions by replacing fossil fuels with renewable energy for electricity and heat production. Currently the world relies on coal for about 40 percent of its electricity consumption. In the Plan B economy, coal will be phased out and replaced by wind energy. Wind is abundant, inexhaustible, widely-distributed, clean, climate-neutral, and increasingly cheap. While coal seams will eventually be depleted and oil wells will run dry, the wind keeps on blowing. The Plan B goal for wind energy is 3 million megawatts by 2020. This would require erecting 1.5 million wind turbines over the next 10 years. 1.5 million turbines sounds like a lot, but we make 65 million cars each year. In fact, many of these wind turbines could be constructed in now-shuttered automobile assembly plants.

Wind energy is no longer marginal. The modern wind industry began in the United States in the late 1980s, but because of lack of investment in the United States, European countries, particularly Denmark and Germany, had long dominated the industry. Now turbines are going up around the world.

Today the U.S. state of Texas, long the country's top oil-producer, has wind projects on the books that once completed will produce more electricity than is currently consumed by the state's 24 million people. China has big plans for wind as well. The country is set to overtake the United States as the world's number one generator of electricity from wind within the next year or so. Seven megaprojects of more than 10,000 megawatts are in the works. When they are built they will supply more electricity from wind than was produced worldwide at the start of 2008. A recent study published in the journal *Science* analyzing wind speeds across the country found that China could generate enough electricity from the wind to meet its current consumption 7 times over.

Energy from the sun will also play a major role in the Plan B energy economy. One exciting development is the number of new solar water heaters in the world. Today in China some 27 million homes get hot water heated by the sun. In Austria, 15 percent of households have solar water heaters. Installations of solar photovoltaics that harness the sun's energy to create electricity are now doubling every couple of years, sprouting up on rooftops and soon to be seen in more utility-scale operations. (I like to envision "no rooftop left behind" campaign, where every building will sport solar panels, solar water heaters, and/or rooftop gardens.)

Another way to make use of the sun's abundant energy is with concentrating solar thermal power (CSP). This relatively simple technology uses mirrors to concentrate sunlight to heat a fluid that drives a turbine. It is taking off in Spain and undergoing a renaissance in the United States. The exciting thing about solar thermal power is that energy can be stored in molten salt for up to 8 hours after the sun has set.

This past summer a consortium of companies, including ABB, Deutsche Bank, Munich Re, and Siemens, announced funding for the DESERTEC initiative to develop concentrating solar thermal power in the deserts of North Africa for delivery locally and also to Europe via undersea cables. Some predict that such projects could meet half of Europe's electricity needs. Already Algeria is planning to develop 6,000 megawatts of CSP for export to Europe, enough to power a country the size of Switzerland.

Geothermal energy is also seeing renewed interest. Nearly all of Iceland's homes have long been heated geothermally. Close to a quarter of the electricity produced in the Philippines is from geothermal power plants. In Indonesia, where declining oil production meant the country could not retain its OPEC membership, the state oil company Pertamina is starting to see the future and looking to become a big geothermal player.

All together, switching our electricity systems away from coal, oil, and some natural gas to wind, solar, geothermal, and small-scale hydro, tidal, and wave power can cut carbon emissions by more than a third.

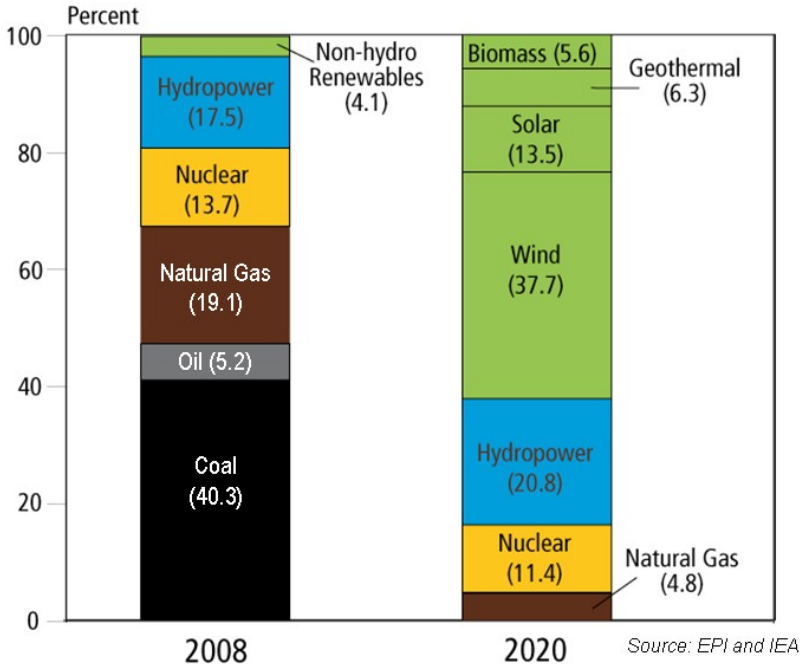

Figure 7. World Electricity Generation by Source in 2008 and in the Plan B Economy of 2020

Trees and Soils Store Carbon

On top of the energy goals, Plan B reduces emissions through improved management of forests and soils. Putting an end to net deforestation worldwide can cut CO_2 emissions by another 16 percent. As most of the forest loss is occurring in developing countries, with Indonesia and Brazil responsible for the lion's share, this would require financial assistance from industrial countries.

Last, planting trees and managing soils to sequester carbon can absorb 15 percent of our current emissions. The United Nations Billion Tree Campaign can serve as an example.

Creating an Honest Market

Not one of these Plan B initiatives depends on new technologies. We know what needs to be done to reduce CO_2 emissions 80 percent by 2020. Examples from around the world show us that we have the pieces of the puzzle. What is needed now is an honest market and the leadership to put the pieces together.

Our environmental bubble economy, dependent on continuous depletion of our natural capital, cannot be sustained. Leaving costs off the books can lead to disaster, yet our economy is full of costs that are not correctly accounted for. Until we incorporate the climate change and health costs of burning fossil fuels into their prices, young people and future generations are left to bear the full burden.

Plan B recommends restructuring our tax system so that we "tax what we burn, not what we earn," as some people (including Vice President Al Gore) have phrased it. This would mean increasing the price of carbon pollution by $20 per ton each year so that we hit close to $200 per ton by 2020, and offsetting that increase with a reduction in income taxes.

A Wartime Mobilization

Plan B 4.0 examines one particular historical model of rapid social transformation: the entry of the United States into the Second World War. On January 6, 1942, one month after the bombing of Pearl Harbor, President Franklin D. Roosevelt stood before the country and gave his State of the Union Address. In it he laid out the U.S. arms production goals, saying that the country would produce 45,000 tanks, 60,000 planes, 20,000 anti-aircraft guns, and 6 million tons of merchant shipping capacity. He challenged: "Let no man say it cannot be done."

These were enormous numbers, larger than anyone could reasonably fathom. Yet what Roosevelt realized was that the largest industrial capacity in the world at the time was in the U.S. automobile sector. So he called in the leaders of the auto companies and explained how they would help. And, indeed, from early 1942 through 1944 virtually no cars were produced, but we exceeded every one of those arms production goals.

It took ingenuity. Toy factories began producing compasses. Instead of spark plugs, we made machine guns. Instead of undergarments we made grenade belts. Every sector and every person got involved. The country mobilized its resources and completely restructured the economy, not in decades, not in years, but in a matter of months.

During World War II, it was a way of life that was at stake. Now, with our food supply ever dependent on healthy soils, water, and climate stability, it is the future of civilization that is at stake. We are in the middle of a race between tipping points, tipping points in our natural systems and in our political systems. Will the growing movement to close coal-fired power plants move fast enough to hold off the melting of the Greenland ice sheet? Can we cut carbon emissions quickly enough to minimize crop-withering heat waves? Can we slow deforestation in the Amazon rain forest fast enough to avoid it weakening and becoming vulnerable to fire?

Now is the time to act if we want to win this race. As Lester Brown notes, "Saving civilization is not a spectator sport." We all have a role to play.


Janet Larsen
USA
MARIO
GIAMPIETRO
(SPAIN)

Global trends of fossil energy use in food production (1991-2003) in the context of peak oil and rising food prices.

Abstract of the lecture by Mario Giampietro
ICTA Universitat Autonoma Barcelona

In the last decades agriculture has shown a continuous increase in the energy input/output ratio (increasing dependency on fossil energy) of food production. This continuous increase has been driven by a steady trend in socioeconomic and demographic changes considered at the national level. Previous studies of the link between fossil energy consumption and food production (Giampietro, 1997; 2002; 2003 Conforti and Giampietro, 1997; Giampietro et al. 1994; 1999) focused on the changes in the output/input energy ratio of agriculture - where output is the food energy in crops and input is the commercial energy embodied in technical inputs.

Changes in this ratio can be explained by looking at two key factors:

1. a continuous increase in socio-economic pressure defined as labor productivity, in terms of crop produced per hour of labour - generated by the reduction of the fraction of farmers in the work force, associated with economic growth, which makes it necessary to produce more crops per hour of work in agriculture; and

2. a continuous increase in demographic pressure defined as land productivity, in terms of crop production per hectare - generated by the reduction in available cropland per capita, associated with population growth and alternative land uses in society, which makes it necessary to boost the yields per hectare.

This type of analysis is particularly relevant in the current context of rising oil prices, related to the issue of peak oil, and rising food prices that could represent a dramatic problem for the urban population (in 2008 more than 50% of the world population is urban!). A possible reduction of fossil fuel inputs to agriculture, accompanied by an increase requirement in labour inputs and a reduction of transportation could eventually lead to a pattern of food

production being devoted primarily to local consumption. This could be a recipe for disaster for the growing mass of urban poor in many developing countries.

The analysis presented is based on a database covering a time window going from 1991 to 2003. The selected sample includes 21 countries representing America, Europe, Asia, Africa and Australia. The data are from the United Nations Food and Agriculture Organization (FAO).

The results show clearly that population growth and economic growth are determining a continuous increase in both demographic and socioeconomic pressure for national countries. This translates into the need of continuously boost the productivity of land and labour in food production, which in turn translates into a continuous increase in the requirement of capital and fossil energy to be invested in food production. Unfortunately, this severe lock-in is continuously increasing the requirement of fossil energy in food production. This is taking place at the very same moment in which: (i) the first consequences of peak-oil are becoming evident. We can no longer expect that oil will be cheap and abundant in the future; (ii) the concern for the environment is growing due to the growing awareness of the importance of preserving habitat for biodiversity (Millennium Ecosystem Assessment , 2004). We are told that we should decrease the intensity of exploitation of terrestrial ecosystems (moving away from High External Input Agriculture); (iii) the “biofuel fever” is reducing the amount of land, labour, technology and fossil energy that can be invested in food production.

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Reflections on the Power of Oil and Other Fossil Fuel Issues

Klaus Illum, ECO Consult, Denmark. December 2009

We live in a world powered by fossil fuels. Nowadays there is nothing - no thing - that is bought for money which is produced without using fossil fuels all along the production and distribution lines. Our food, clothing, transportation etc. is produced using fossil fuels. And fossil fuels are needed to build nuclear power plants as well as windmills.

For a minority of 1 billion people out of the world population soon reaching 7 billion fossil fuels have provided living conditions which our predecessors 200 years ago could and the billions of poor people today can only imagine to find in paradise: plenty of delicious food, plenty of clean and hot water in every tap, comfortable cars taking you anywhere at 100 kilometres per hour, Christmas holidays on other continents, etc. etc. - you name it.

Do we - the rich - rightfully enjoy the fruits of our ingenuity? No, not quite so. Rather we enjoy the entirely accidental occurrence of cheaply recoverable fossil fuels in the crust of the earth and we enjoy the divide between us, the rich minority, and the poor majority which historically is the result of the 500 years of Europe's gun-powder powered colonization of the rest of the world.

Now, as things fall apart, and we - the rich - are desperately, against all odds, seeking ways and means to sustain our paradisal living conditions, there is reason to reflect on the power of oil and some fossil fuel issues in general:

In the course of a century the abundance of physical power provided by fossil fuels has changed the world - the way we live and as importantly the way we think. As we now enter the final stages of this short era in the history of mankind where all physical technologies, infrastructures, etc. are based on the abundance of cheap fossil fuel power, there is reason to reflect on the magnitude of this power as compared with the physical power available to mankind before the fossil fuel era and the power mankind may have to make do with hereafter.

Also, to comprehend the bad omens and the multitude and magnitude of the tasks involved in the transition to the post-fossil fuel world, one must recapitulate the accidental historical and geological circumstances which led to the present, unprecedented, singular point in the history of mankind.

Moreover, as we seek from this historically exceptional point of departure to find ways and means to accomplish the transition to the post fossil-fuel world in a constructive manner, we must thoroughly review the basic concepts and literary stereotypes which constitute the specific intellectual framework of the fossil-fuel era, primarily the concept of energy as a commodity and the concept of never ending economic growth inherent in economic theory and the liturgy of the modern political economy.

The physical power of oil

First, a few examples may serve to visualise the physical power of oil as compared with the power which men or animals can yield.

We all have a feeling of the force of gravity and the power it takes to lift a heavy item. Building Stonehenge, the Egyptian pyramids, the Greek temples, the Roman aquaducts, and other great edifices around the world, men constructed leverage mechanisms which enabled hundreds or thousands of workers or slaves to lift huge blocks of stone or marble and place them in position high above the ground. Many tons of food were eaten to provide the men with the energy needed to carry out the heavy work. Nowadays a mobile crane powered by a diesel engine can lift a ten tonnes block 20 metres in less than a minute, burning only a spoonful or two of diesel oil to do the job.

The shifts in the orders of magnitude in the fossil-fuel world:
Imagine:
13 persons in a lift. Total weight, say, 1,000 kg = 1 ton
The work done lifting them 4 floors up, 10 metres, is 0.027 kWh.
About the same as the electric power used by a low-energy light bulb in one hour.

Surprising to the modern city-man, using 5,000 kWh of electric power a year: *Does it only take so little power to lift 13 persons 10 metres?*

Conversely surprising to an Indian peasant having his first electric lamp installed: *Does it really take so much work to keep a low-energy bulb alight for one hour?* He knows by experience how much work it takes to lift 1 ton 10 metres.

Or compare the power of a horse toilsomely drawing a single-furrow plough through the soil at slow walking speed with a diesel-powered tractor easily drawing a ten-furrow plough four times faster. Or the *six*-horse team royal carriages in the 19th century with today's common *sixty*-horsepower small European cars.

The thrust power of the jet engines of a 40-tonnes aeroplane taking off at 500 kilometres per hour is a hundred times the power of any machine seen before the

20^{th} century. The millions of tons of bombs which devastated the European cities during World War II and Korea and Vietnam thereafter could not have been spread without the power of oil. Neither could the atomic bombs which razed out Hiroshima and Nagasaki have been carried over the Pacific Ocean without oil.

The power of oil and fossil fuels in general came very cheaply as compared with power from other energy sources. Wind power is relatively cheap as compared with other non-fossil power sources. Yet, it would be an enormous economic undertaking to replace fossil fuels by wind power, even if the energy needs of the presently affluent OECD countries were reduced to 1/3:

> World car production 2009: ~70 million cars* $10,000/car = ~$700 bn
> A global windmill industry with similar capacity could annually produce:
> 250,000 big 2 MW windmills of ~$3 million/windmill = ~$700 bn
>
> Imagine that in the OECD countries by 2050 the total amounts of
> - electric power
> - heat, and
> - motive power for transportation
>
> are reduced to 1/3 of the present amounts, and that
> - people in other countries by 2050 enjoy the same per capita amounts as people in the OECD countries.
>
> Were the resulting global power supply in 2050 to be achieved by wind power, using the most energy efficient conversion techniques, about 10 million 2 MW windmills should be erected around the world.
>
> At a production rate of 250,000 windmills per year, comparable to the present global automobile production, it would take 40 years to produce and erect these 10 million windmills.
>
> And along the way the costs of new electric grids plus the windmill maintenance costs would rise to about the same as the costs of producing and erecting the windmills.
>
> Moreover, the costs of new electric transportation infrastructures are to be taken into account.

This example may serve to visualize the magnitudes of the investments needed to construct a future world in which a population of 7 or 9 million live in way which is comparable with the way we live in the presently affluent societies, albeit with much lower per capita energy needs. Indeed, fossil fuel power came very cheaply as compared with anything else.

The ominous logics of the oil-based economy

All over the world cars, lorries, trucks and ships powered by oil have determined the development of cities and local, regional, national and international transportation infrastructures. Today no society can function without these ubiquitous vehicles.

There is a simple logic behind this development. Namely, that oil must be consumed at the same rate as it is extracted from the oil fields. At the beginning of the 20th century when abundant amounts of oil became cheaply available from the oil fields in Pennsylvania and Texas, there was little demand for oil. However, in 1876 the German engineer Nicolaus Otto had made his first four-stroke petrol engine and Rudolf Diesel had patented his diesel engine in 1892. Already in World War I these engines became essential sources of power in the war industry, powering military lorries and tanks, and cars for the high ranking officers.

After the war the proliferation of petrol and diesel engines in cars, lorries, trucks and tractors provided outlets for the equally rapid growth in the oil flow from the oil fields. Thus the profitable production of oil-powered vehicles made oil extraction profitable and vice versa. The vehicle industry and the oil industry went hand in hand, inseparably. The saving of oil by the construction of fuel-efficient engines was in nobody's interest as very cheap oil kept flowing in abundant amounts and powerful cars met the consumers' desires.

By this logic the world was transformed into the new shapes and dynamics one can see from the windows of an aeroplane circling over a city. The flows of cars on its motorways and roads and in its streets, like blood in its arteries and veins.

The future of this oil-based technology and economy holds an ominous perspective. As long as growing demand for oil, meaning more cars, trucks, tractors, and aeroplanes is met by growing amounts being extracted year by year, the world economy is becoming increasingly dependent on oil. Governments - building more motorways and airports - the motorcar industry, the aeroplane industry, and the oil industry all nourish the hope that this dependency on oil will continue to grow in the foreseeable future.

While the annual extraction capacities from existing oil fields are in decline, some new fields are still being found and by means of enhanced extraction techniques more oil can be squeezed out of what is called mature fields. However, some day the annual amounts which can be profitably extracted will decline - irreversibly. The sooner the better. Because the more oil the oil companies manage to squeeze out of the oil fields and sell at a competitive price, the steeper the fall in supply when the decline sets in. The more the world economy becomes dependent on cheap oil, the more cataclysmic the consequences when the demand can no longer be met.

This is illustrated by the US Department of Energy in Figure 1 below. In this figure it is assumed that 'Ultimate recovery', i.e. the total amount of oil recovered from oil fields in the 20th and 21st century, is 3,000 billion barrels, equal to the areas under the two curves (US Geological Survey's mean value estimate). If the annual oil extraction (production) = annual global consumption peaks in 2016 the decline rate could be 2 percent per annum. Should the oil companies find it profitable to make the huge investments needed to prolong the period of growth another 20 years, the world economy would in 2037 be much more dependent on oil (twice as many oil powered cars, lorries, tractors, airplanes, etc.) when the dramatic decline sets in. This scenario is, however, unlikely because the high oil prices needed to make the investments profitable would curtail demand and thus extraction.

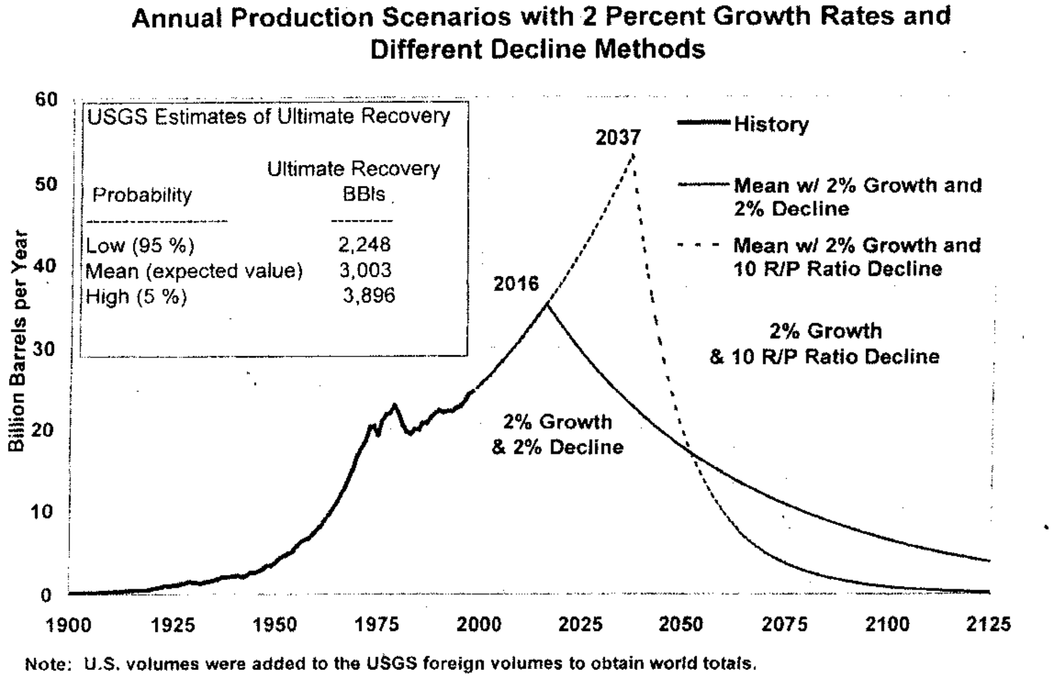
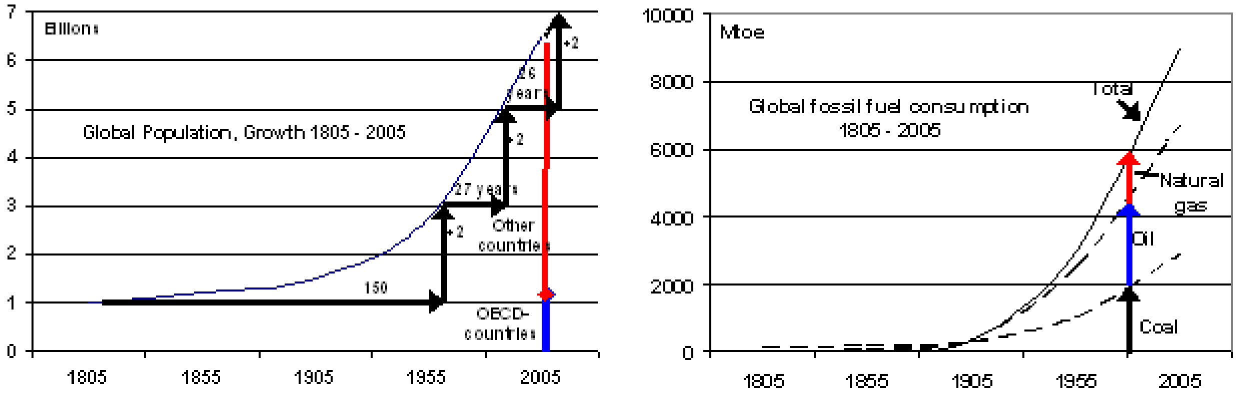


Figure 1. This figure was presented in 2000 by the US Department of Energy, Energy Information Administration (EIA). It shows in principle the dire consequences of continued efforts to defer the downturn of the annual supply of a limited resource, in casu oil: The higher the rise, the steeper the fall. In reality we will hardly see a pointed peak but rather an undulating plateau for some years before the irreversible decline sets in.

The accidental circumstances

The modern - physically speaking - powerful world is generally considered to be the result of the continual progression in science and technology, a progression which will change its direction towards other power sources when oil becomes scarce. But that is not the case.

The history of mankind may in all respects be accidental. However, the accidental circumstances which resulted in exponential growth in populations and production, beginning in the 18th century and gaining unprecedented momentum in the 20th (see Figure 2) are unique. In the first place, the climatic and biological events about 150 millions of years ago which resulted in the deposition of organic material in deep waters, poor in oxygen, were accidental. So were the later tectonic upheavals which buried some of these organic masses deep in the crust of the Earth where the conversion to oil and gas took place under high temperatures and pressures. Most of the oil and gas escaped to the surface but some was trapped in pockets under impenetrable layers - the oil and gas fields. The estimates of the amounts of oil which at reasonable costs can be recovered from the oil fields range from 2,000 billion to 4,000 billion barrels. Presently about 1,100 billion barrels have be recovered and burnt. The amount is accidental. Had there been only 1,000 billion barrels, our world had been very different from what it is today.



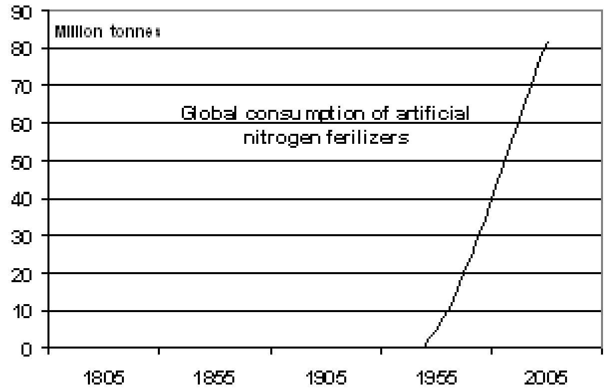


Figure 2. The exponential growth in the world's population could not have taken place without the concurrent exponential growth in the consumption of fossil fuels and the consumption of artificial fertilizers, produced, transported and spread by means of fossil fuels (natural gas for the production of artificial nitrogen fertilizers).

As regards the natural sciences, it was the discovery of the atmosphere and the pressure of air in the 16th and the 17th century that blazed the intellectual trail which enabled Thomas Newcomen to foster the idea of a steam engine and in 1712 to build an engine that actually worked. From then on, the development of powerful machines driven by coal, oil or gas was primarily the result of the symbioses between the fossil fuels and the machines, brought about by a few key inventions made by a few ingenious engineers.

Without coal the proliferation of the steam engine could not have taken place and without the steam engine, coal could not be mined and transported.

Without the steam engine as a forerunner, the petrol and diesel engines could not have been constructed within a few years because the industrial manufacturing of the engine parts - cylinder blocks, pistons, crank shafts, connection rods, etc. - would not have been in place.

And without the oil-powered engines the exploration of oil fields and the extraction of their contents would have been neither technically nor economically feasible to the extent we have seen since the 1930s.

Nevertheless, as oil becomes scarce and fossil fuels in general must be abandoned because of their impact on the global climate, it is generally believed that other energy technologies can provide the same abundance of power which was accidentally provided by oil, gas and coal. It's believed that unsustainable economic growth, based on fossil fuels, can be transformed into sustainable economic growth, based on the so-called 'renewable energy sources'. That without fossil fuels sufficient food can produced to feed a global population which may grow to 9 billion people by 2050.

However, there is no factual evidence to support such wishful thinking. It may appear that the accidental occurrence of fossil fuels is a curse rather than a blessing as metaphorized by the following little allegory:

> On an island far out at sea a flock of hens, roosters and chickens live very well. Their number is limited by the annual recuperation cycle of the grass, other vegetation, worms, and insects on which they feed. But one day a hundred barrels of grain are washed ashore from a wrecked ship. Suddenly there is plenty of food. Within a short time they grow in numbers. They grow big and fat from the ample supply of food and their excrements pollute the soil. The island's natural life cycles are disrupted. After a while most of the grain has been consumed and what is left has been trampled down into the soil. Now they are too many to live from the vegetation, much of which has been laid waste.
>
> Had they found only a few barrels of grain, they would not have been led into such disarray.

Visions of change

In the so-called developed world the access to abundant amounts of cheap fossil fuels has not only led to overweight economies. It has also brought about the economic surplus needed to develop the multitudes of new technologies which might provide ways and means to develop viable post fossil-fuel societies.

However, the analysis of ways and means to accomplish the transition to the post fossil-fuel world has been left mainly to economists, visionary greens, politicians, journalists, authors and some industrialists who find profitable prospects in the marketing of green technologies. Even though the combined technological, societal, and economic challenges involved in the transition call for comprehensive, multi-disciplinary analyses of feasible strategies.

In his widely quoted report *The Economics of Climate Change* - The Stern Report - the economist Nicolas Stern wrote in 2007, two years ago:

> "If economics is used to design cost-effective policies, then taking action to tackle climate change will enable societies' potential for well-being to increase much faster in the long run than without action; we can be 'green' and grow. Indeed, if we are not 'green', we will eventually undermine growth, however measured".

If economics provides guidance on the way to green prosperity, why then did mainstream economists lead us into the present economic and environmental calamities? Since 1987, when the Brundtland report *Our Common Future* introduced the concept of 'sustainable development' and warned about the risk of climate change, economists have dismissed the ever-growing evidence that the liturgically praised economic growth is unsustainable. The policies they designed are cost-effective only as long as fossil fuels are very cheap and the environmental costs of burning them are paid by those not enjoying their power or, regarding the affluent societies, are deferred a decade or two.

As we have seen, the exponential economic growth in the 19th and the 20th century was accidental - based on the power provided by cheap fossil fuels. Current conventional economics are based on economic growth theories and models emanated from the fossil-fuel powered economy. Without the abundance of fossil fuel power they would hardly have come into existence.

Regarding technology, the most salient vision of changes which the cost-effective, new economic conditions should bring about is conveyed by the notion of 'energy efficiency' - meaning that in future the use of fossil fuels should be less wasteful than it has been hitherto. What the notion of 'energy efficiency' tacitly implies is the lamentable fact that because fossil fuels, oil in particular, have been so cheap, the depletion of the resources and the accompanying CO2 emission has taken place at a much faster rate than would have been the case if the economic measures now advocated had been adopted twenty years ago.

Alongside the prospects of 'energy efficiency', progress in the development of 'renewable energy sources' should mitigate climate change and pave the way to the post fossil-fuel world. It should be noted, however, that 'renewable energy' is not a technological category of energy sources. It is a popular notion which encompasses every earthly energy source except fossil fuels and nuclear power. The amount of 'renewable energy' being utilized is unmeasurable and in any case an irrelevant quantity. What matters is the amounts of fossil fuels being burned and the amounts of radioactive waste being produced in nuclear power stations and there is no simple relationship between these quantities and the quantities of renewable energy, however measured .

The fossil concept of energy as a commodity

These reflections on the concepts of 'energy efficiency' and 'renewable energy' lead to the question: What, in the minds of economists, politicians, public servants, and other laymen in the field of thermodynamics, does the word 'energy' actually mean?

Etymologically the word stems from the Indoeuropean word 'uergon' which - as one can hear - is the origin of 'work'. In classical Greek it became 'érgon', 'en-érgon', and 'enérgeia' meaning the ability to perform work. Until the 19th century the word was rarely used in literature. Nowadays it is commonly used in expressions like "he is very energetic", "one uses a lot of energy when jogging", "I don't have the energy to do the job", etc.

That 'energy' is lost in the carrying out of any kind of work and has to be renewed is well known. Life is incredibly complex organizations of unstable chemical and electro-chemical states constantly decaying into entropy and renewed by recuperating energy flows. The technological aids to human life are very simple imitations of biological organizations: Machines which utilize the chemical energy potentials of fuels and free oxygen (in engines and boilers); the gravitational potentials (in hydro power stations); the kinetic potentials of the atmosphere (in windmills); and finally the electric potentials generated by the machines (in electric motors, lamps, etc.).

All potential energy sources decay into entropy sinks of low-temperature heat. Thermodynamic engineering is about the design of machines which control the decay in such a manner that the decay processes yield useful energy, viz. the loss of potential gravitational energy in a waterfall as against the generation of electric power by means of a turbine which controls the water flow; or the loss of potential chemical energy when oil is burned in a simple boiler as against the generation of mechanical power when the combustion is controlled in an engine.

Energy is lost in all processes and must be replenished or renewed. Biology and technology is all about organization and control of the flows of energy towards the low-temperature entropy sinks in such a manner that useful power is obtained along the way.

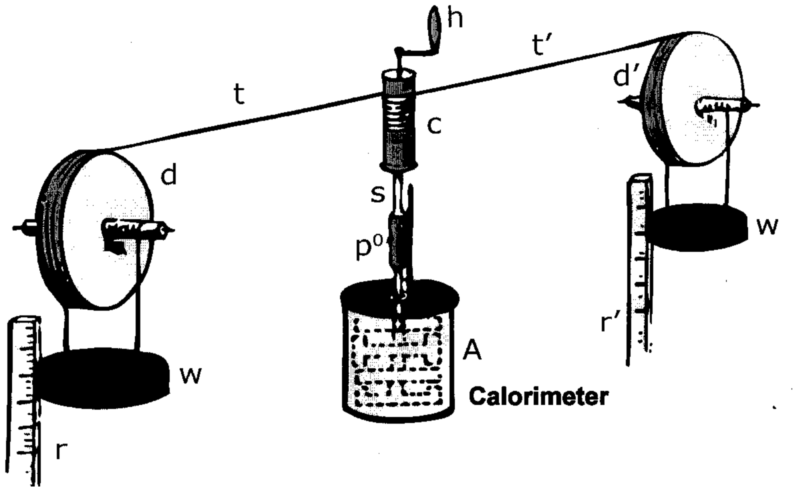


Figure 3. Joule's experiment: The work performed by the force of gravity when the two weights move downwards is not lost but converted into heat (calories, the imaginary substance) by the propeller rotating in the calorimeter. However, the small rise in temperature is of no useful value. What is potentially useful is lost. Likewise, the potentially useful power from the electric grid or from oil - which can move trains and lift heavy items - is mostly lost when converted into low-temperature heat for room heating or warm water.

Electrically driven heat pumps can provide low-temperature heat using less than a third of the power spent in a simple electric heater, even though losses because of temperature differences within the device also occur in heat pumps. However, if the electric power is generated in fossil fuel-driven power stations with an efficiency of about 40 percent, the fuel consumption for low-temperature heating is only about 20 percent smaller than the fuel consumption using an oil or gas boiler. By means of an oil or gas fired engine driving a heat pump the fuel consumption can be reduced to less than 50 percent as compared with an oil or gas boiler because the heat from the engine's cooling circuits is added to the heat from the heat pump. Thus the amounts of electric power or fuels needed to provide low-temperature heat strongly depends on the technique being used.

In classical physics, however, energy is something else. The conservation of energy is one of the basic principles, like the conservation of mass and the conservation of electric charge. It was discovered by James Joule (1818-1889). His famous ground-breaking experiment - see Figure 3 - showed that when the weights moved down, the work transferred to the propeller in the cylinder vessel - the calorimeter - was converted into heat. Something is conserved: the mechanical work is not lost but converted into an equivalent amount of heat. That 'something' Joule - unfortunately - called 'energy'. Later, as the theory of thermodynamics matured, 'energy' was defined as a thermodynamic state function - something very abstract and entirely incomprehensible to laymen.

Thus, the word 'energy' has two very different meanings. The one is the original, intuitively comprehensible meaning: the energy of unstable states driving all biological processes and machines and lost in the process. The other is the physical meaning: the thermodynamic state function which is constant (conserved) but incomprehensible to laymen who nevertheless believe that they know what it means.

Strangely, many believe that they comprehend the 1. law of thermodynamics, which states the conservation of energy in a closed (adiabatic) system, although the 1. law is a corollary (an immediate implication) of the definition of energy, which very few are acquainted with. There against, the 2. law of thermodynamics is believed to be difficult to comprehend although it essentially states the well known experience that any system when kept in isolation without renewal of its internal unstable states will decay into a stable (dead) state.

'Energy' found its way into the political vocabulary during the oil crises from 1973 to 1980. Few of the politicians, economists and bureaucrats who adopted the word pondered on its meaning. Most had learned in school that 'energy' is something which can be measured by means of a calorimeter: some substance - calory - which exists in different forms: fuels, electricity, heat, and mechanical power. An understanding which allows energy bookkeeping accounts to be kept in the same manner as monetary bookkeeping accounts. Disregarding the fact that the sum of the energy values of a quantity of oil, a quantity of electric power, and a quantity of low-temperature heat from a solar absorber is a number which is no more relevant than the sum, measured in litres, of a bottle of water, a bottle of whiskey, and a bottle of milk.

It is true that
* 1 litre of water + 1 litre of whiskey + 1 litre of milk makes 3 litres.
Likewise,
it is true that
* 1 GJ of oil + 1 GJ of electric power + 1 GJ of heat from solar collectors makes 3 GJ.
But the summations are irrelevant for any practical purpose.
Nevertheless, the energy statistics upon which energy policies are based consist of such irrelevant summations, e.g. gross energy consumption, renewable energy totals, etc.

Moreover, the concept of energy as a tradeable commodity is readily derived from the concept of energy as a substance.

In particular, electric power, conceived of as an energy commodity, is traded on electricity markets where all sorts of different means of power generation: coal-fired power stations, gas-fired power stations, hydropower, nuclear power, biomass fired power stations, windmills, and photovoltaic panels compete although they generate electric power under very different economic and operational conditions. This is clearly irrational because market competition implies that producers whose costs are higher than others loose their market share. But we need windmills, solar power, biogas-fired cogeneration plant, etc. even though these power sources may be more expensive than power stations fired by cheap coal.

Had the development of the industrialized societies not been powered by fossil fuels, this obviously irrational concept of energy as a substance and a tradeable commodity would not have prevailed. It is inherently associated with the unique properties of coal and oil and partly natural gas: high energy intensity and easy to transport and store.

Towards a future world without fossil fuels and nuclear power

In a future world without fossil fuels and nuclear power there'll be no consumption of energy. A forest, a green field, a windmill and a photovoltaic panel does not consume energy. These biological subsystems and technological artefacts will all be integral parts of complex energy systems, designed and operated so as to provide the energy in the form of food, fuels and electric power needed to support life in human habitats. Economic management will have been restored to its original objective: namely to ensure that available resources are efficiently used in a sustainable manner.

The term 'renewable energy' will be relegated to the chapters in history books which tell about the late fossil-fuel era. 'Renewable energy' is a meaningless concept in a world where energy technology is all about the organization of energy systems which make efficient use of the many different energy flows in the atmosphere, the hydrosphere, and the biosphere.

In the search for ways and means to accomplish the transition to the post fossil-fuel world in a constructive manner we must abandon the conceptual stereotypes which are rooted in the fossil-fuel economy. In particular, we must reinstall the original concept of 'energy' as a useful property of unstable states in complex systems, as against the fossil-fuel world's concept of 'energy' as a substance and a tradeable commodity.

As Albert Einstein said: "No problem can be solved from the same level of consciousness that created it". We will not find feasible solutions to the climate problem created by fossil fuels as long as we think in terms and stereotypes which have their origin in the economy and technology of the fossil-fuel world.

In conclusion

Oil, natural gas, and coal are power sources external to the biosphere. They have exceptional energy intensities as compared to the energy sources originating from the annual life cycles of the biosphere and the aero- and hydrodynamics of the atmosphere. They are easy to transport and store, and they have been cheaply recoverable.

In symbiosis with the oil-powered-vehicle industries the oil industry has created a global industrial production system in which trans-national companies can move their factories to countries where, for the time being, labour is cheapest. On satellite photos of the globe at night one can see the electric light radiating from the cities of the affluent countries but not the smoke from the mostly coal-fired power stations which provide cheap electricity to high-rise city centres and suburbs, built with fossil fuel and heated with fossil fuels. At daytime the satellite photos show the scars where rainforests have been cut down by means of oil-powered machinery and replaced by soya fields delivering feedstock to distant animal farms or palm trees delivering palm oil to the world growing motorcar fleets. Also, one can see the glaciers and polar ice sheets, which are retreating as the temperature rises because of the greenhouse effect of the billions of tonnes CO2 emitted by the burning of fossil fuels and the burning of forests. However, one cannot see the extinction of life in the oceans caused by the globally operating trawler fleet's depletion of fish stocks and the heating of the water.

Thus the unrestricted use of fossil fuels - power sources external to the biosphere - has rendered unprecedented wealth to a minority of the worlds population and caused havoc in the planets life cycles. In the economic-growth theories of the fossil-fuel era the destructions are included as the so-called 'externalities. In the Stern report *The Economics of Climate Change* (2007) Nicolas Stern writes: "Climate change is an externality that is global in both its causes and consequences. Both involve deep inequalities that are relevant are relevant for policy" (op.cit.p.33). That does not make sense because outside the infected biosphere there is the empty space. Climate change with its associated calamities are not external but internal to the biosphere. It causes internal dysfunctions of the life cycles of the entire biosphere. Particular externalities may be repaired by specific economic remedies. Internal dysfunctions of the global economic system as a whole call for a thorough revision of the economic principles governing the behaviour of people: an economy for the common good which serves to utilize the planet's natural resources in manners which preserve them for future generations.

A peaceful, constructive transition to the post fossil-fuel era is not only a matter of new technologies. It entails a revolution in the way we conceive of ourselves as party in the life cycles of the biosphere. We must acknowledge that the unprecedented external physical power of fossil fuels, which for a short while in history has rendered exponential growth in populations and production possible, has not enabled us to control the basic conditions for life on Earth.


Will
embassies
take seats
now
Thank

Climate Conflicts and Food Security

Jürgen Scheffran

Institute for Geography, KlimaCampus, Hamburg University

Research Group Climate Change & Security

clisec.zmaw.de

Symposium on Energy, Climate Change and Global Food Security

Ørsted Institute, University of Copenhagen

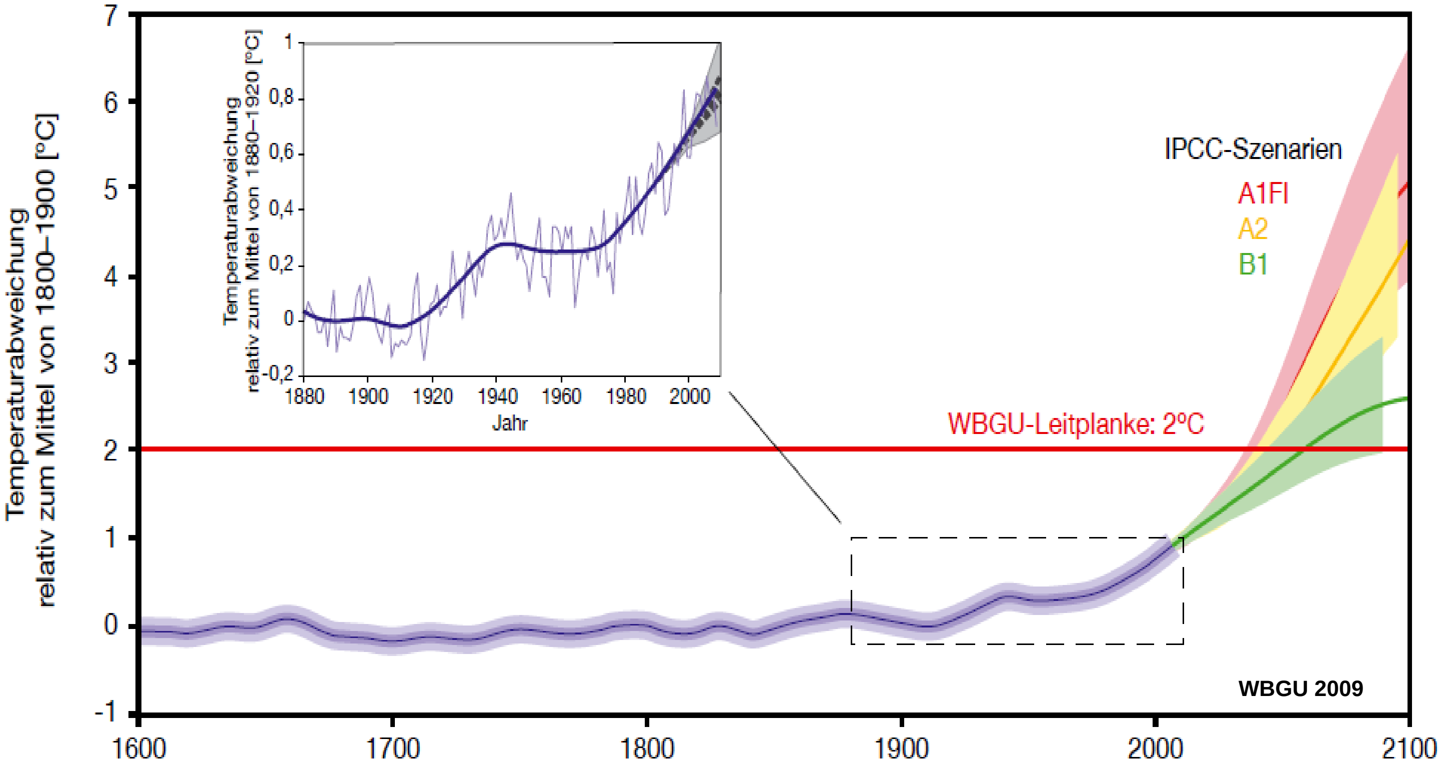
Friday, 4 December, 2009



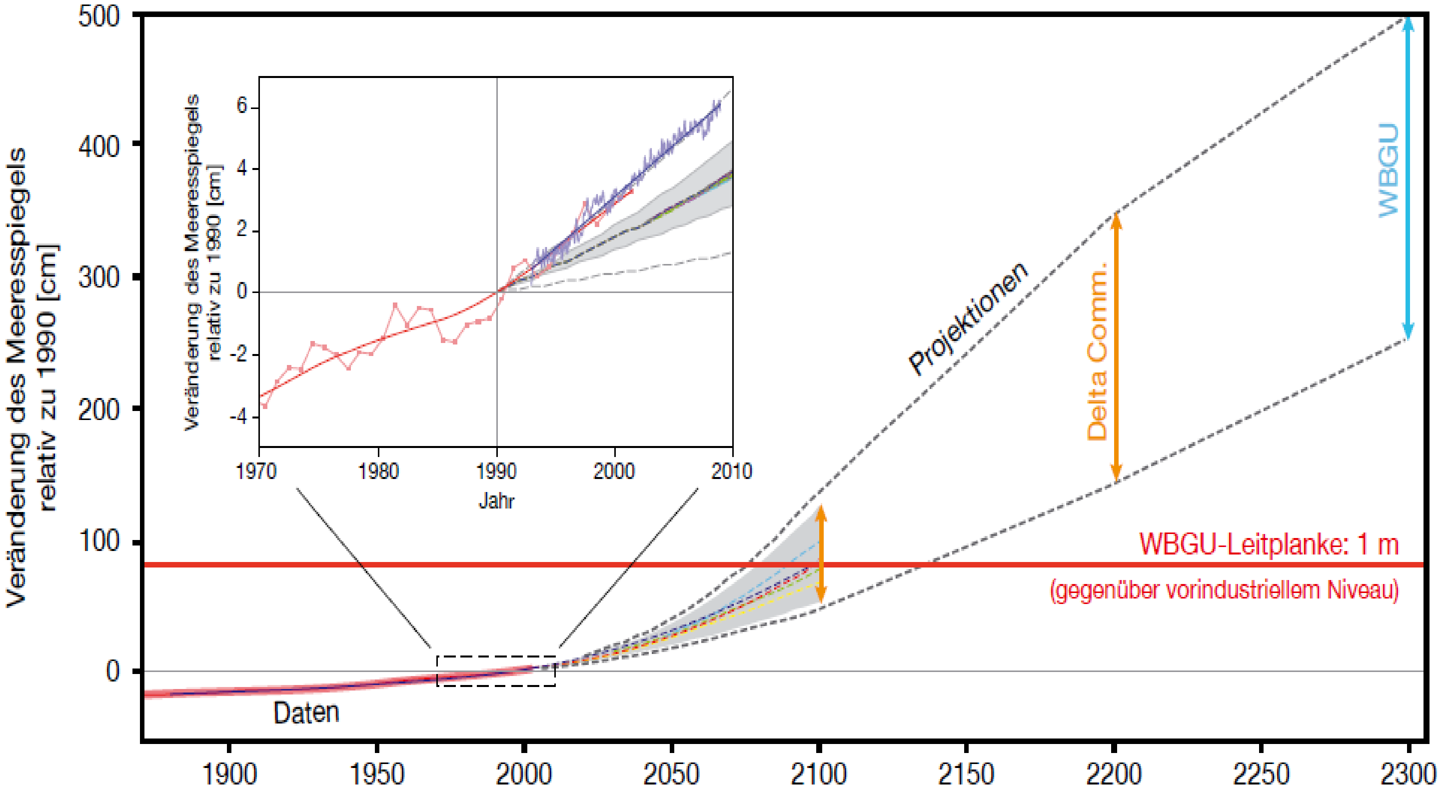
Overall questions

- Are natural resources, in particular food, a relevant conflict factor?
- Which regions will be affected by global environmental change and how do different factors combine to food insecurity?
- Will climate change lead to more societal instabilities and conflicts or to more cooperation?
- How do human beings and societies respond to climate change?
- What are appropriate strategies for the prevention of security risks, the management of environmental conflicts and the stabilization of societies?

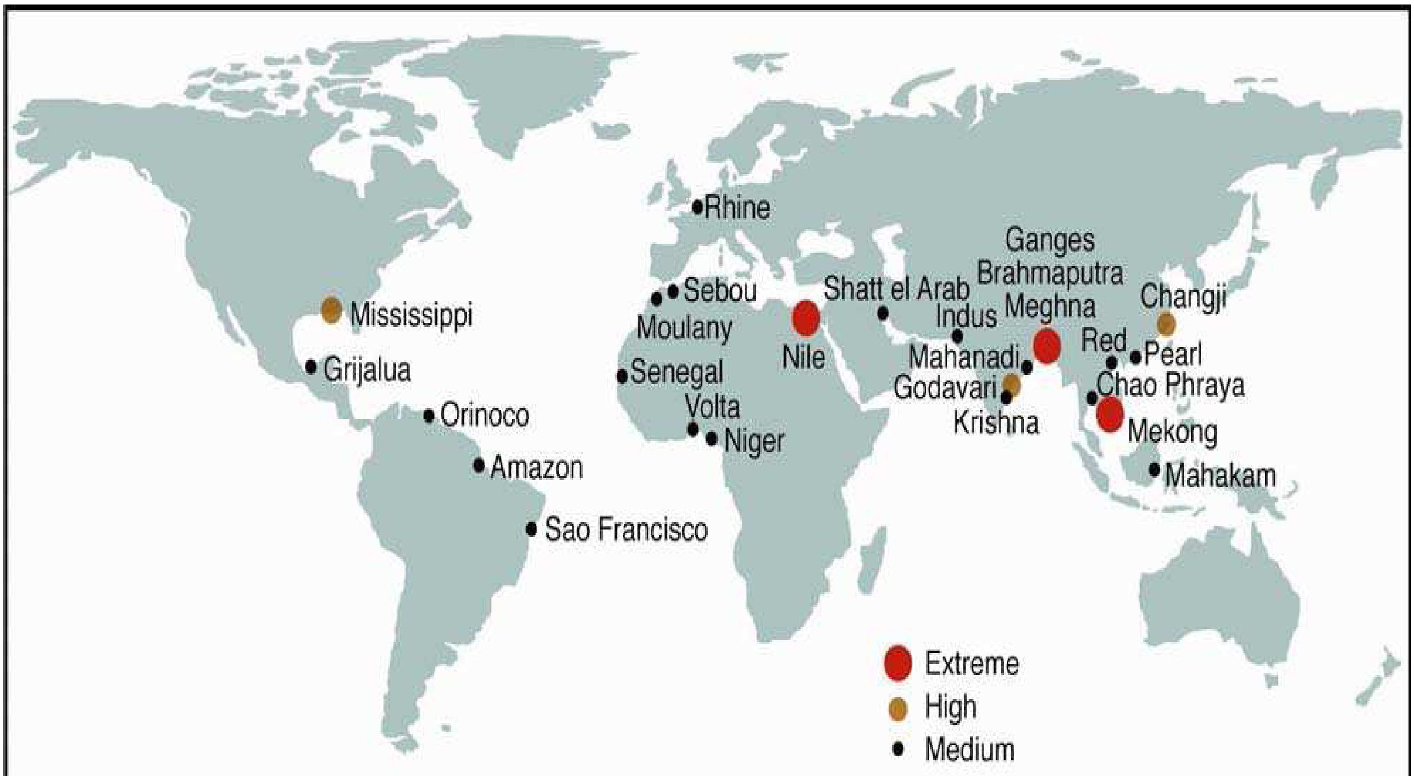
Projections of global mean temperature



Projection of sea-level rise



Vulnerability of coastal population against sea-level rise



Source: IPCC 2007

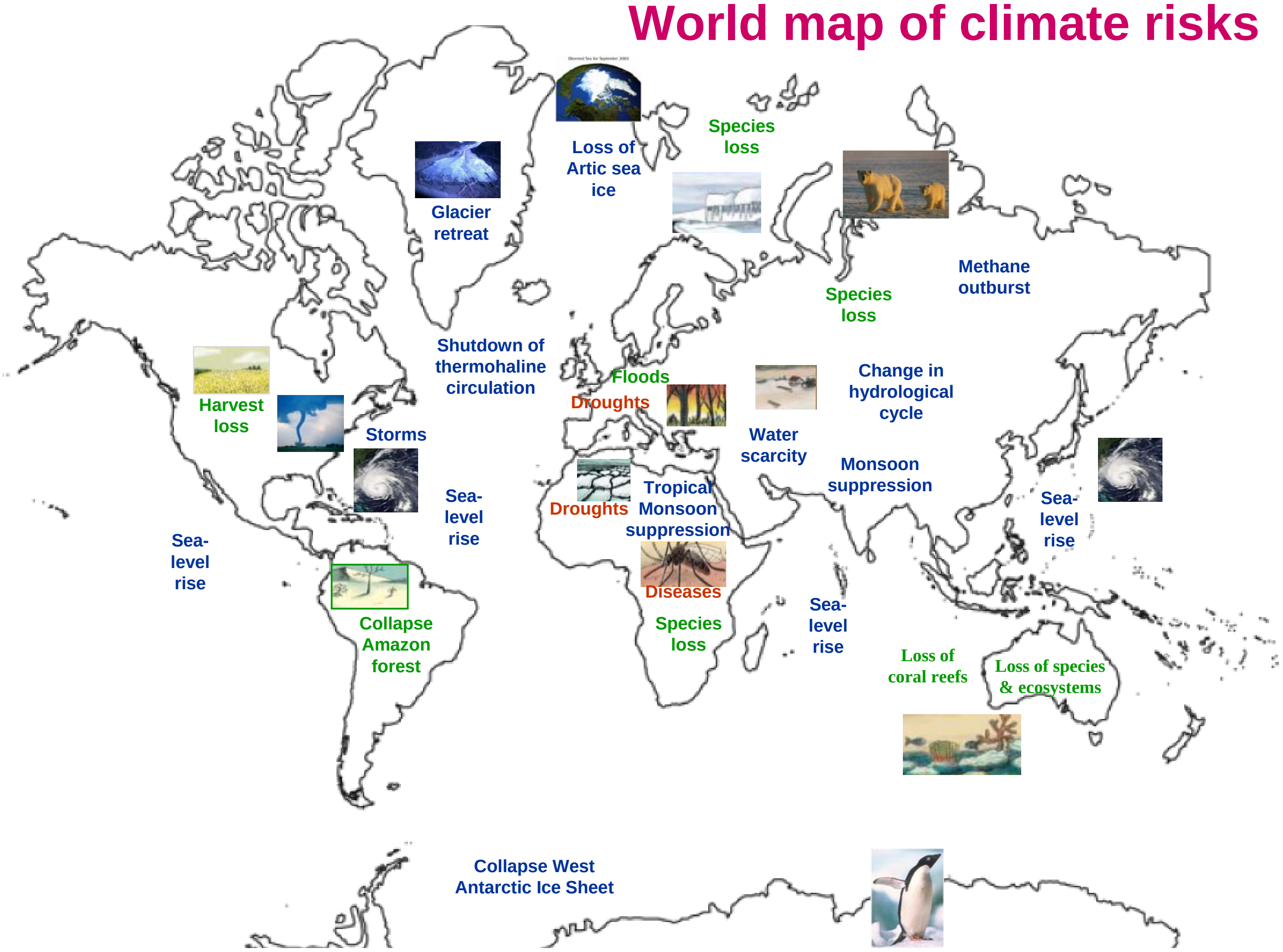
Social and economic impacts of rising sea levels

Magnitude of sea level rise (m)	Impact (% of global total)					
	Land area	Population	GDP	Urban area	Agricultural area	Wetland area
1	0.3	1.3	1.3	1.0	0.4	1.9
2	0.5	2.0	2.1	1.6	0.7	3.0
3	0.7	3.0	3.2	2.5	1.1	4.3
4	1.0	4.2	4.7	3.5	1.6	6.0
5	1.2	5.6	6.1	4.7	2.1	7.3

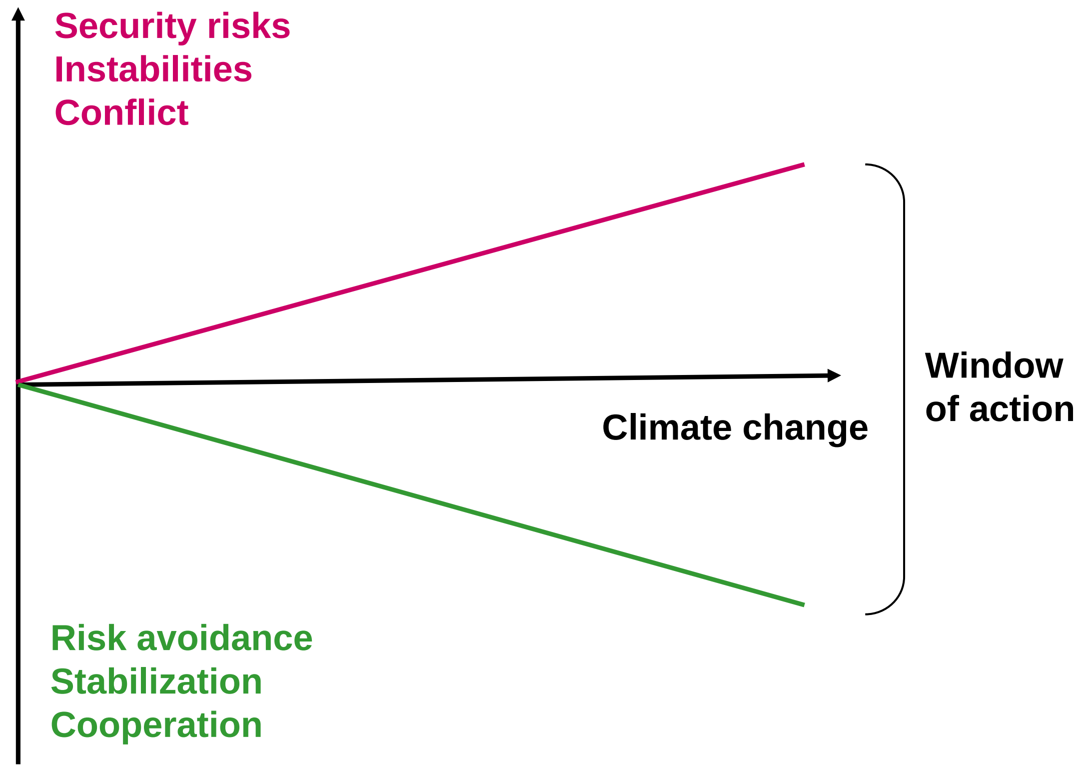
Source: Dasgupta et al. 2007.

Source: Human Decvelopment Report 2007

World map of climate risks



How will human beings and societies respond?




Is climate change a security risk?

Security risks of climate change

Climate change may "pose as much of a danger to the world as **war."** (UN Secretary General Ban Ki-Moon)

Climate change is characterized as a **"threat multiplier"** in already fragile regions of the world, exacerbating conditions that lead to failed states — the breeding grounds for extremism and terrorism. (National Security and the Threat of Climate Change, April 2007)

Security risks of climate change

German Advisory Council on Global Change (2007)

Without resolute counteraction, climate change will overstretch many societies' adaptive capacities within the coming decades, which could result in **destabilization and violence**, jeopardizing national and international security to a new degree.

Climate change could also unite the international community to set the course for avoidance of dangerous anthropogenic climate change by adopting a dynamic and globally **coordinated climate policy**.

If it fails to do so, "climate change will draw ever-deeper lines of **division and conflict** in international relations, triggering numerous conflicts between and within countries over the distribution of resources, especially water and land, over the management of migration, or over compensation payments between the countries mainly responsible for climate change and those countries most affected by its destructive effects."

Conflicts may spread to neighbouring states, e.g. through refugee flows, ethnic links, environmental resource flows or arms exports. Spillover effects can destabilize regions and expand the geographical extent of a crisis, overstretching global and regional governance.

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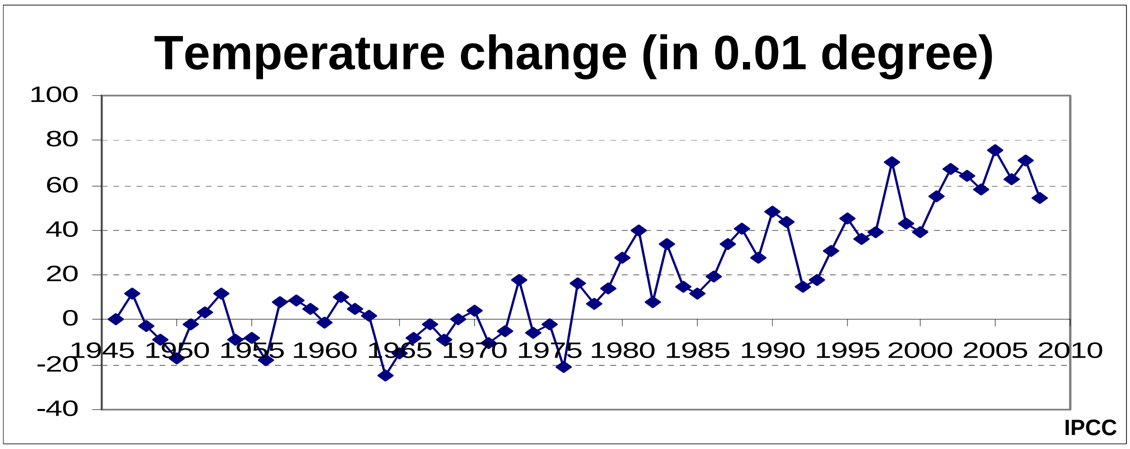
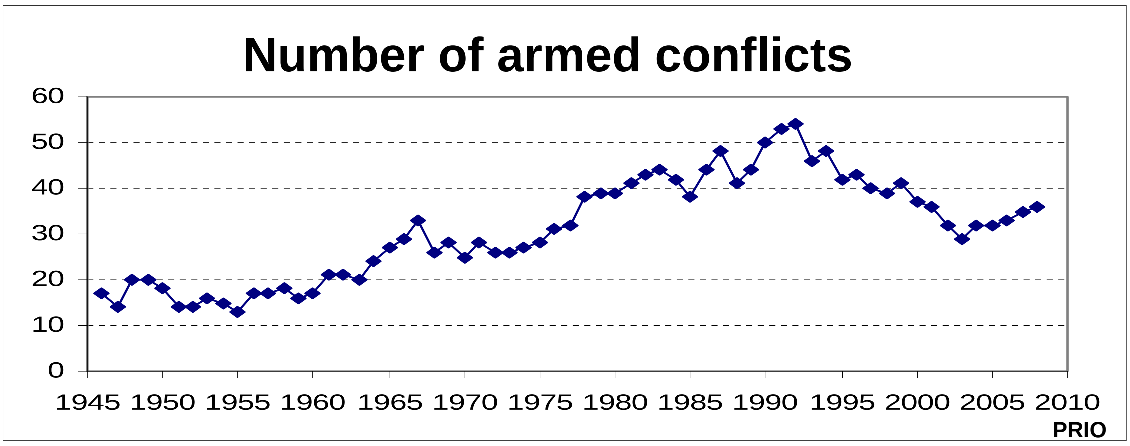
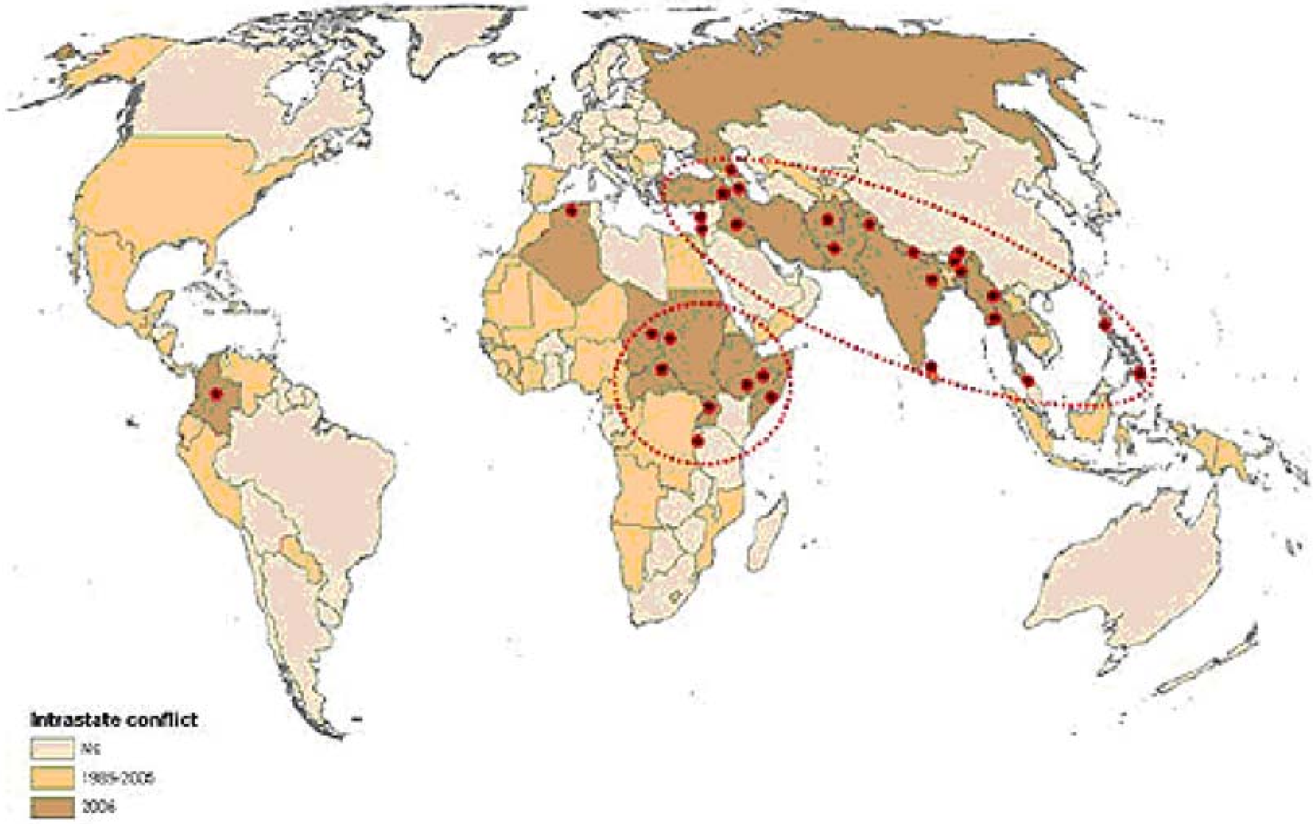
Can the link between climate change and conflict be empirically justified?



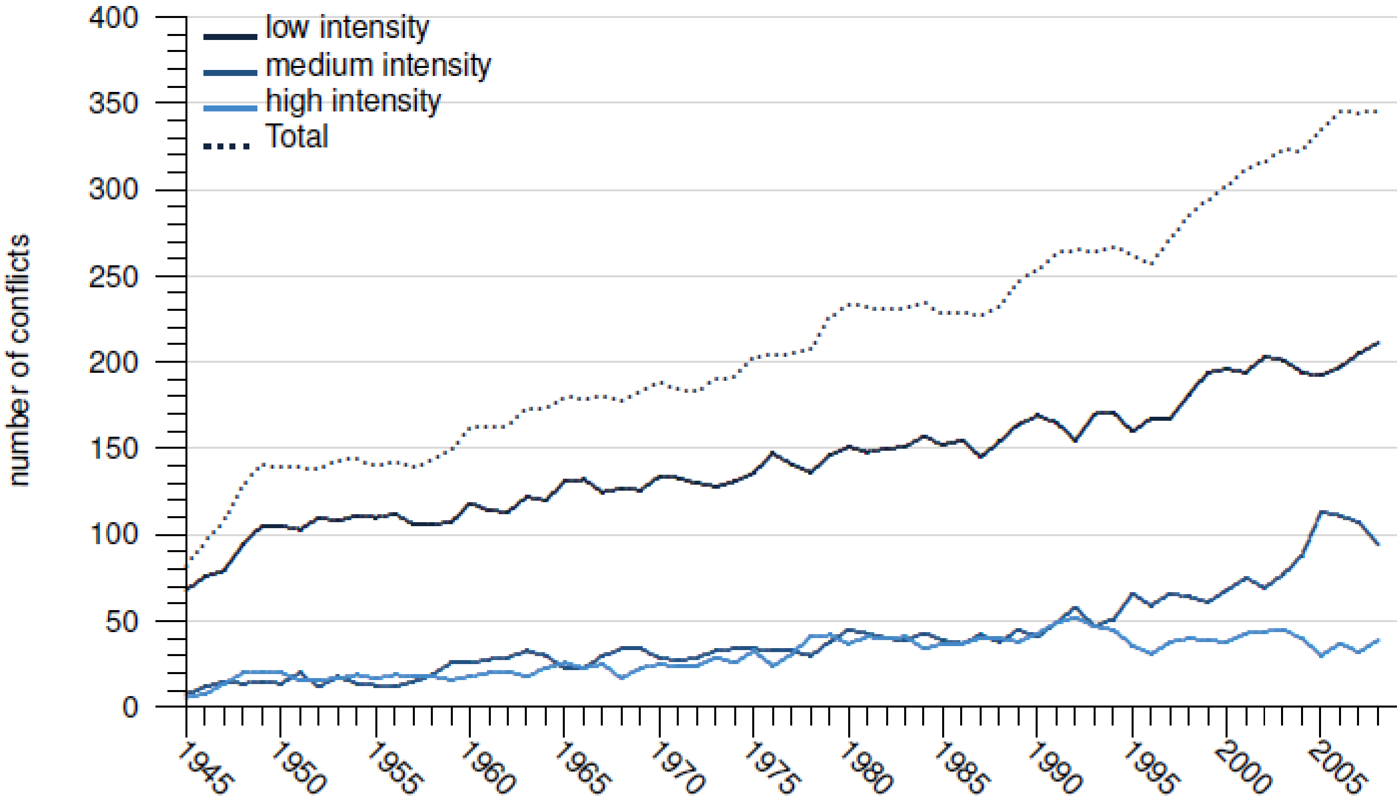


Armed conflicts in 2006



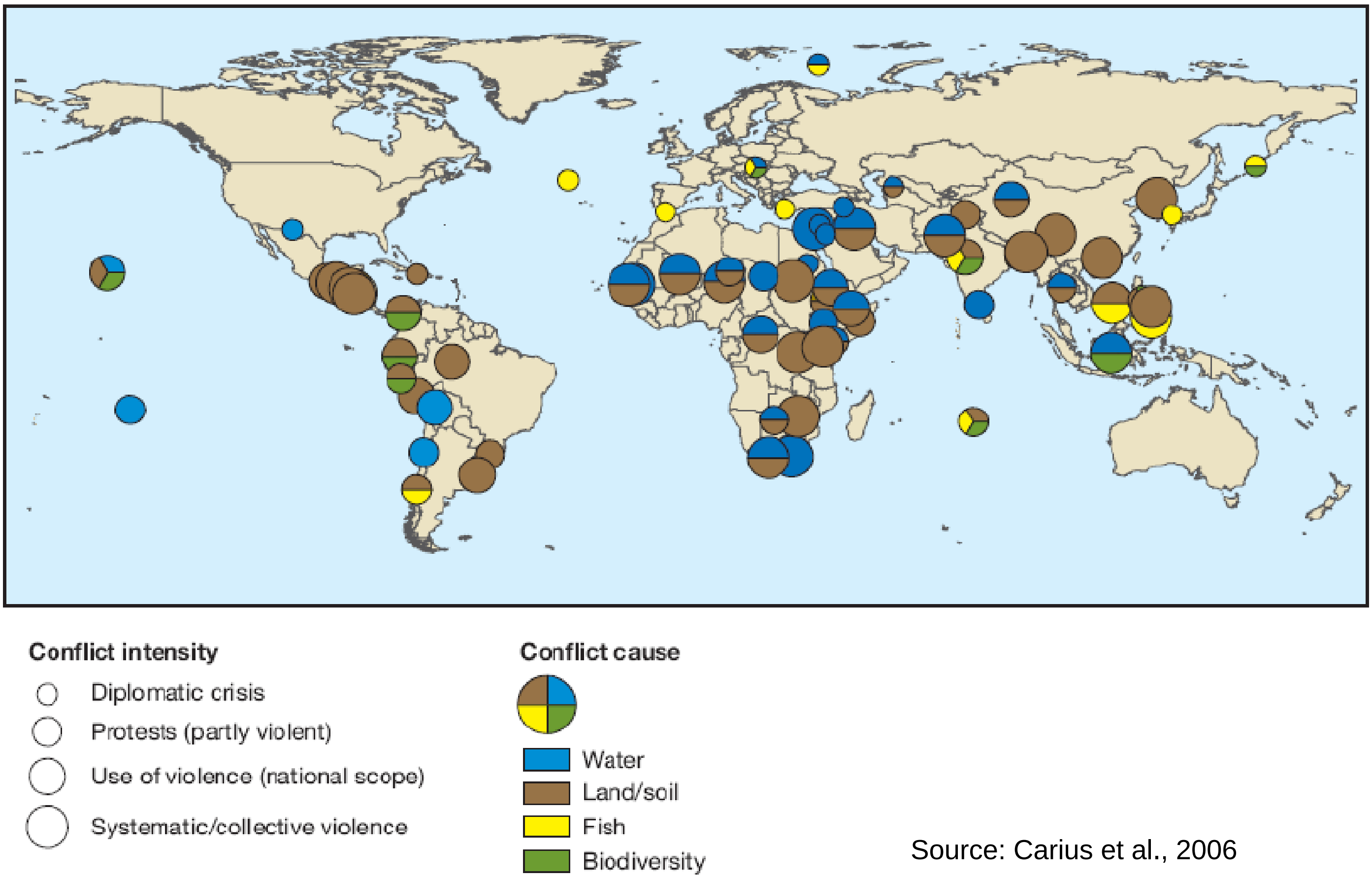
Source: PRIO

Global conflicts of low, medium and high Intensity
1945 to 2008



Source: Conflict Barometer; Heidelberg 2008

World map of environmental conflicts (1980–2005): Causes and intensity



Source: Carius et al., 2006

Climate-induced conflict constellations

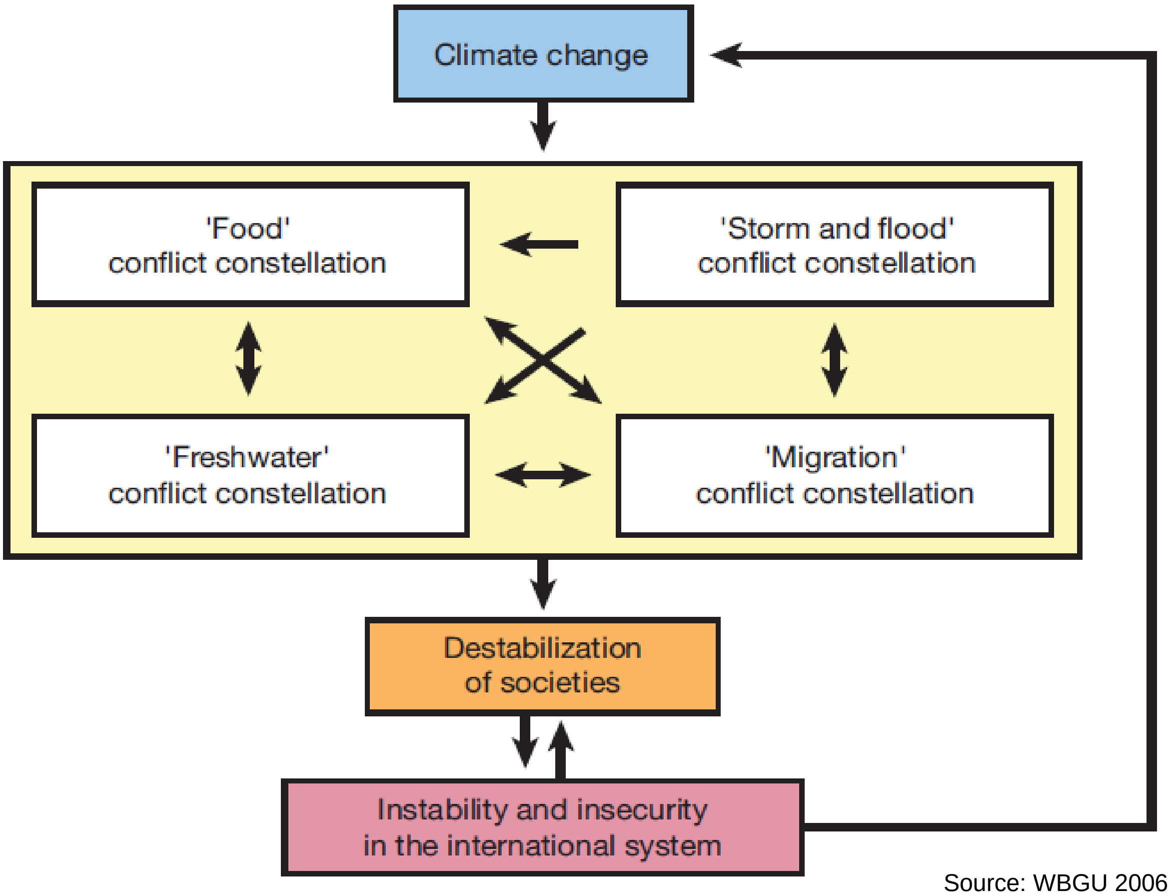
Conflict constellations: “causal linkages at the interface between the environment and society, which interact dynamically and are capable of induc-ing social destabilization or violence.”

1. Degradation of freshwater resources
2. Climate-induced decline in food production
3. Increase in storm and flood disasters
4. Environmentally induced migration

→ Trigger or amplify conflicts and social destabilization?

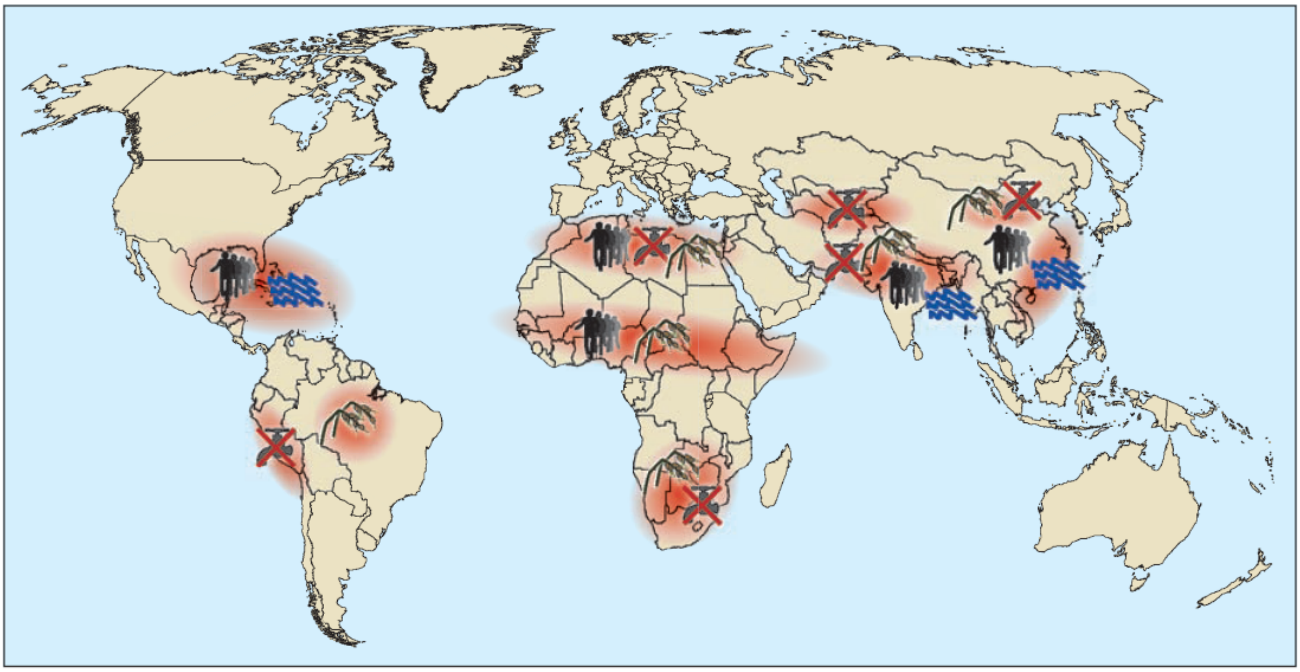
(Source: WBGU 2007)

Conflict constellations as drivers of international destabilization



Source: WBGU 2006

Conflict constellations in climate hotspots



Conflict constellations in selected hotspots

Climate-induced degradation of freshwater resources

Climate-induced decline in food production

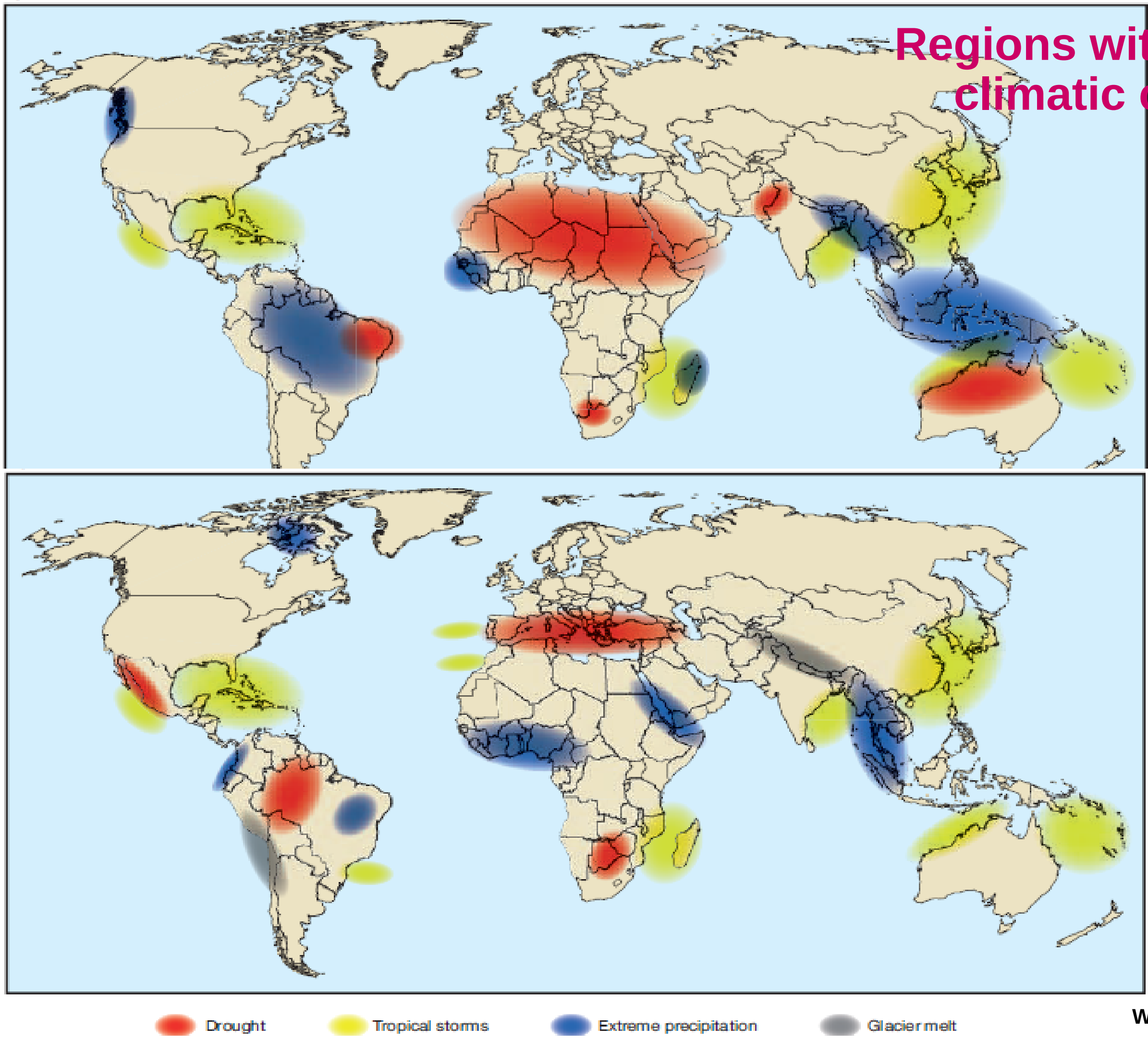
Hotspot

Climate-induced increase in storm and flood disasters

Environmentally-induced migration

Source: WBGU 2007

Regions with extreme climatic conditions

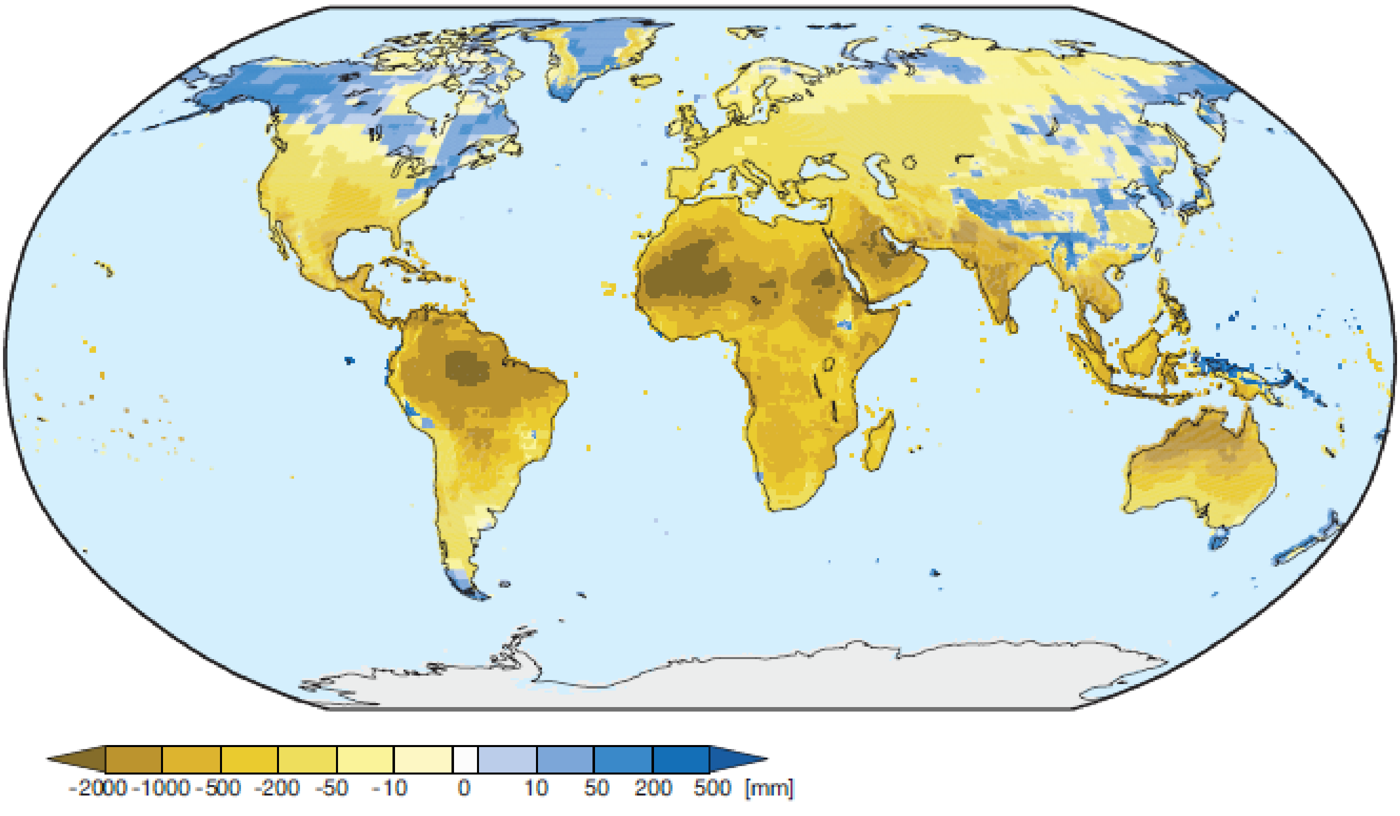


Today

Future

WBGU 2007

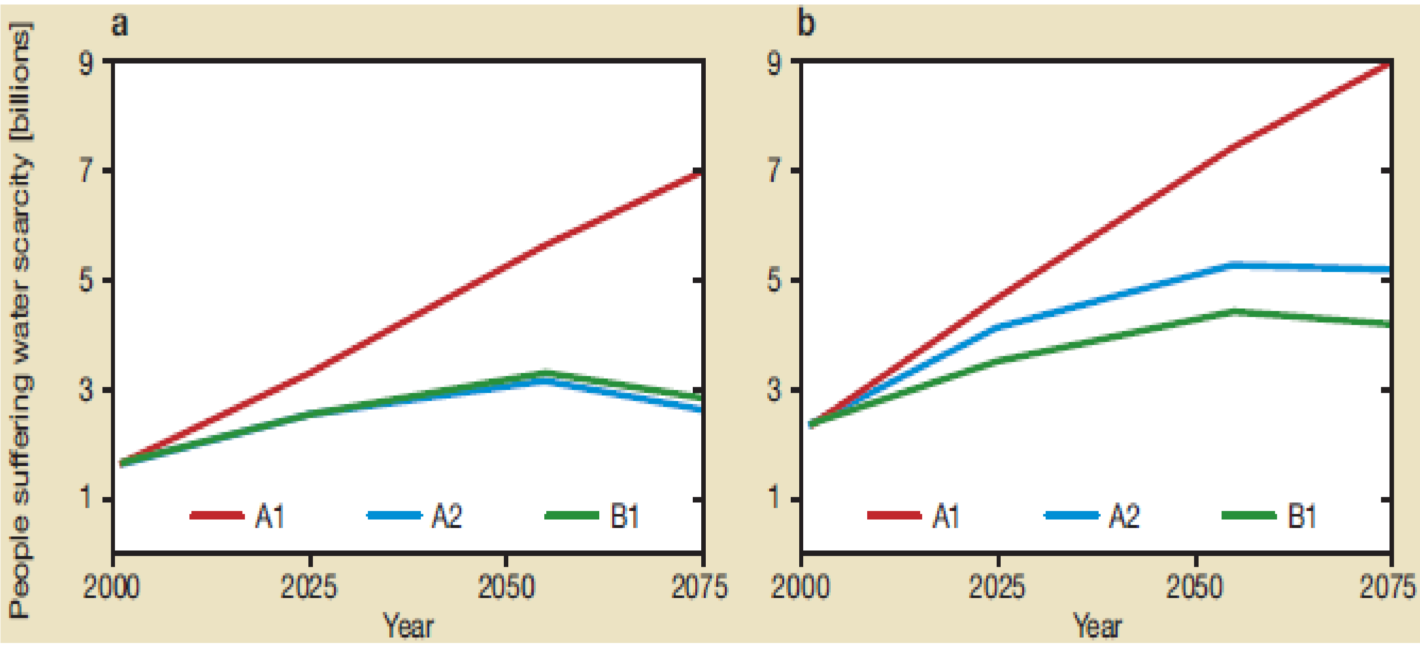
Future dynamics of drought risk
(2041–2070 compared to 1961–1990)



Absolute changes in climatic water balance between periods

WBGU 2007

Projections of populations suffering severe water stress



a) Falkenmark indicator:
available water amount < 1,000m3/capita

b) Quotient between water withdrawal and available amount > 0.4.

A1, A2, B1: IPCC/SRES scenarios

WBGU 2007 p. 21

Water use: conflict or cooperation?

- ➢Water scarcity undermines human security and heightens competition for water and land resources, undermining living conditions of communities.

- ➢Uneven water distribution: migration or resource capture in neighbour region

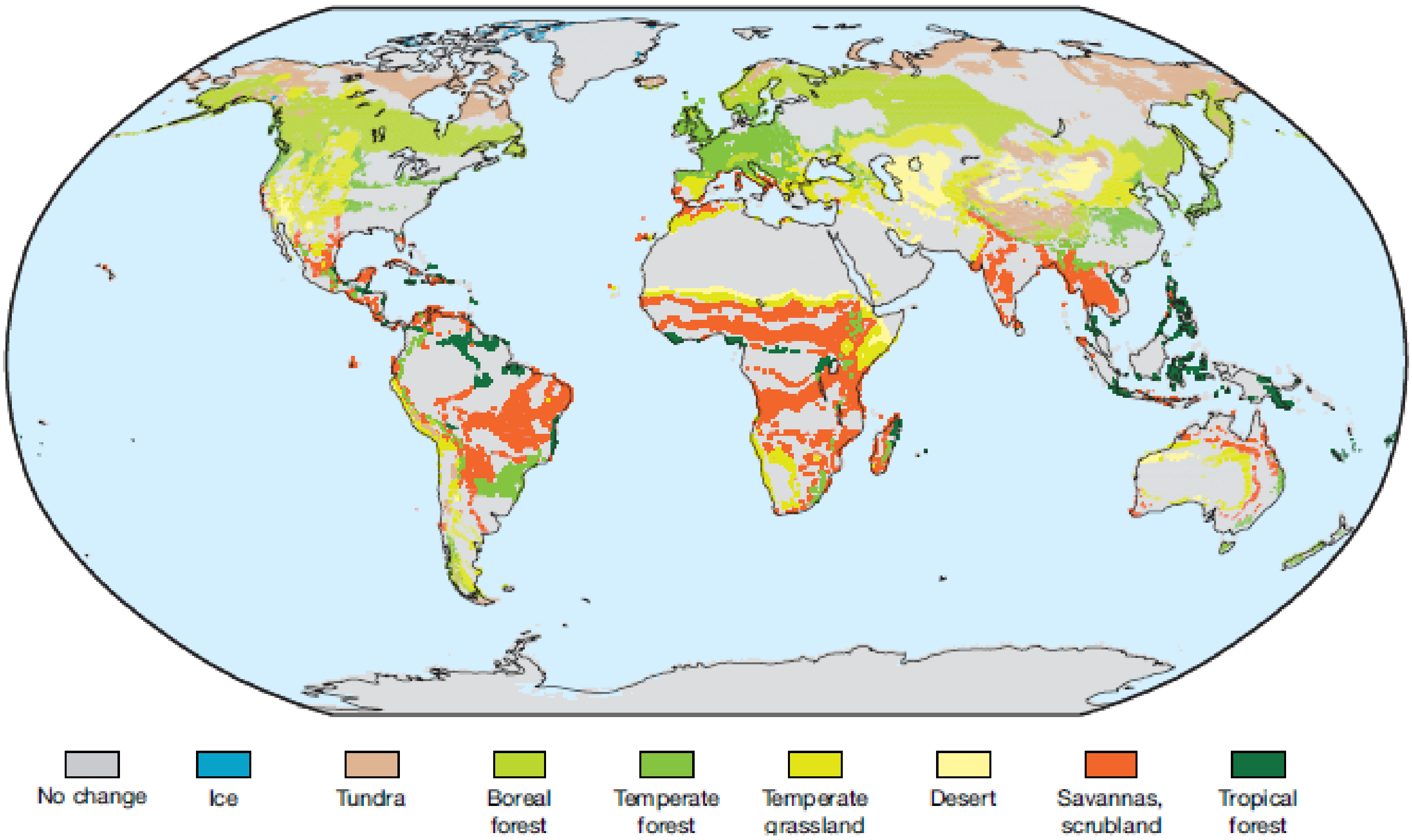
- ➢Disadvantaged groups could seek to displace another group from water-rich territory or water-rich region could secede from central government control.

- ➢Shared freshwater resources: overwhelmingly cooperative, rare violent conflict far outweighed by international water agreements.

- ➢Greatest water stress in countries without political and institutional framework for crisis management and conflict resolution.

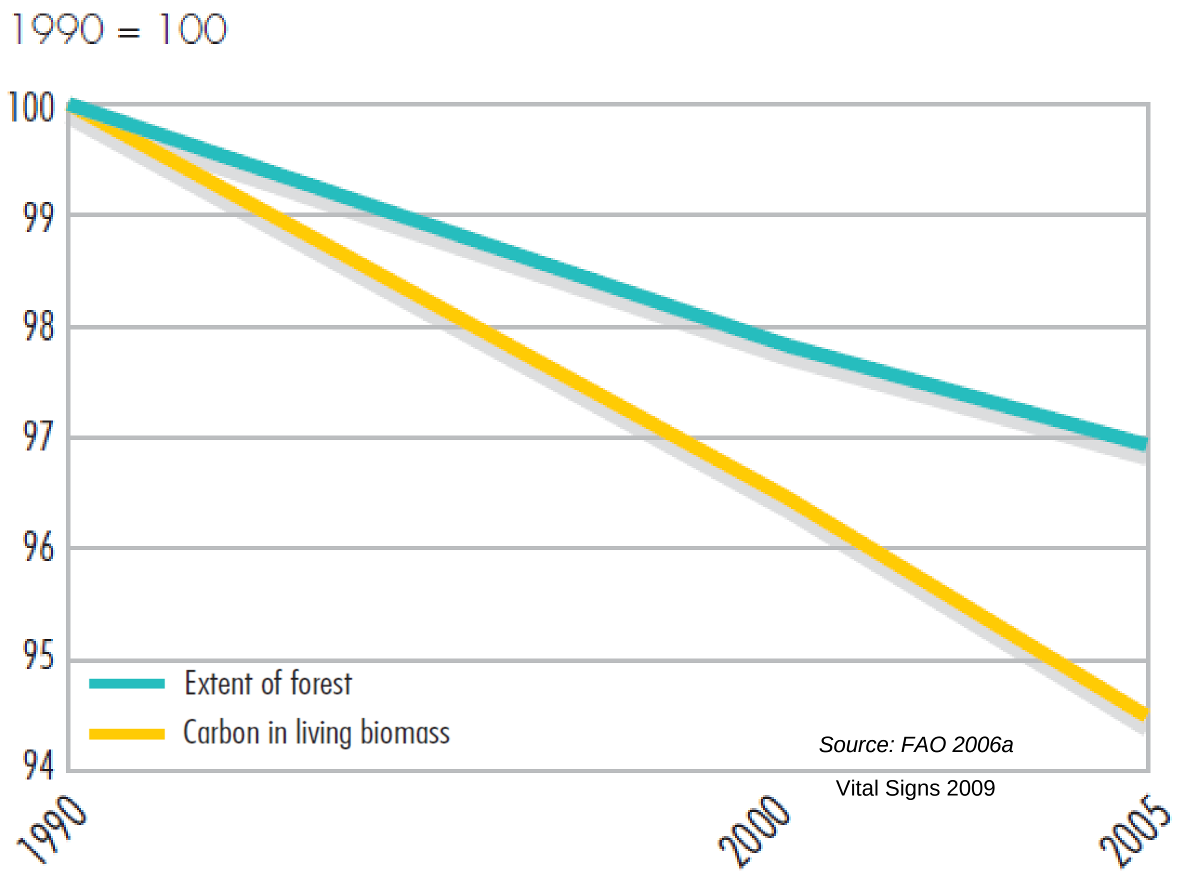
→ Complex causal relationship between hydro-climatology and water-related political relations which depends on socioeconomic conditions and institutional capacity

Ecosystems affected by 3°C temperature change



WBGU 2007

Declining carbon in living biomass and in extent of forest



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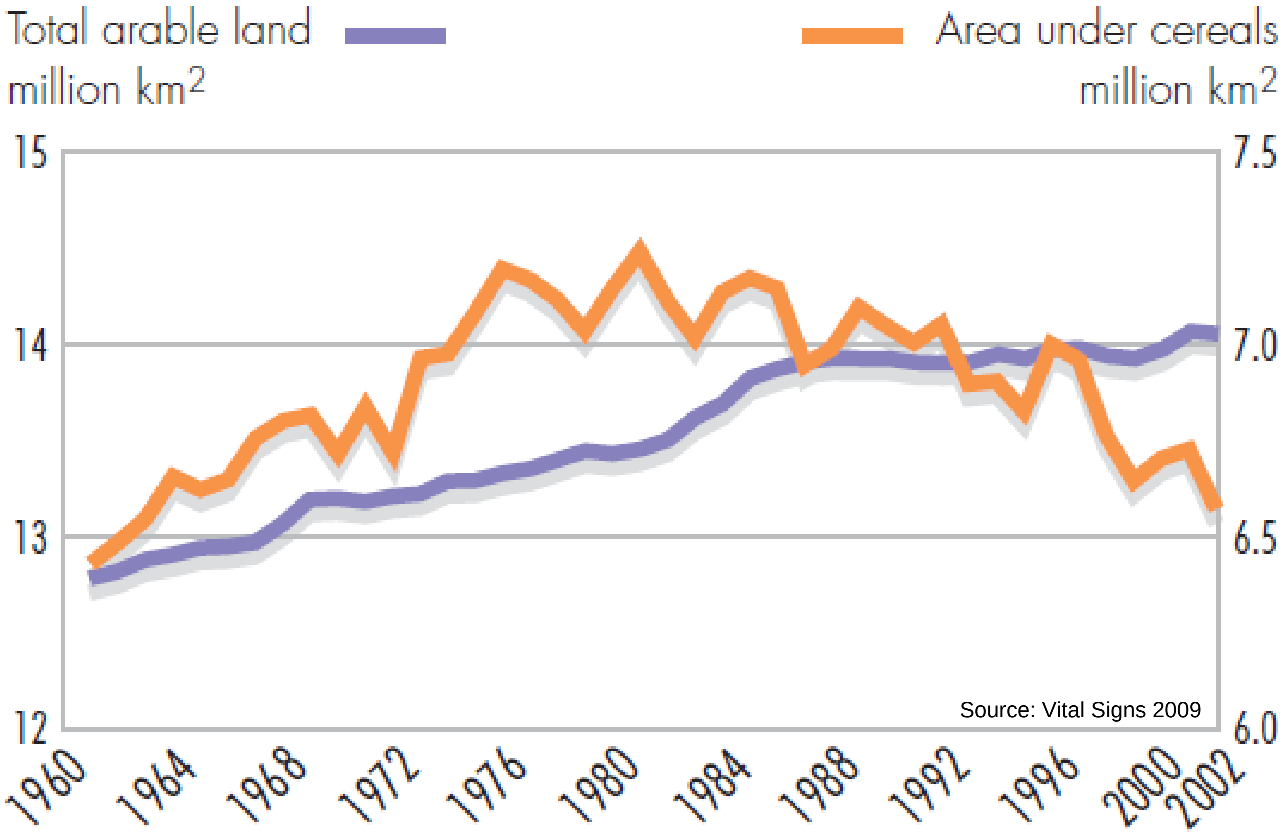
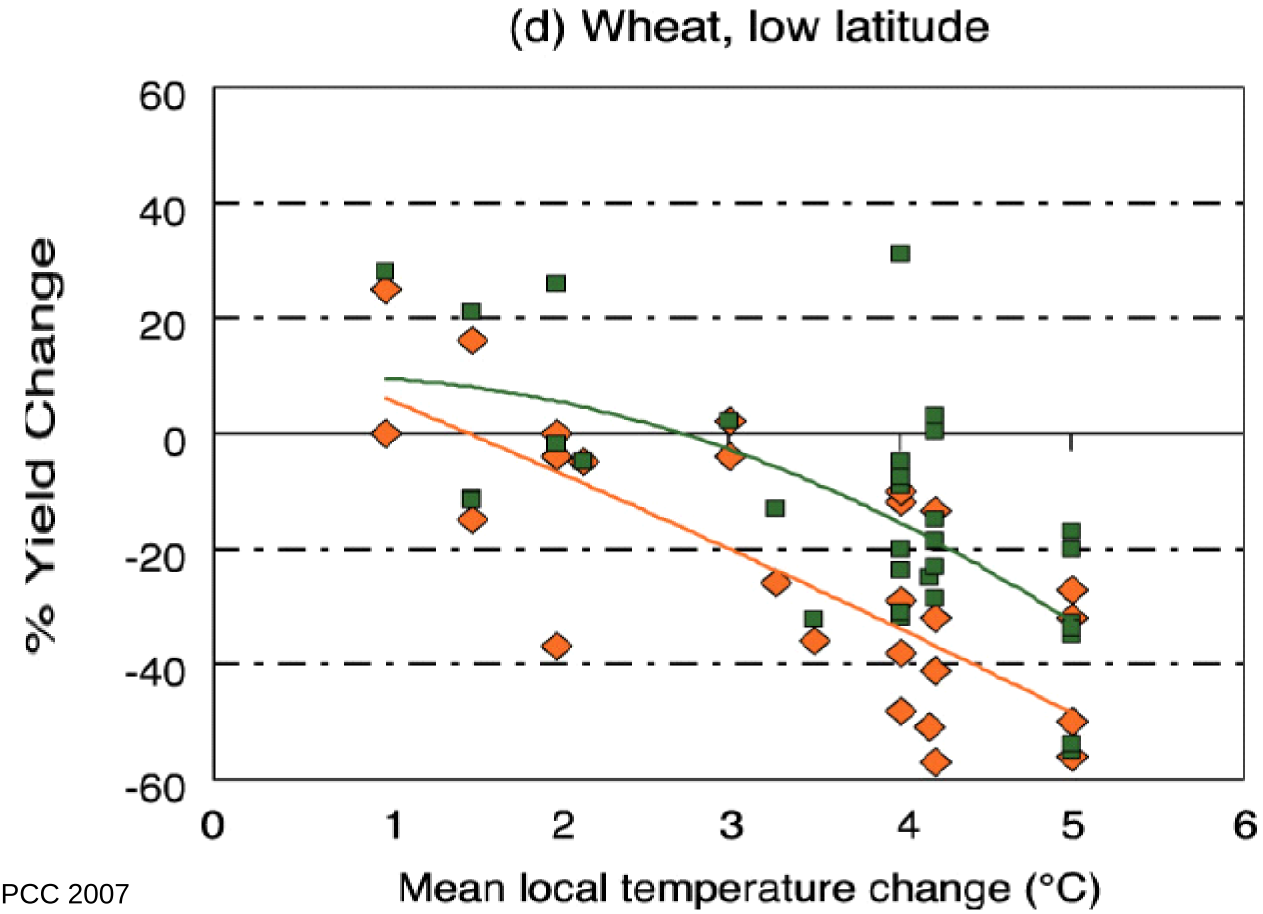
Arable land



Total arable land
million km2
Area under cereals
million km2
15
14
13
12
7.5
7.0
6.5
6.0
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2002
Source: Vital Signs 2009

Sensitivity of cereal yield to climate change



IPCC 2007

Land use and food security

More than 850 million people undernourished, and agricultural areas overexploited in many parts of the world.

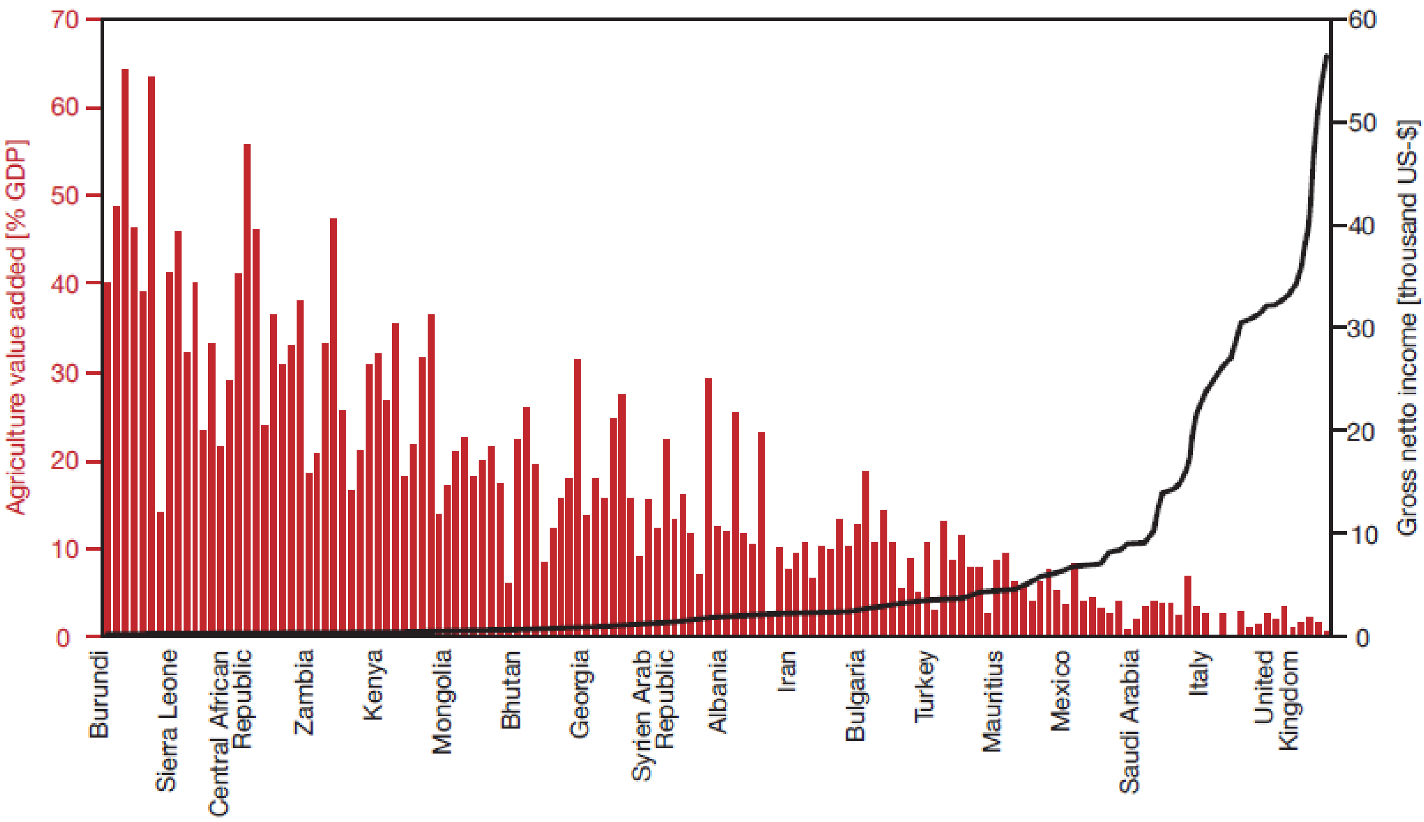
Climate change will likely reduce crop productivity and worsen malnutrition and food insecurity; significant variations from region to region.

Global warming of 2-4 ^{o}C decreases agricultural productivity worldwide and reinforced by desertification, soil salinization, and water scarcity (WBGU 2007).

Food production severely threatened by global warming in lower latitudes, particularly through loss of cereal harvests and insufficient adaptive capacities (IPCC 2007b).

Temperature rise of >4 °C with major negative impacts on global agriculture.

Share of agriculture in GDP and per capita income (2004)



Source: WBGU 2007

Food and climate change in developing countries

65 developing countries could lose cereal production of 280 mio.t, loss of US$ 56 billion or 16% of GDP in agriculture in 1995

→ In India 125 mio.t (18%) of cereal production could be destroyed.

Africa’s food production particularly vulnerable

→ Agricultural land fell from 0.5 to 0.3 ha per capita (1965-1990)

→ Per-capita food production declined for more than 20 years.

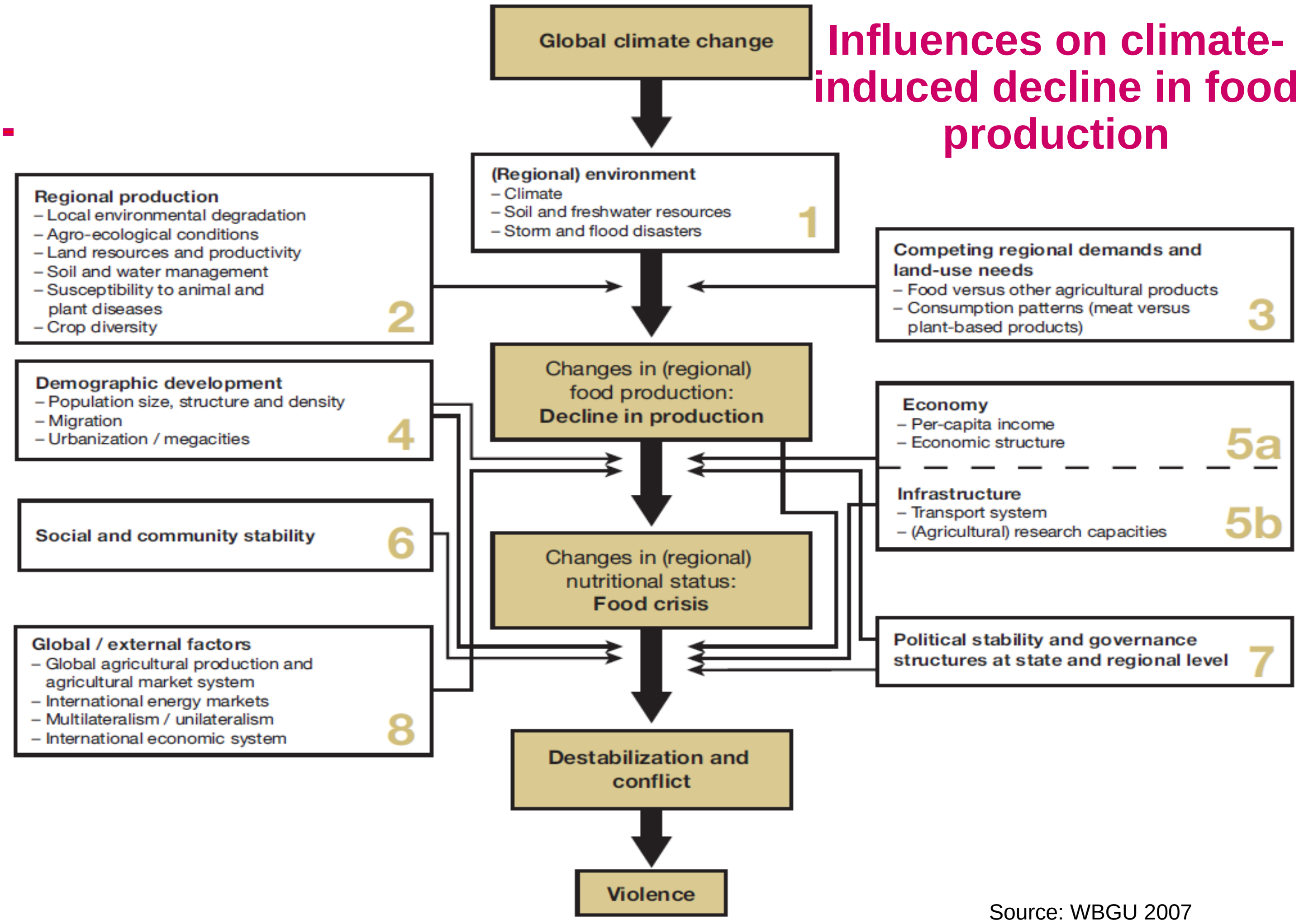
→ Poor water supply could reduce yields from rain-fed agriculture by up to 50% in some African countries by 2020.

→ Soil degradation, population growth, unequal land distribution transformed environmental crisis in Rwanda into a genocide.

Trigger regional food crises, global increase in food prices, and undermine economic performance of weak and unstable states.

Predicted loss of agricultural land due to climate change would lead to additional decline in food production of about 20%

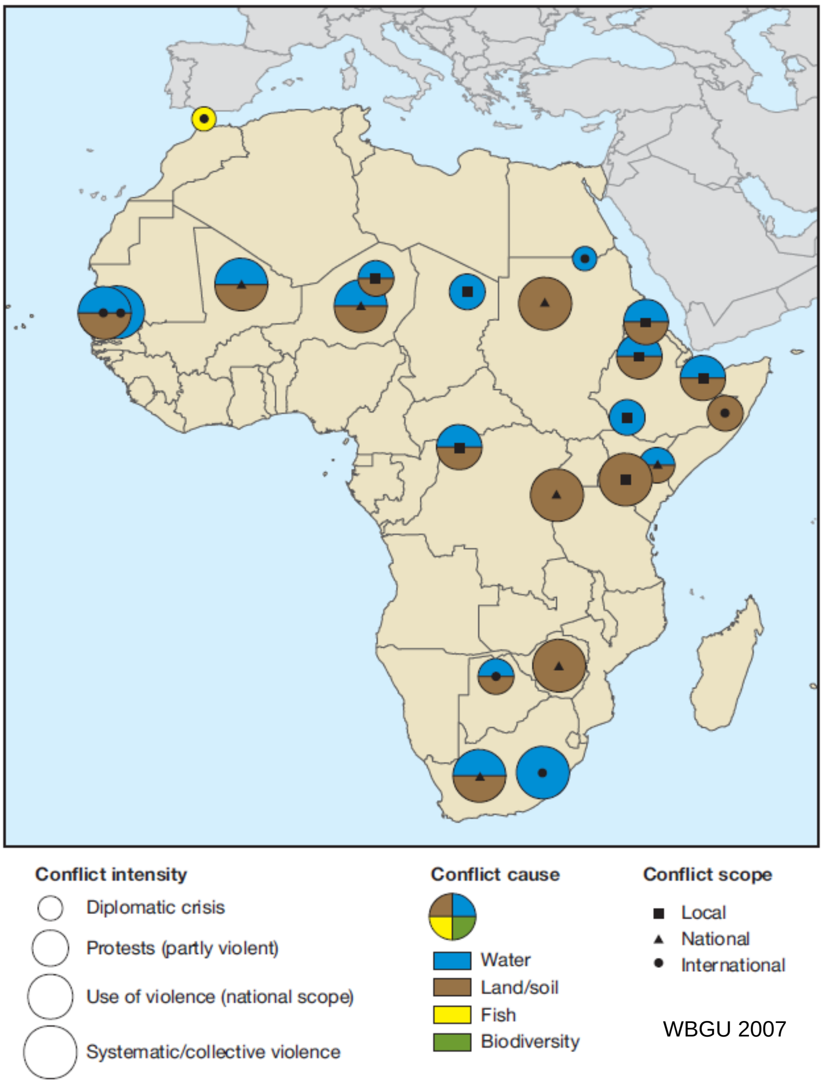
Influences on climate-induced decline in food production



Source: WBGU 2007

Boxes 1–8: Dimensions of influence with key factors

Environmental conflicts in Africa (1980–2005)



Warming increases the risk of civil war in Africa

First comprehensive examination of potential impact of global climate change on armed conflict in sub-Saharan Africa.

➢Strong historical linkages between civil war and temperature in Africa: warmer years leading to significant increases in likelihood of war.

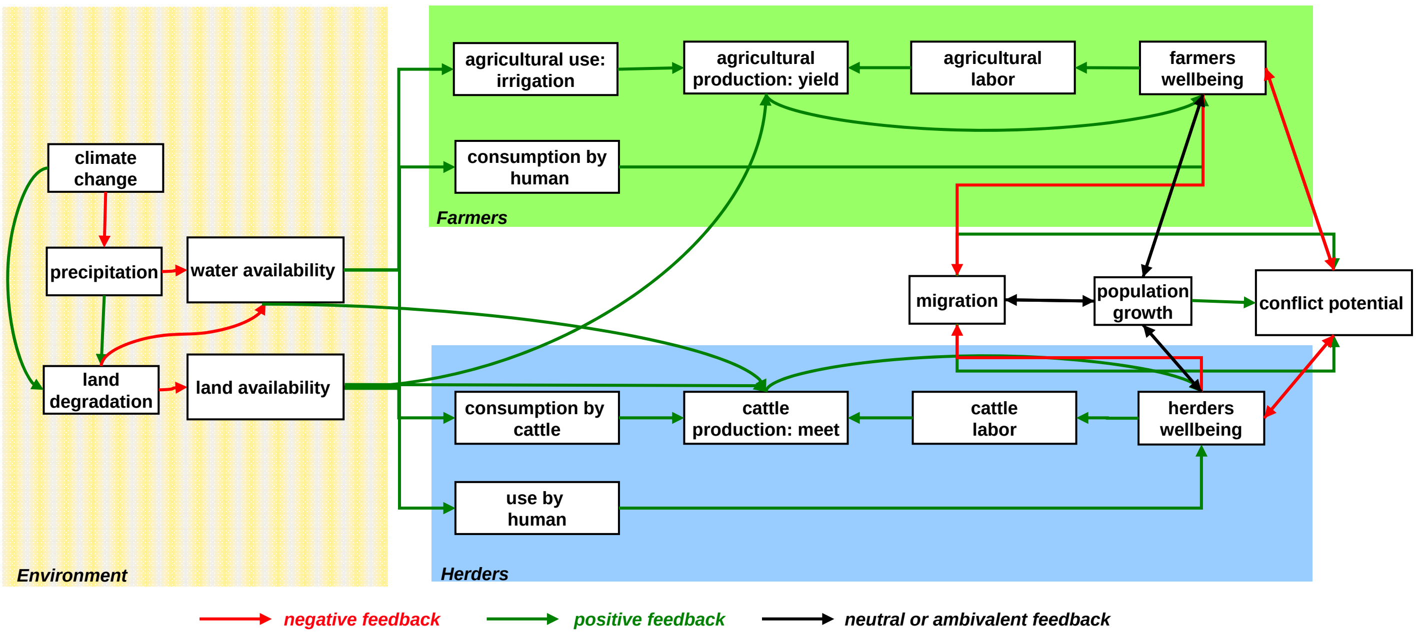
➢Historical data combined with climate model projections of future temperature trends: 54% increase in armed conflict incidence by 2030, or additional 393,000 battle deaths if future wars are as deadly as recent wars.

→Urgent need to reform African governments' and foreign aid donors' policies to deal with rising temperatures.

Source: Marshall B. Burke, Edward Miguel, Shanker Satyanath, John A. Dykema, and David B. Lobell, Warming increases the risk of civil war in Africa, PNAS December 8, 2009 vol. 106 no. 49, 20670–20674.


Farmer-herder land use conflicts in Africa:
the case of Darfur Sudan
Boundary semi-desert to desert moved southward by 50 to 200 km since 1930s. Significant drop in food production (20%)
Drought & desertification in Sahara increased migration of nomadic groups into more fertile areas of Darfur.
AMIS
Arabic herders from north migrated south and cattles trampled fields of African farmers
Darfur is considered a “tragic example of the social breakdown that can result from ecological collapse” (UNEP 2007).

Systemic overview of the farmers-herders land use conflict in North Africa



Challenges in the Nile Basin

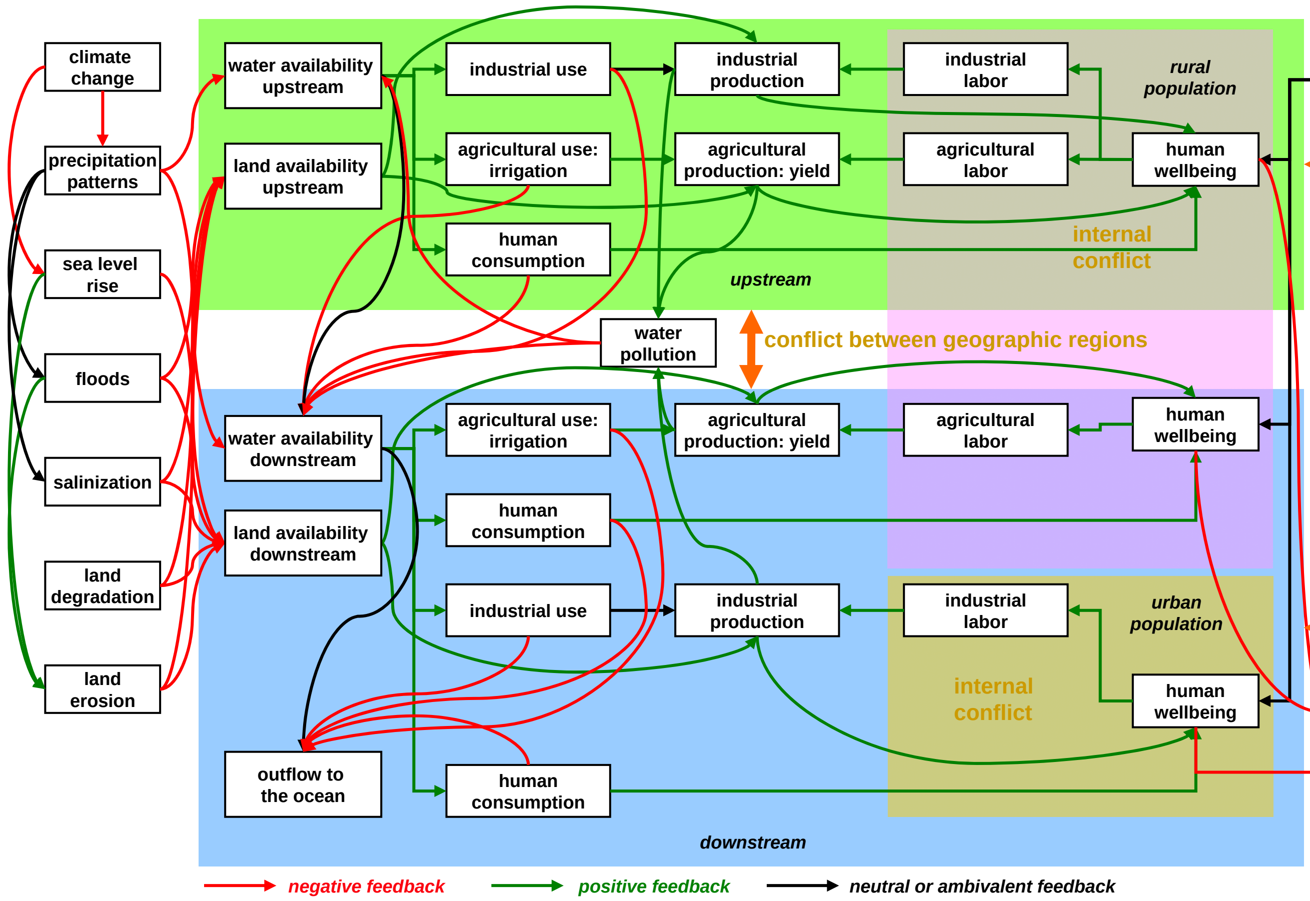
Cairo under pressure:

➢Fast growing population (16 million)
➢Thousands of migrants from rural areas
➢City infrastructure under pressure

Egypt highly vulnerable to climate change

➢Water scarcity and lower agricultural productivity in Upper Nile
➢0,5 m sea-level rise: displace 4 mio. people Increased likelihood of severe diseases
➢Increasing migration and social tensions
➢Strengthens extremist groups
➢Land degradation and loss in agricultural productivity (wheat/maize by 20% by 2050).
➢Demographic pressure (double 2005-2050)
➢Intensified competition over arable land
➢Social unrest may spread to urban centers
➢In 2008, global food price hikes led to food riots and strikes across Egypt Brauch 2006

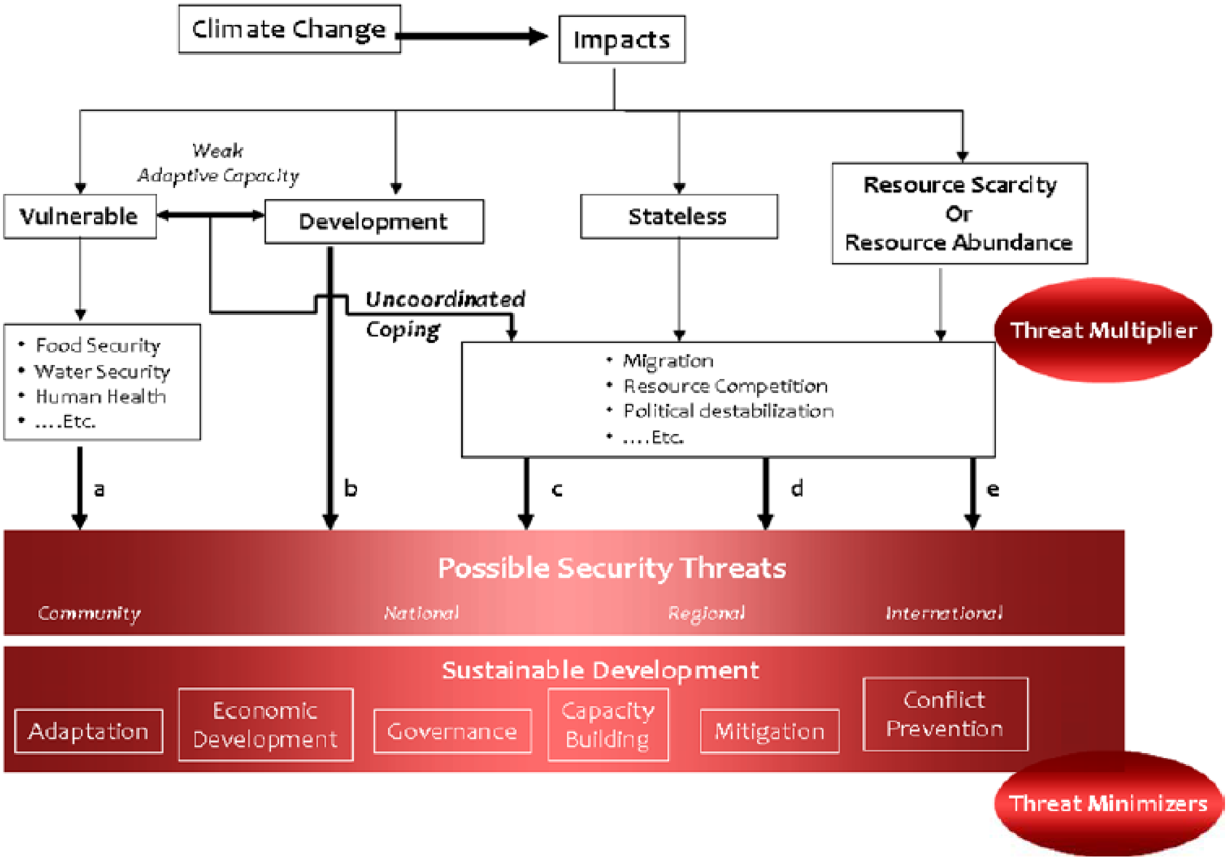
Systemic overview of the Nile water conflict



Lessons on the climate-security link

- Environmental factors do not by themselves cause conflict but are part of a **multicausal complex network** of factors that may increase the risk of conflict. Socio-economic factors and governance decisive.
- Impacts and conflicts related to scarcities and migration are most relevant at the **local level**.
- More likely than large-scale civil and international war is **low-level violence**.
- **Risk factors** are variability, vulnerability and adaptive capacity.
- In some cases environmental degradation leads to **more cooperation**.

From threat multiplier to threat minimizer



Source: United Nations Secretariat, based on submissions of Member States and relevant organizations.

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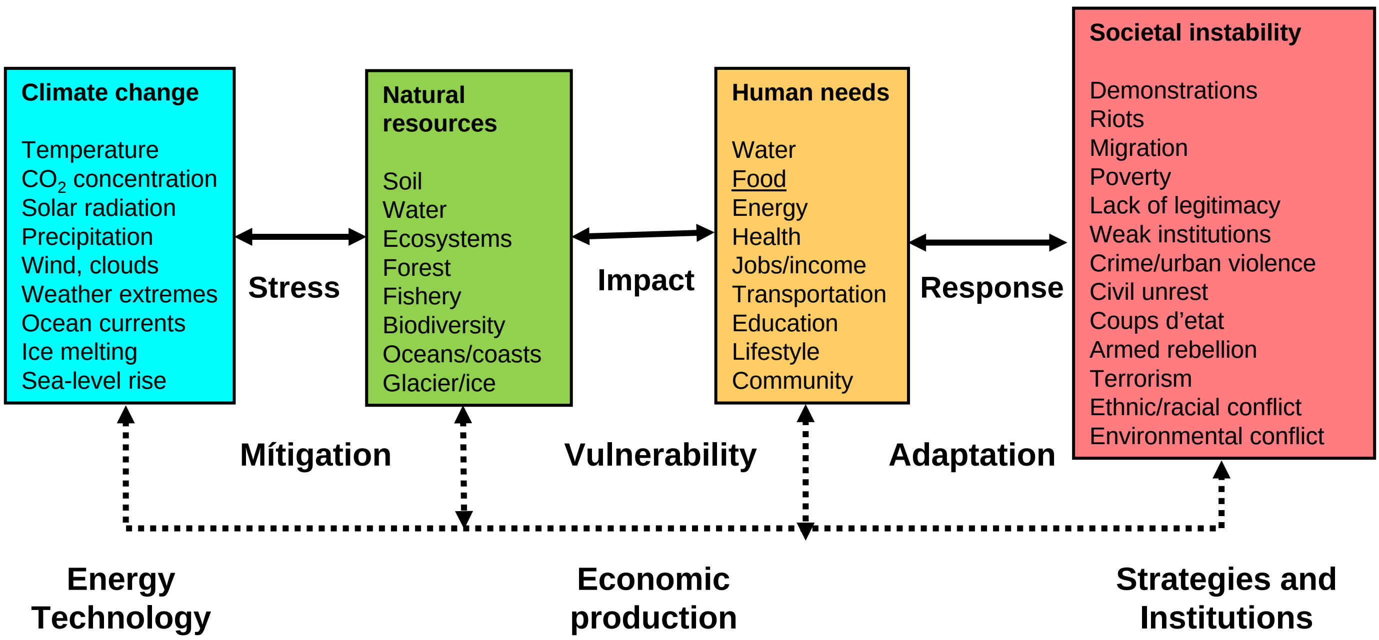
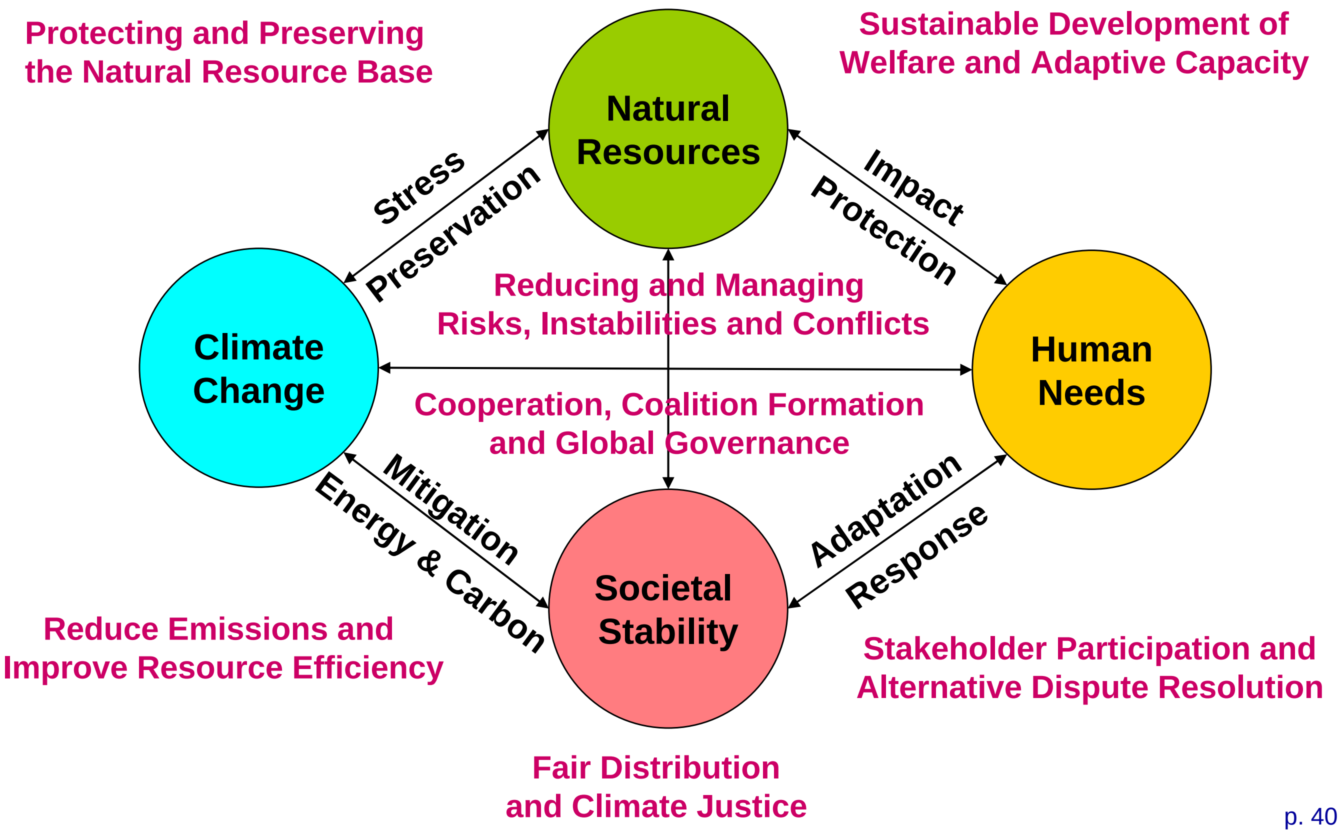
Interaction between climate change, natural resources, human needs and societal stability



Integrated strategies for preventing climate risks and conflicts



UN Framework Convention on Climate Change

UNFCCC Article 2 ultimate objective (Rio 1992):

“stabilization **of greenhouse gas concentrations in the atmosphere at a level that would** prevent dangerous **anthropogenic interference with the climate system.**

Such a level should be achieved within a time-frame **sufficient**

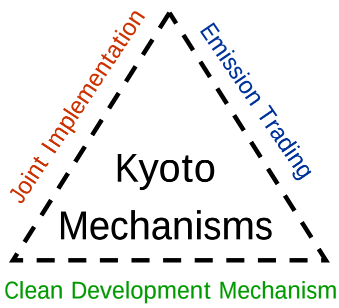
to allow ecosystems to adapt naturally to climate change,

to ensure that food production is not threatened and

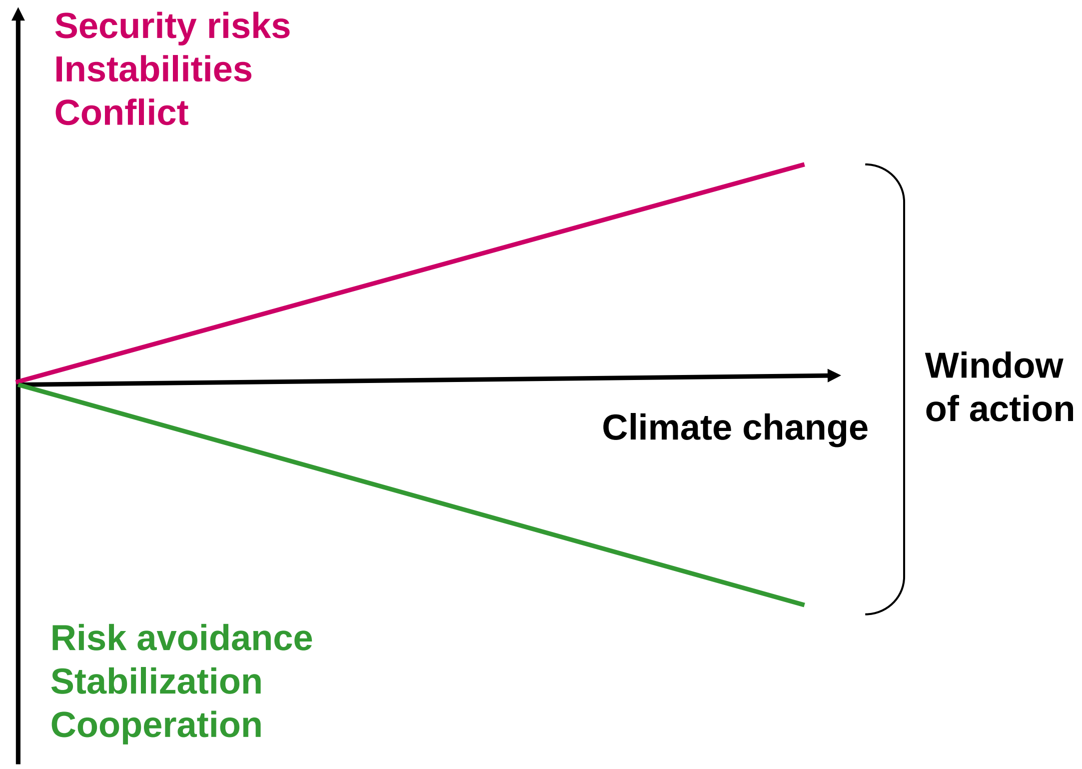
to enable economic development to proceed in a sustainable manner.”

1997 Kyoto Protocol to the UNFCCC:

- GHG emission reductions average -5.2% of 1990 level until 2008-2012
- Enters into force February 16, 2005



How will human beings and societies respond?



Deadly Climate Change From Nuclear War:
A threat to human existence

Steven Starr, PSR, University of Missouri

Abstract

A tiny fraction of the operational nuclear arsenals, if detonated within large cities, would generate enough smoke to cause catastrophic disruptions of the global climate[1]and massive destruction of the protective stratospheric ozone layer.[2] Environmental devastation caused by a war fought with many thousands of strategic nuclear weapons would quickly leave the Earth uninhabitable.[3]

Deadly Climate Change and Massive Ozone Destruction from Nuclear War

Nuclear detonations within urban and industrial areas would ignite immense firestorms which would burn everything imaginable and create millions of tons of thick, black smoke. Much of this smoke would rapidly be lofted above cloud level, into the stratosphere, where it would block warming sunlight from reaching the lower atmosphere and surface of the Earth. Sunlight would then markedly heat the upper atmosphere and cause massive destruction of the protective ozone layer, while darkness below would produce average surface temperatures on Earth characteristic of those experienced during an Ice Age.

The darkness and global cooling predicted to result from nuclear war (along with massive radioactive fallout, pyrotoxins, and ozone depletion) was first described in 1983 as "nuclear winter".[4] These initial studies estimated the smoke from nuclear firestorms would stay in the stratosphere for about a year. However in 2006, researchers using modern computer models found the smoke would form a global stratospheric smoke layer that would last for ten years.[5]

The longevity of such a smoke layer would allow much smaller quantities of smoke than first predicted in the 1980's to have a great impact upon both global climate and atmospheric ozone which blocks ultraviolet (UV) light. Thus scientists predict that even a "regional" nuclear conflict could produce enough smoke to significantly cool average global surface temperatures, reduce precipitation, and vastly increase the amount of dangerous UV light reaching the surface of Earth.

In other words, a nuclear war fought between such nations as India and Pakistan would produce enough smoke to make the blue skies of Earth appear grey. Although the amount of sunlight blocked by this smoke would not produce the profound darkening of the Earth predicted in a nuclear winter (following a nuclear war fought with thousands of strategic nuclear weapons), the

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1 A. Robock, L. Oman, G. L. Stenchikov, O. B. Toon, C. Bardeen, and R. Turco, "Climatic consequences of regional nuclear conflicts", Atmospheric Chemistry and Physics, Vol. 7, 2007, p. 2003-2012.
2 M. Mills, O. Toon, R. Turco, D. Kinnison, R. Garcia, "Massive global ozone loss predicted following regional nuclear conflict", Proceedings of the National Academy of Sciences (USA), Apr 8,2008, vol. 105(14), pp. 5307-12.
3 O. Toon , A. Robock, and R. Turco, "The Environmental Consequences of Nuclear War", Physics Today, vol. 61, No. 12, 2008, p. 37-42.
4 R. Turco, O. Toon, T. Ackermann, J. Pollack, and C. Sagan, "Nuclear Winter: Global consequences of multiple nuclear explosions", Science, Vol. 222, No. 4630, December 1983, pp. 1283-1292.
5 A. Robock, L. Oman, G. Stenchikov, "Nuclear winter revisited with a modern climate model and current nuclear arsenals: Still catastrophic consequences", Journal of Geophysical Research – Atmospheres, Vol. 112, No. D13, 2007. p. 4 of 14.

deadly climate change created by the *regional* conflict would likely have devastating *global* effects upon all human populations through its negative influence upon agriculture.[6]

Nuclear War Fought with Hiroshima-size (15 kiloton) Low-Yield Nuclear Weapons

In 2006, U.S. researchers used a NASA computer model (Model 1E, also used for the Intergovernmental Panel on Climate Change to predict global warming) to evaluate the effects of a regional nuclear war fought in the sub-tropics.[7] 50 Hiroshima-size nuclear weapons (15 kilotons per weapon) were detonated in the largest cities of each combatant nation (100 total detonations).

The studies predicted the nuclear explosions would kill 20 million people in the war zone, the equivalent to half of all the people who died during World War II. The conflict would also significantly disrupt global climate. Up to 5 million tons of smoke from burning cities would quickly rise above cloud level into the stratosphere, and within 2 weeks would form a global stratospheric smoke layer which would remain in place for about 10 years.[8]

The computer models estimated this smoke layer would block 7–10% of warming sunlight from reaching the surface of the Earth. Average surface temperatures beneath the smoke would become colder than any experienced during the last 1000 years. There would be a corresponding shortening of growing seasons by up to 30 days and significant reductions in average rainfall in many areas, with a 40% decrease of precipitation in the Asian monsoon region.[9]

Such rapid and drastic climate change would have major impacts on global grain reserves, which already are at 50 year lows.[9] Grain exports would likely cease for several years from large exporting nations like Canada.[10] The 700 million people now living on the edge of starvation, along with those populations heavily dependent upon grain imports, would face mass starvation as grain reserves disappeared, prices skyrocketed and hoarding occurred. Global nuclear famine is the predicted result of this scenario. As many as one billion people could die during the years subsequent to the deadly climate change created by this level of nuclear conflict.[11]

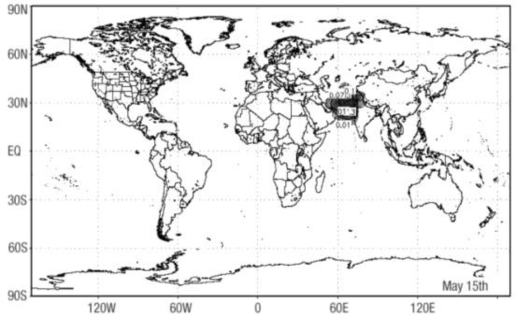
Stratospheric Ozone Destruction and Increased Levels of Harmful Ultraviolet (UV-B) Light

A stratospheric smoke layer would also cause massive destruction of the protective ozone layer. Studies in 2008 predicted smoke from a regional nuclear conflict (as described above) would create ozone losses of 25-45% above mid latitudes, and 50-70% above northern high latitudes persisting for 5 years, with substantial losses continuing for 5 additional years.[12] Severe ozone depletion would allow intense levels of harmful ultraviolet light (UV-B) to reach the surface of the Earth – even with the stratospheric smoke layer in place.

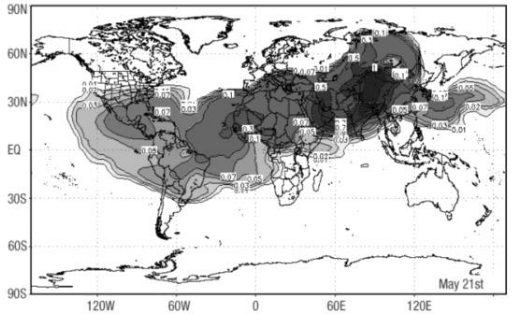
6 I. Helfand, "An Assessment of the Extent of Projected Global Famine Resulting From Limited, Regional Nuclear War", 2007, International Physicians for the Prevention of Nuclear War, Physicians for Social Responsibility, Leeds, MA.
7 In 2009, India and Pakistan were estimated by the NRDC to have a total of 140 to 160 operational nuclear weapons, and there are 32 other non-nuclear weapon states which have sufficient fissionable nuclear materials to construct weapons, some in a relatively short period of time.
8 Robock, et al., "Climatic consequences…, op. cit., p. 2003-2012.
9 Ibid.
10 S. Starr, "Catastrophic Climatic Consequences of Nuclear Conflicts", INESAP Bulletin 28, April 2008, Figure 1.
11 I. Helfand., op. cit.
12 M. Mills, et al, "Massive global ozone loss . . . op. cit.

REGIONAL NUCLEAR WAR BETWEEN INDIA AND PAKISTAN

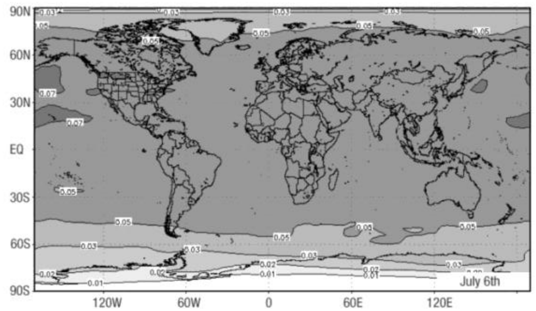
100 HIROSHIMA-SIZE (15 KILOTON) NUCLEAR WEAPONS DETONATED IN URBAN AREAS



Day 2: smoke enters stratosphere



Day 8: global smoke layer forms



Day 64: 10% of sunlight blocked

100 nuclear explosions create massive firestorms in the cities of India and Pakistan. 5 million tons of smoke rises above cloud level into the stratosphere and forms a global smoke layer which will remain in place for 10 years. The smoke will block 7–10% of sunlight from reaching the surface of the Earth. Loss of warming sunlight creates the coldest average surface temperatures on Earth in the last 1000 years. Prolonged cold acts to reduce average precipitation by 40% in some regions. Smoke acts to destroy 25–45% of the protective ozone layer above the populated mid-latitudes and 50–70% of the ozone above the northerly latitudes, allowing massive amounts of harmful UV light to reach marine and terrestrial ecosystems. The sun will burn human skin in as little as 7 minutes in the northern mid-latitudes.

The decreases in average temperature, precipitation, sunlight and stratospheric ozone will act to significantly shorten growing seasons and markedly reduce agricultural production for several years. Conditions would then slowly return to normal over a period of about a decade. Given that world grain reserves are now only adequate to sustain human populations for about 30 to 50 days, it is likely that prolonged and severe food shortages will result from such drastic changes in global climate. Those human populations already living at the verge of starvation and dependent upon imported food supplies will be at extreme risk of famine and starvation if grain exports from North America and Eurasia are suddenly halted by Ice Age weather conditions. It has been estimated that up to 1 billion people could starve to death in the years following this regional nuclear conflict.

CREDITS

The smoke images were created by Dr. Luke Oman of Rutgers University and are reproduced with his permission. The data on deadly climate change from regional nuclear conflict is taken from "Climatic consequences of regional nuclear conflicts", by Robock A., Oman L., Stenchikov G., Toon O. B., Bardeen C., and Turco R., Atmospheric Chemistry and Physics, Vol. 7, 2007, p. 2003-2012; the data on ozone depletion is from "Massive global ozone loss predicted following regional nuclear conflict", by Mills M, Toon O, Turco R, Kinnison D, Garcia R (2008). Proceedings of the National Academy of Sciences (USA), Apr 8, vol. 105(14), pp. 5307-12; data on famine, I. Helfand, An Assessment of the Extent of Projected Global Famine Resulting From Limited, Regional Nuclear War, 2007, International Physicians for the Prevention of Nuclear War, Physicians for Social Responsibility, Leeds, MA

Global stratospheric ozone levels would fall to near those now seen only over Antarctica during the formation of the "ozone hole". The UV index in the mid-latitudes would increase by 42–108%, which would cause fair skinned people to suffer sunburn in as little as 7 minutes. In the high northerly latitudes, the UV index would increase by 130–290%, shortening the time required for fair skinned people to sunburn from 32–43 minutes to 8–19 minutes.[13]

Massive increases of UV-B light would clearly have negative impacts upon marine and terrestrial ecosystems, yet no research is being done to investigate the consequences of such a scenario. Likewise, no studies using modern climate models have yet been done to assess ozone depletion following larger nuclear conflicts fought with high-yield strategic nuclear weapons.

Nuclear War Fought with High-Yield Strategic Nuclear Weapons[14]

The high-yield strategic nuclear weapons in the operational arsenals of the U.S. and Russia have a combined explosive power at least 500 times greater than the low-yield weapons detonated in the regional war conflict. A large fraction of these strategic weapons are kept on high-alert status (in 2009, more than 2000 U.S. and Russian strategic warheads were on high-alert).[15] Virtually all their land-based intercontinental ballistic missiles are kept ready to launch within 30 seconds to 3 minutes, apparently operating under the policy of Launch-On-Warning.[16]

In 2008, scientists predicted the detonation of 4400 strategic nuclear weapons in large cities could cause 770 million prompt fatalities and produce up to 180 million tons of thick, black smoke.[17] Ten days after detonation, the smoke would form a dense global stratospheric smoke layer which would block about 70% of warming sunlight from reaching the surface of the Northern Hemisphere and 35% of sunlight from reaching the Southern Hemisphere.[18]

The resulting nuclear darkness would cause rapid cooling of more than 20º C (36º F) over large areas of North America and of more than 30º C (54º F) over much of Eurasia (Figure 2). Daily minimum temperatures would fall below freezing in the largest agricultural areas of the Northern Hemisphere for a period of between one to three years. Average global surface temperatures would become colder than those experienced 18,000 years ago at the height of the last Ice Age.[19]

The cooling of the Earth's surface would weaken the global hydrological cycle and the Northern Hemisphere summer monsoon circulations would collapse because the temperature differences that drive them would not develop. As a result, average global precipitation is predicted to decrease by 45%.[20]

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13 Personal correspondence with Dr. Paul Newman of NASA, Nov. 20, 2009.
14 High-yield weapons are generally 8 to 75 times more powerful than low-yield Hiroshima-size weapons.
15 S. Starr., "High-Alert Nuclear Weapons: the Forgotten Danger", SGR Newsletter, Autumn, 2008, p.1.
16 Launch-On-Warning (LOW) is a launch of nuclear weapons after Early Warning Systems (EWS) identify an incoming nuclear attack, but before one or more nuclear detonations provide unequivocal proof that the perceived attack is in fact a nuclear attack. High-alert nuclear-armed ballistic missiles, EWS and nuclear command and control systems, all working together, provide the U.S. and Russia the capability to implement LOW. The combination of LOW capability with LOW policy has created what is commonly referred to as launch-on-warning status.
17 O. B. Toon et al, "The Environmental Consequences of Nuclear War", p. 38.
18 Personal correspondence with Dr. Luke Oman of NASA, Dec. 1, 2008.
19 A. Robock, et al, "Nuclear winter revisited . . . op. cit., p. 6 of 14.
20 Ibid.

The cumulative effects of deadly climate change and ozone destruction would *eliminate* growing seasons for more than a decade. Catastrophic climatic effects lasting for many years would occur in regions far removed from the target areas or the countries involved in the conflict.[21] Under such conditions, it is likely that most humans and large animal populations would die of starvation.[22]

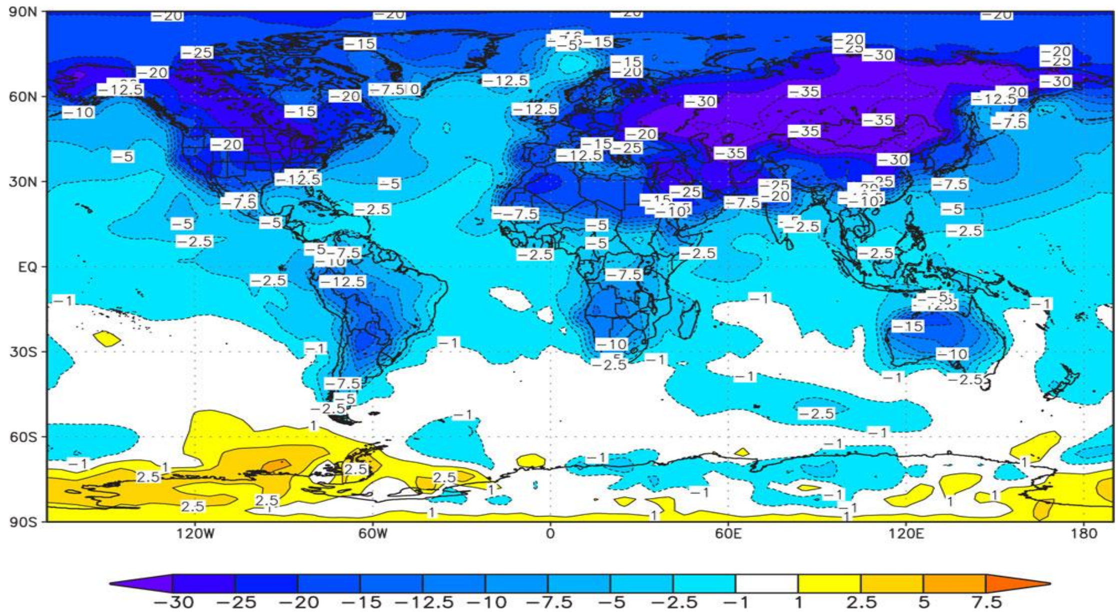

Figure 2: Surface Air Temperature (degree C) changes averaged for June, July, and August in the year after 150 million tons of black smoke forms a global stratospheric smoke layer.[23]

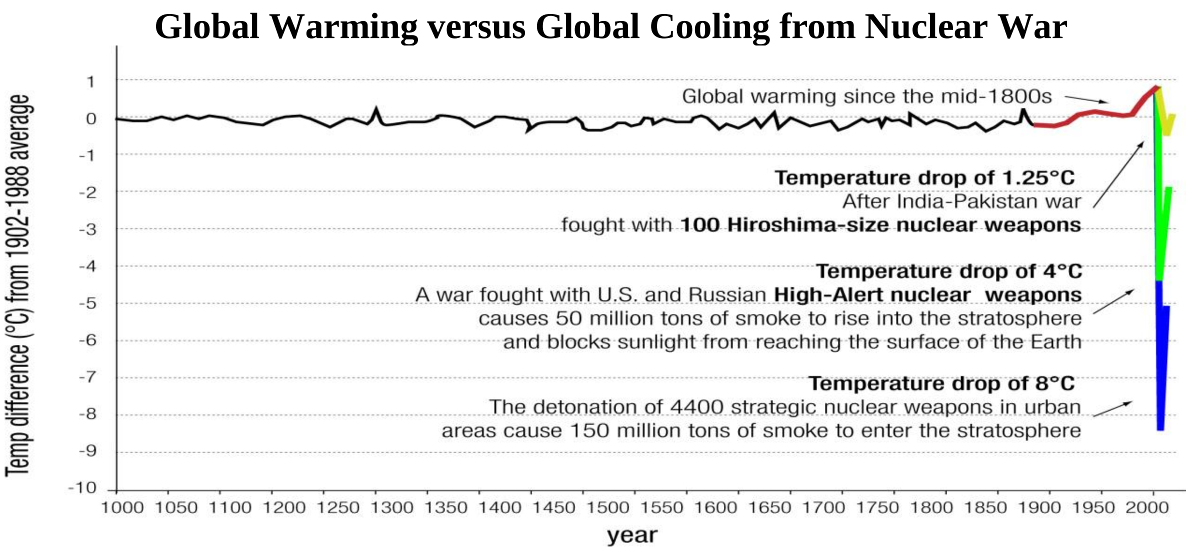

Figure 3: Northern Hemisphere average surface air temperatures during the last 1000 years contrasted with forecast temperature drops from a range of nuclear conflicts.[24]

[21] Ibid, p. 6 of 14.
[22] O. Toon, et al, "The Environmental Consequences of Nuclear Wa", op. cit. p. 37.
[23] Robock et al., "Nuclear winter revisited…, op.cit., Figure 4.

Conclusions

The scientific studies summarized in this paper make it clear that the environmental consequences of a "regional" nuclear conflict could kill hundreds of millions of people far from the war zone. Deadly climate change caused by a war fought with the strategic nuclear arsenals of the U.S. and Russia would threaten the continued survival of the human species.

Yet neither the U.S., nor Russia, nor any other nuclear weapons state has ever officially evaluated what effects a war fought with their nuclear arsenals would have upon the Earth's climate and ecosystems.[25] Surely it is time for such evaluations to be openly conducted and made subject to public discussion. Nations with nuclear weapons should be required to create Environmental Impact Statements on the likely results of the detonation of their arsenals in conflict.

Deadly climate change from nuclear war must become a primary topic in the debate about the need for "a world without nuclear weapons". This discussion must include the dangers posed by the nuclear arsenals of *all* nations, including those in the U.S. and Russia. A failure to recognize and describe the omnicidal potential of strategic nuclear arsenals will prevent the abolition discussion from developing the sense of urgency needed to bring about fundamental change in the nuclear status quo.

The nuclear weapons which are kept ready for virtually instant use constitute a well-maintained self-destruct mechanism for the human race. What political or national goals can possibly justify the existence of such a threat? There can be no "victory" in universal suicide.

Therefore, the U.S. and Russia must recognize the senselessness of continued preparations for a nuclear war, or a "successful" nuclear first-strike, which would make the whole world – including their own country – uninhabitable. It is imperative that they renounce the first use of nuclear weapons, stand-down their high-alert nuclear forces (which make accidental nuclear war possible through launch-on-warning postures),[26] and dismantle the tens of thousands of nuclear weapons in their active and reserve arsenals.[27]

Nuclear weapons cannot ultimately provide "national security" when a single failure of nuclear deterrence can end human history. Unless deterrence works perfectly forever, nuclear arsenals will eventually be used in conflict. We must abolish these arsenals – before they abolish us.

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[24] S. Starr, "Catastrophic Climatic Consequences of Nuclear Conflicts", Updated 2009 version (from INESAP Bulletin 28, April 2008), Fig. 4, http://www.nucleardarkness.org/warconsequences/catastrophicclimaticconsequences/

[25] There are also other important considerations which must be made when estimating the environmental and ecological impacts of nuclear war. These include the release of enormous amounts of radioactive fallout, pyrotoxins and toxic industrial chemicals into the ecosystems.

[26] A. Phillips, S. Starr, "Change Launch on Warning Policy", Moscow Institute of Physics and Technology Center for Arms Control, Energy and Environmental Studies, 2006; www.armscontrol.ru/pubs/en/change-low.pdf

[27] According to the Bulletin of the Atomic Scientists, Russia has about 13,000 nuclear weapons and the U.S. has about 9,400 nuclear weapons, see R. Norris, H. Kristensen, "Nuclear Notebook: Worldwide deployments of nuclear weapons, 2009", Bulletin of the Atomic Scientists, Nov/Dec 2009, DOI: 10.2968/065006010, http://thebulletin.metapress.com/content/xm38g50653435657/fulltext.pdf

About the Author: Steven Starr is a Senior Scientist with Physicians for Social Responsibility, and Director of the Clinical Laboratory Science Program at the University of Missouri. He has been published in the Bulletin of the Atomic Scientists and by the Center for Arms Control of the Moscow Institute of Physics and Technology. For further detailed information on the environmental consequences of nuclear war, please visit his website at www.nucleardarkness.org