World Future Council

DISARMAMENT WORKING GROUP

Climate Change, Nuclear Risks and Nuclear Disarmament

From Security Threats to Sustainable Peace

Jürgen Scheffran

Written for the World Future Council Peace & Disarmament Working Group

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Disarmament Working Group

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It addresses challenges to our common future and provides decision makers with effective policy solutions.

In November 2009 the World Future Council established the Peace and Disarmament Working Group, which unites experts from around the world and brings to bear on the disarmament work the three core strengths of the WFC: 1) integrated thinking, 2) future orientated, and 3) policy focused. Its work program ranges from spreading best policies in the peace and disarmament domain to studying the linkages between nuclear disarmament and issues such as climate change, environmental protection, human rights, development and security.

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Jürgen Scheffran*

Summary

In the future, nuclear and climate risks may interfere with each other in a mutually enforcing way. Conflicts induced by climate change could contribute to global insecurity and create more incentives for states to rely on military force, including nuclear weapons. Rather than being a direct cause of war, climate change significantly affects the delicate balance between social and environmental systems in a way that could undermine human security and societal stability with potentially grave consequences for international security.

Increased reliance on nuclear energy to reduce carbon emissions will contribute to the risks of nuclear proliferation. A renewed nuclear arms race would consume considerable resources and undermine the conditions for tackling the problem of climate change in a cooperative manner. Nuclear war itself would severely destabilize human societies and the environment, not to speak of the possibility of a nuclear winter that would disrupt the atmosphere.

On the other hand, finding solutions to one problem area could help to find solutions in the other. Preventing the dangers of climate change and nuclear war requires an integrated set of strategies that address the causes as well as the impacts on the natural and social environment. Institutions are needed to strengthen common, ecological and human security, build and reinforce conflict-resolution mechanisms and low-carbon energy alternatives, and create sustainable lifecycles that respect the capabilities of the living world.

This article examines the linkages between nuclear and climate risks, identifies areas where both threats converge, and offers an approach to move from living under these security threats to building sustainable peace. By bringing to light the multidimensional interplay between climate change, nuclear risks and nuclear disarmament, this study aims to help the reader grasp their interconnectedness and recognize its critical implications for the strategic security environment. In addition, it explores prospects and openings to tackle these key challenges.

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Introduction

In his 2007 book *The Seventh Decade: The New Shape of Nuclear Danger*, Jonathan Schell writes on the linkages between nuclear weapons and global warming: "The two perils have a great deal in common. Both are the fruit of swollen human power—in the one case, the destructive power of war; in the other, the productive power of fossil-fuel energy. Both put stakes on the table of a magnitude never present before in human decision making. Both threaten life on a planetary scale. Both require a fully global response. Anyone concerned by the one should be concerned with the other. It would be a shame to save the Earth from slowly warming only to burn it up in an instant in a nuclear war."

This powerful statement points to the important but largely neglected linkages between two key dangers of our time. The nuclear menace has survived the Cold War and will continue to threaten life on earth as long as its destructive potential persists. Similarly, global warming is increasingly posing severe dangers for natural and social systems in many regions of the world, as it could exceed their adaptive capacities and undermine international stability. This article examines the linkages between nuclear and climate risks and offers an approach to move from living under these security threats to building sustainable peace.

Figure 1: Existential threats of our time: nuclear explosions and carbon emissions (Source: L: **getty**images/R: iStockphoto)

The Security Challenges of Nuclear Weapons and Climate Change

Nuclear war and global warming are existential threats to humanity.

While the nuclear arsenals have been reduced, more than 20,000 nuclear weapons still remain, enough to destroy the planet multiple times over. Although the stocks of nuclear weapons in the United States and Russia have diminished, nuclear weapons exist–and are often being extended and modernized–in an additional seven countries (United Kingdom, France, China, Israel, India, Pakistan, North Korea). In a few countries, such as Belgium, Germany, Italy, the Netherlands and Turkey, foreign nuclear weapons are still being deployed. In other countries (Ukraine, Belarus, Kazakhstan, South Africa) nuclear weapons capabilities have been dismantled after 1989. In addition, over the years several states have been suspected of building nuclear weapons, the latest being Iran. Besides nuclear weapons, a number of countries are acquiring ballistic missiles, while others enter the arena of missile defence and space warfare. These developments show that the nuclear spiral is still alive and fed by powerful forces of economic growth, political power and a culture of war.

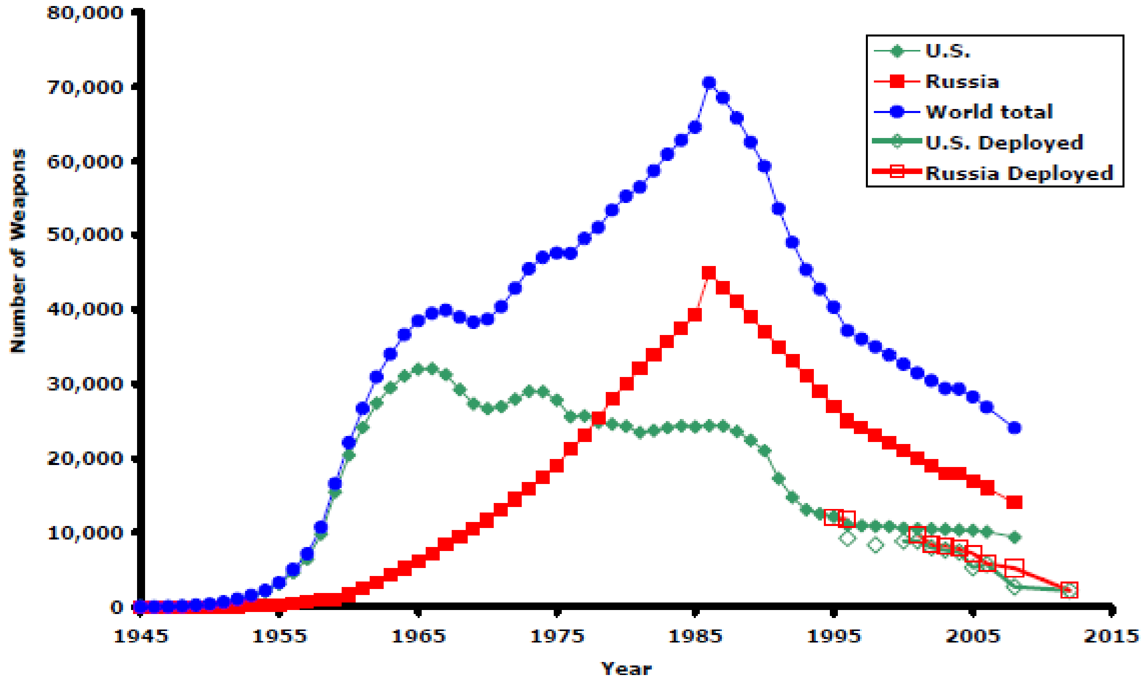

Figure 2: Worldwide, US and Russian nuclear stockpiles (Source: Robock 2010)

The continued existence of nuclear weapons bears incalculable risks and undermines efforts to prevent further states and non-state actors from acquiring the bomb. With nuclear deterrence strategies still in place, the risks of nuclear war remain imminent. More than a thousand tons of nuclear-weapons usable materials remain as well, and with the projected increase of nuclear energy the precursors for nuclear weapons development are thus proliferating. The possibility that nuclear weapons or sensitive nuclear materials could fall into the hands of terrorists cannot be ruled out. Indeed, intelligence assessments deem such a scenario worryingly plausible, due mostly to weak borders and ill-secured nuclear facilities and depots (Zenko 2006).

The nuclear weapon states set a bad example that continues to drive the pursuit of know-how and technology for nuclear weapons by other states. Military responses, including missile defence, counter-proliferation and nuclear weapons, fuel the arms race and undermine the political stability necessary for the controlled maintenance of nuclear weapons, which, in any case, cannot be guaranteed in the long run. Fatal accidents remain possible. Without a systematic and controlled elimination of the nuclear threat, an intentional or accidental use of nuclear weapons is a matter of time. To move away from the nuclear abyss, the world needs to abolish all nuclear weapons as well as the main incentives for their development (Falk/Krieger 2008).

Figure 3: The nuclear and climate threat in popular culture: movie posters for The Day After (1983) and The Day After Tomorrow (2003) (Source: Internet Movie Database)

Not less dramatic are the risks of global warming, caused by the emissions of carbon dioxide and other greenhouse gases. The fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007) has drawn a dire picture.

Climate change endangers ecosystems and social systems all over the world. The degradation of natural resources, the decline of water and food supplies, forced migration, and more frequent and intense disasters will greatly affect population clusters, big and small. Climate-related shocks will add stress to the world's existing conflicts and act as a "threat multiplier" in already fragile regions. This could contribute to a decline of international stability and trigger hostility between people and nations.

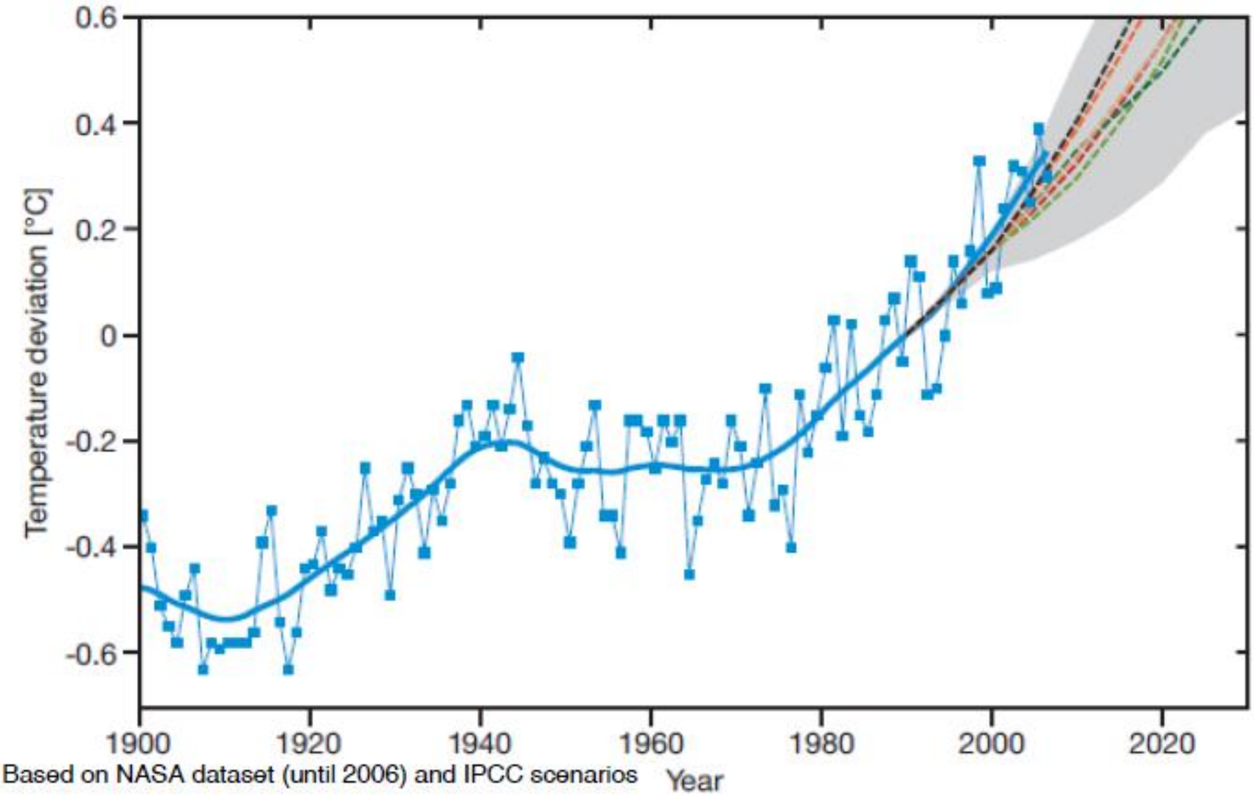

Figure 4: Relative change in global average temperature with IPCC projections compared to 1990 levels (Source: Intergovernmental Panel on Climate Change)

Despite many similarities, there are significant differences between nuclear and climate risks.

Timeframe | A nuclear war would result from short-term decisions of a small group of political and military leaders. It may be fought in a time span from hours to days and decisions are made within hours, even minutes. The consequences are felt within the same time span, e.g. a nuclear explosion can eradicate a whole city within seconds, but there are also long-term consequences spanning multiple generations, e.g. due to radioactive fallout. For comparison, climate change occurs over long timescales and gradually undermines the living conditions of humanity and other life on earth over an extended period. Decisions on climate change have an impact decades and centuries later and can hardly be attributed to anyone in particular. Nevertheless, extreme weather events such as hurricanes and tornados or floods and landslides may occur on rather short notice and affect millions of people who are unable to get out of harm's way in time. With the possibility of abrupt climate change, a sequence of cascading events and tipping points could make humanity feel the drastic changes within decades (Lenton, et al. 2008).

Spatial scale | Nuclear proliferation is a global problem like climate change, even though the sources and impacts of either problem occur on a local scale. Nuclear proliferation and terrorism are driven by regional security problems and power structures. Global warming is caused by local emissions that accumulate in the atmosphere to induce global change which in turn affects ecological and social systems locally. While an all-out nuclear war can lead to human extinction, this is more unlikely for global warming because the consequences can be moderated by adaptive capacities that reduce the vulnerability of affected systems. Despite large uncertainties about the magnitude, frequency and distribution of risks, climate change is now widely recognized, including the impact of human behaviour on it. The likelihood of nuclear war increases with nuclear proliferation and hawkish doctrines, but can hardly be quantified.

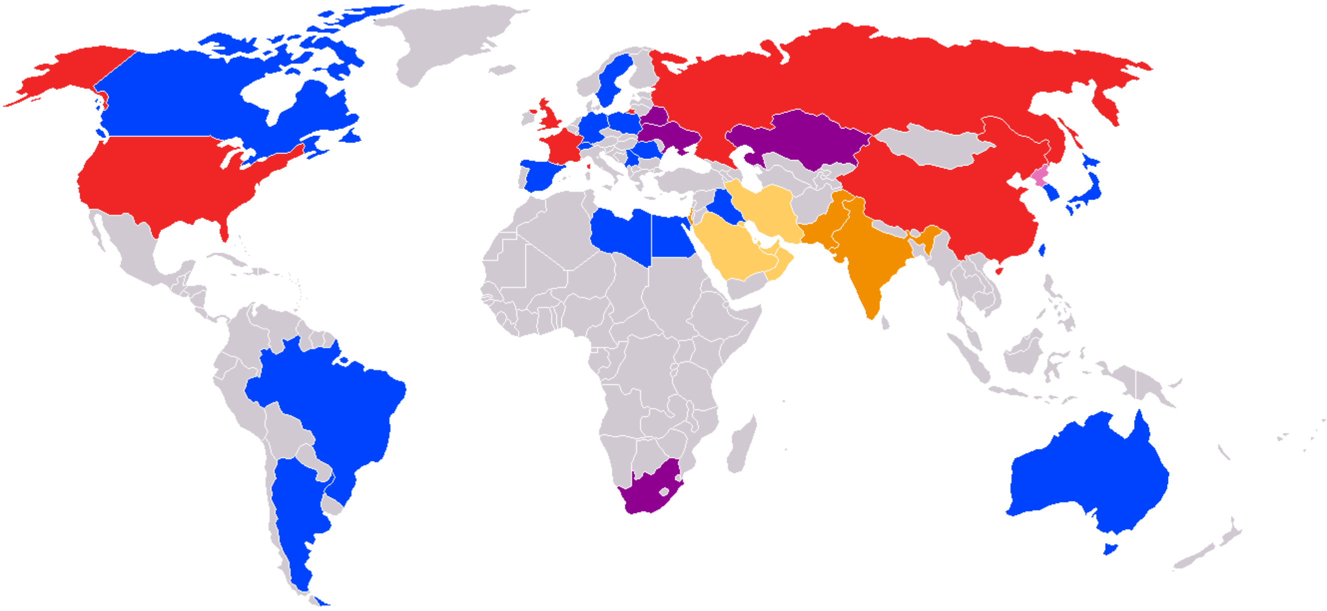

Figure 5: World map with nuclear weapons development status represented by colour (Source: Wikipedia)

- Five "nuclear weapons states" from the NPT
- Other known nuclear powers
- States formerly possessing nuclear weapons
- States suspected of developing nuclear weapons and/or nuclear programs
- States which had nuclear weapons and/or nuclear weapons research programs
- States that possess nuclear weapons, but have not widely adopted them

Who is responsible? The sources of climate change are our lifestyles which cause nature to "respond" in accordance with natural laws. The five initial nuclear weapon states are leading in military expenditure and are among the world's largest carbon emitters. Different from the Non-Proliferation Treaty (NPT), which is a discriminatory regime that puts more restraints on the non-nuclear weapon states than on those with nuclear weapons, the United Nations Framework Convention on Climate Change (UNFCCC) recognizes a universal obligation to prevent dangerous climate change, and assigns the greatest responsibility to the polluters.

Who is affected? During the Cold War nuclear weapons were largely directed against ideological antagonists who possessed the same type of weapons. The end of the Cold War and the spread of nuclear weapons caused the bilateral nuclear threat between the Western and Eastern bloc to fragment, altered the geopolitical landscape in several regions and increased the stakes in related conflicts. By comparison, global warming is not a determined threat against competitors but affects many communities on the planet. The causes and consequences of climate change can be distributed quite asymmetrically across different regions, raising questions of equity and injustice. While the powerful countries contribute the most to the risks, most affected are the weak and the vulnerable, in particular impoverished peoples in developing countries. Ultimately, by undermining human security, large-scale climate change will likely also affect the security of powerful nations, and protection is a costly endeavour.

Who is the enemy? In traditional security thinking there are determined enemies that seek to acquire weapons of mass destruction, notably nuclear weapons, to challenge the powerful nations. While nuclear explosions can be attributed to an intentional act by a determined adversary (provided they are not accidental), motivations and perceptions are different for climate change, which is involuntary and not caused by a particular enemy. Global warming results from all human beings' greenhouse gas emissions, and at the same time is affecting humans across the globe by its impact. For those who are suffering the most from climate change, those who contribute more to the problem can be seen as more significant "threats". Using this kind of security thinking is, however, questionable and distracts attention from the causes and possible solutions to the climate problem, which is more an environmental than a security issue (Scheffran 2011).

Nuclear and climate risks are key issues in current security debates.

During the East-West conflict, nuclear war was seen as humanity's gravest threat, and it may still be in terms of potential destructiveness. After September 11, 2001, international attention shifted towards terrorism, and the Bush Administration used the terror attacks as an argument to make nuclear disarmament, as well as climate policy, a low priority. This short-sighted view neglected the fact that the continued existence of nuclear weapons perpetuated the possibility of nuclear terror attacks. Furthermore, international destabilization resulting from climate change could provoke conflicts in fragile regions of the world which, in turn, could create more fertile "breeding grounds of terrorism" (CNS 2007).

After a lost decade for disarmament, parts of the US establishment began to recognize that the continued existence of nuclear weapons could no longer be beneficial and that nuclear proliferation to other countries and non-state actors would undermine their own security interests. This view has been expressed by the group of US elder statesmen, George Shultz, Henry Kissinger, William Perry and Sam Nunn, in their 2007 Wall Street Journal op-ed (Shultz, et al. 2007). They predict that, without a major change in policy, the US will soon enter a "new nuclear era that will be more precarious, psychologically disorienting, and economically even more costly than

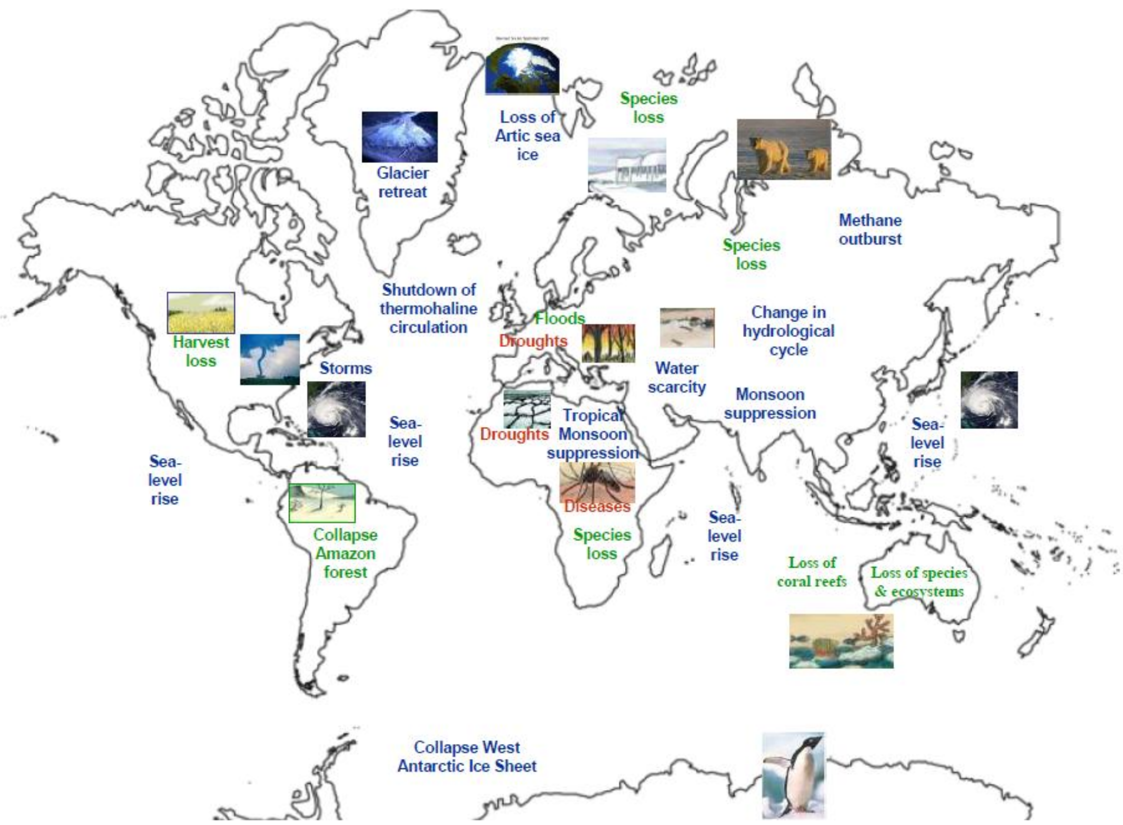

Figure 6: World map of climate risks

was Cold War deterrence." Similarly, the former British Foreign Minister Margaret Beckett at the end of her term warned of nuclear risks and made clear that, as with the abolition of slavery, the ultimate goal would not be regulation or reductions, but the elimination of nuclear weapons (Beckett 2007a). These calls for a nuclear weapon-free world have been repeated by officials and former statesmen from many other countries, including nuclear weapon states.

Following hurricane Katrina in 2005 and the IPCC reports in 2007, attention increasingly shifted to the security risks of global warming (see the discussion in WBGU 2007, Scheffran 2008, 2009). There was growing concern about large-scale cascading events in the climate system that could lead to international instability and become as devastating as a nuclear disaster. Among the potential tipping elements are the loss of the South Asian monsoon and the Amazon rainforest, the breakdown of the North Atlantic thermohaline circulation, polar ice melting and global sea-level rise (Schellnhuber, et al. 2006). UN Secretary-General Ban Ki-moon warned that climate change may pose as much of a danger to the world as war. In April 2007, the UN Security Council held its first debate on climate change indicating that global warming has elevated to the top of the international security agenda, rivaling the threat of war. Initiated by the United Kingdom, Margaret Beckett compared emerging climate change to the "gathering storm" before World War II: "An unstable climate risks some of the drivers of conflict – such as migratory pressures and competition for resources – getting worse" (Beckett 2007b). In Spring 2008, the European Commission issued a report stating that climate change "is already having profound consequences for international security" which are not just of a "humanitarian nature" but include political and security risks that directly affect European interests. It held that, "Climate change is best viewed as a threat multiplier which exacerbates existing trends, tensions and instability. The core challenge is that climate change threatens to over-burden states and regions which are already fragile and conflict prone." (EC 2008)

Finally, as several natural disasters in recent years have demonstrated, extreme weather events, environmental degradation and major seismic events can also directly cause dangers for nuclear safety and security. The wildfires that spread through Russia in the summer of 2010 posed a severe nuclear risk to the country when they were on their way to engulf key nuclear sites. In addition, there was widespread concern that radionuclides from land contaminated by the 1986 Chernobyl nuclear disaster could rise together with combustion particles, resulting in a new pollution zone. Luckily, the authorities managed to contain the fires in time. Another example is the earthquake that hit Chile in February 2010. As was later revealed, at the time of the quake, a team dispatched by the US National Nuclear Security Administration (NNSA) was on a top-secret mission in Chile to gather up dangerous nuclear stock. Only twelve hours before the earthquake, the NNSA engineers had secured the irradiated uranium by fitting protective impact limiters on it and placing it in an airtight cask. Thus, the release of radioactive substances was luckily averted (Van Riet 2010).

Figure 7: Fukushima Daiichi nuclear power plant's unit 4 reactor damaged by explosions and fires caused by earthquake and tsunami (Source: Air Photo Service)

Japan was less fortunate when a 9.0-magnitude earthquake and subsequent tsunami hit the country on 11 March 2011 and caused major damage to the Fukushima Daiichi nuclear power plant, disabling the reactor cooling systems and triggering a widespread evacuation surrounding the plant. As this article went to press, the nuclear crisis was still unfolding, with the authorities trying to stave off successive nuclear meltdowns at the plant and control contamination. Worryingly, the Fukushima nuclear power plant is not the only facility located in a natural disaster-prone area. Research conducted by the International Atomic Energy Agency reveals that 20 percent of the world's 442 working nuclear power stations are in areas of "significant" seismic activity. These events confirm what many intuitively already feel: in this seismically active world, characterized by an increasingly unpredictable environment, nuclear facilities, weapons and materials represent a highly volatile variable in an already unstable equation (Van Riet 2010).

Nuclear war can lead to a dramatic and immediate cooling of the atmosphere.

Although US-Russian nuclear arsenals have been significantly reduced (by more than two-thirds since 1989) the total number of nuclear weapons in the world is still sufficient to destroy the planet multiple times over. A comprehensive nuclear attack would eject so much debris into the atmosphere that it could result in a drastic cooling on a global scale ("nuclear winter"). Huge fires caused by nuclear explosions, in particular from burning urban areas, would lift massive amounts of dark smoke and aerosol particles into the upper parts of the atmosphere where the absorption of sunlight would further heat the smoke and lift it into the stratosphere. Here the smoke could persist for years and block out much of the sun's light from reaching the earth's surface, causing surface temperatures to drop drastically.

Recent scientific studies on nuclear winter suggest that even a limited regional nuclear exchange could rapidly cool down the planet to temperatures not felt since the ice ages and significantly disrupt the global climate for years to come. In a regional nuclear conflict scenario where two opposing nations (such as India and Pakistan) would each use 50 Hiroshima-sized nuclear weapons (about 15 kiloton each) on major populated centres, the researchers estimated that as much as five million tons of soot (impure carbon particles) would be released (Robock 2010).

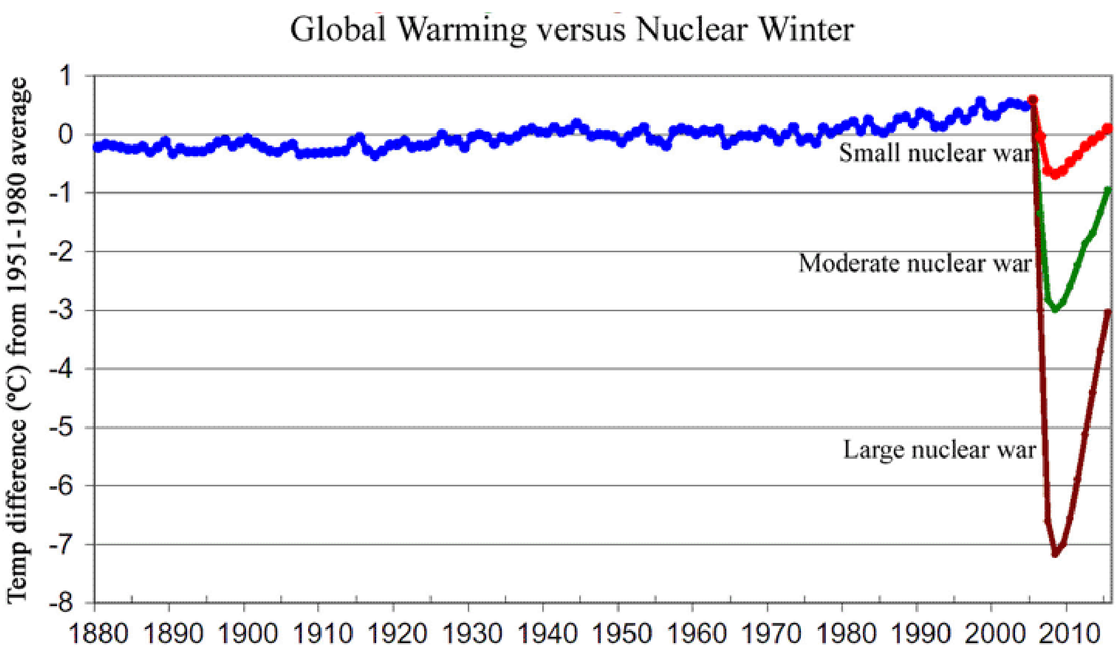

Figure 8: Global average surface air temperature changes for small, moderate, and large nuclear wars in the context of the change in climate of the past 125 years. Predicted temperature drops from the three nuclear conflicts are shown as three separate V-shaped curves, each progressively deeper (Source: Starr 2008).

Nuclear Energy: No Solution to Fossil Energy Dependence and Global Warming

Nuclear power is no viable alternative to the fossil-dominated energy system which generates three quarters of the world's energy.

Nuclear energy cannot significantly replace the huge amounts of fossil energy and causes additional risks. While fossil energy sources release carbon into the atmosphere, which is driving global warming, the nuclear "fuel cycle" (which is more a chain or a spiral than a closed cycle) contains a variety of problems and risks (Liebert 1996, Kalinowski 1998, Scheffran/Kalinowski/Liebert 1996). Radioactive materials are released and accumulated at each stage of the chain, including uranium mining and fuel rod production, reactor operation and reprocessing, and transport and disposal. Even under normal operations, it is difficult to avoid radioactive materials from being released into the environment, not to speak of the dangers of repeated errors and accidents throughout the process. These radioactive emissions present a conflict potential with international dimensions. An increasing number of countries acquiring nuclear power as part of a "nuclear renaissance" would multiply the nuclear safety, health and proliferation risks.

Nuclear power is also inextricably linked to nuclear weapons development (Mian/Glaser 2006, Hall 2006, Hagen 2006, Slater 2006). The linkage between civilian and military nuclear technologies contains potentially high security risks. So far, about one-third of the countries using nuclear power have built nuclear weapons, and only one (South Africa) has given them up, besides the successor states of the Soviet Union. According to the Massachusetts Institute of Technology (MIT) study on "The Future of Nuclear Power" (2003), a four-fold increase of the world's nuclear capacity by 2050 would cause the number of countries using this form of energy to double. At various stages of the nuclear fuel chain, transitions to nuclear weapons technology are possible, contributing to the danger of their worldwide proliferation. A serious problem is the civil-military ambivalence of nuclear technologies and facilities involved in the production and processing of weapons-grade materials. These include uranium enrichment, fuel production and reprocessing of spent nuclear fuel. Around 20 countries already have access to such technologies. This trend would increase with a further global expansion of nuclear energy.

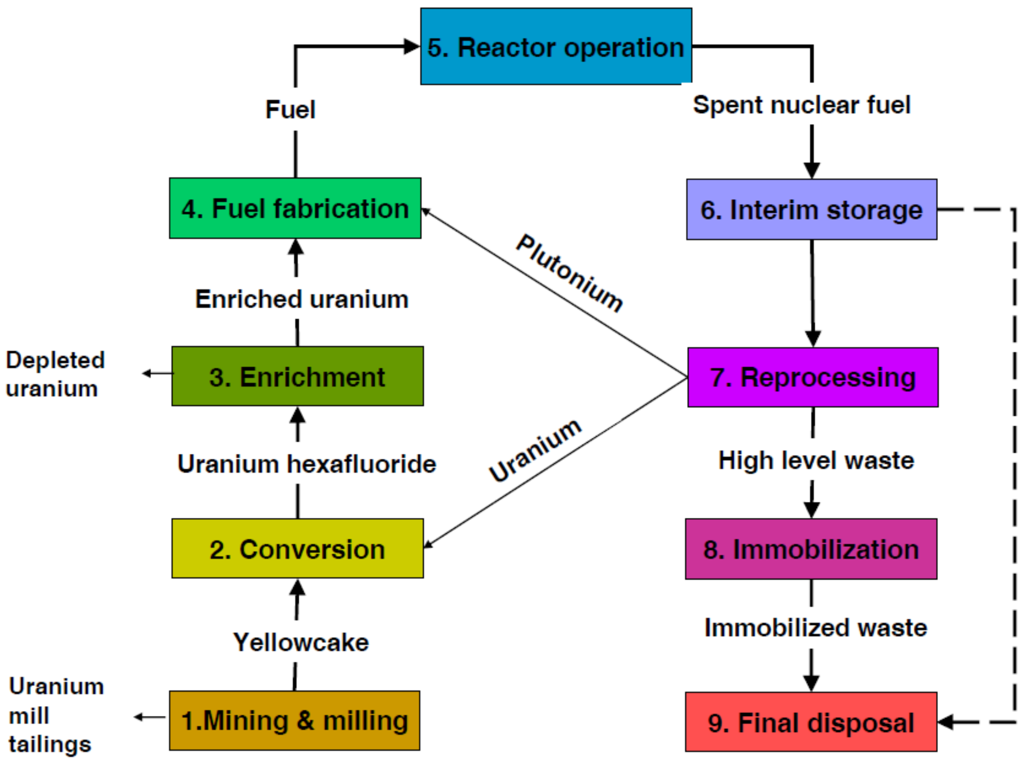

Figure 9: Nuclear fuel chain based on uranium (Source: Adapted from Encyclopaedia of Energy 2004)

Despite the elimination of almost 500 tons of Russian and US highly enriched uranium (HEU), the global inventory still totals around 1600 tons (IPFM 2009). The global stockpile of separated plutonium is about 500 tons, divided almost equally between civilian and military stocks. One hundred tons of plutonium would be theoretically sufficient for up to 20,000 nuclear warheads. A large fraction is still embedded into radioactive nuclear waste, which would have to be reprocessed in order to extract fissile materials. With increasing civilian use, the amount of plutonium also tends to increase. As long as plutonium use is pursued on a global scale, an irreversible path to a nuclear weapon-free world is difficult to achieve. The obvious problems and dangers of nuclear weapons proliferation and continued nuclear weapons programs would be aggravated with more countries establishing national nuclear programs, as this would allow access to nuclear-weapons materials, either intentionally or unintentionally (Lauvergeon 2009, Miller/Sagan 2009).

A considerable international effort of inspections is pursued by the International Atomic Energy Agency (IAEA) to avoid that non-nuclear weapon states that are members of the Non-Proliferation Treaty (NPT) divert material for nuclear weapons. An effective control which excludes the civil-military dual use in the nuclear sector does not exist. Even if there are currently no intentions to build a nuclear weapon, the nuclear option can be technologically prepared or maintained along the nuclear fuel chain. This provides critics and skeptics with reasons to speculate on actual or future intentions to start a nuclear weapons program, which could easily lead to a high stakes confrontation. Undeclared nuclear weapons programs or ambivalent nuclear power programs are often "crisis multipliers" in regional conflicts. The difficulty in distinguishing between civilian and military nuclear ambitions remains a source for discrimination, threat, mistrust and fear in international relations.

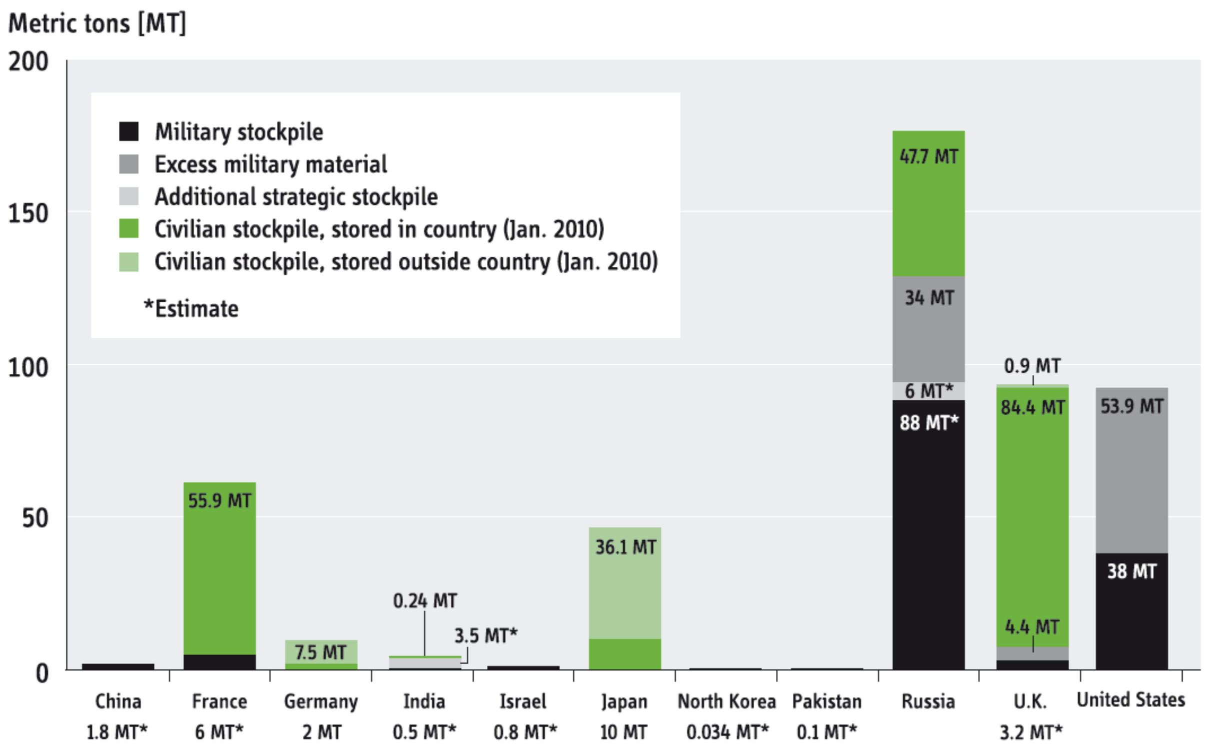

Figure 10: National stocks of separated plutonium (Source: IPFM 2010)

Nuclear power is neither required for nor capable of solving the climate crisis.

Nuclear power is often presented as a solution to the problem of climate change which is caused by fossil energy use. Given the safety and security risks of nuclear power and its limited ability and economic viability in addressing global warming, replacing fossil fuels with nuclear fuels is not a viable alternative (Kalinowski 2009). Nuclear power has been proposed as a carbon-free technology with the potential for a safe, clean and cheap supply of electric power that is able to mitigate climate change (for a discussion see Feiveson 2009, Rowe 2009, Socolow/Glaser 2009). Because of the long planning cycles and its inadequacy for use in combustion and as transportation fuel, nuclear energy cannot replace in a reasonable timeframe the large amounts of fossil fuel currently consumed. Since the uranium resources are limited, a sustainable energy supply based on nuclear energy cannot be realized with a once-through cycle that avoids plutonium reprocessing. Even a drastic increase in nuclear energy could not compensate for the current growth in energy consumption; it would come too late for preventing climate change and lead to an enormous increase in plutonium stocks, with all its aforementioned problems.

Due to the expected shut-downs of aging power plants, it will already be challenging to replace these plants, not to mention multiplying this capacity. In its low-use reference scenario for the nuclear power outlook, the International Atomic Energy Agency predicts that the installed capacity of nuclear power will remain nearly constant by the year 2030. In its high-use scenario, almost a doubling of nuclear power capacity is projected (see Figure 11). In either case, the share of nuclear power in total energy generation and the CO_2 reduction will remain only a few percent. This net effect would easily be negated by the energy growth in the South. What is actually required is a reduction of CO_2 emissions by at least 50 percent by 2050. Even without a massive expansion of nuclear energy, the uranium resources will be consumed within the next five decades. Switching to plutonium processing and fast breeder reactors could stretch the existing resources, but would be far more risky, more expensive and less proliferation-resistant, thus adding to the existing risks of nuclear power.

Given the high economic costs of nuclear power, cheap nuclear electricity has remained a fiction. Although nuclear power has been heavily subsidized by governments and external costs are still not internalised into its market price, nuclear energy is not commercially competitive compared to advanced renewable energies that receive similar financial support. In a comprehensive environmental and economic assessment, including external costs from waste disposal, uranium mining, fuel processing and radioactive emissions during normal operations, most renewable energy sources look better than nuclear energy. This partially explains the apparent slowdown of or withdrawal from nuclear power in industrialized countries and their diminished interest in a further build-up. The investment risk has further increased due to nuclear accidents, protests against nuclear energy and the higher requirements of governmental licensing procedures (especially in the US and Germany).

Finally, nuclear power is not carbon-free if the whole life-cycle of electricity production is taken into consideration. According to the GEMIS (Global Emission Model for Integrated Systems) database of the German Öko-Institut, a 1 GWe nuclear power reactor plant in Germany causes indirect emissions of 200,000 tonnes of CO_2 per year, which is comparable to hydropower, lower than photovoltaic and higher than for wind or improved efficiency of electricity generation and use (Kalinowski 2009). Thus, nuclear power is not an effective means to mitigate climate change and there are alternatives that avoid its negative side-effects. The massive "nuclear renaissance" required for a significant impact would be highly unlikely to take place for economic and security reasons.

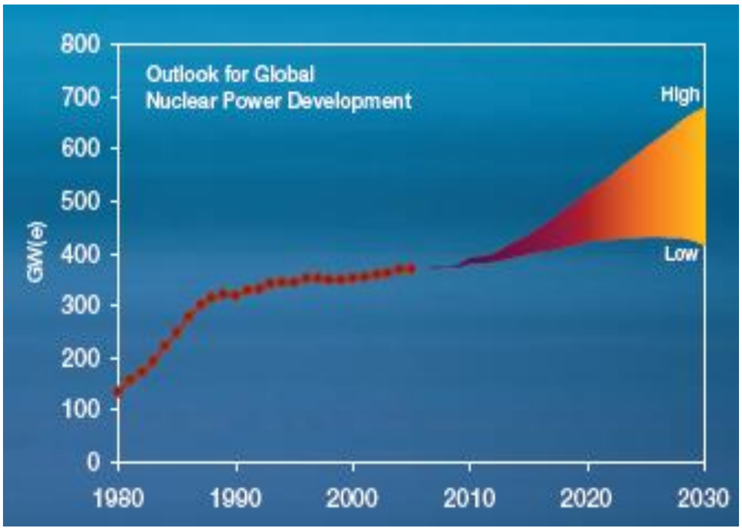

Figure 11: IAEA nuclear power outlook (in Gigawatt (GW)) (Source: International Atomic Energy Agency)

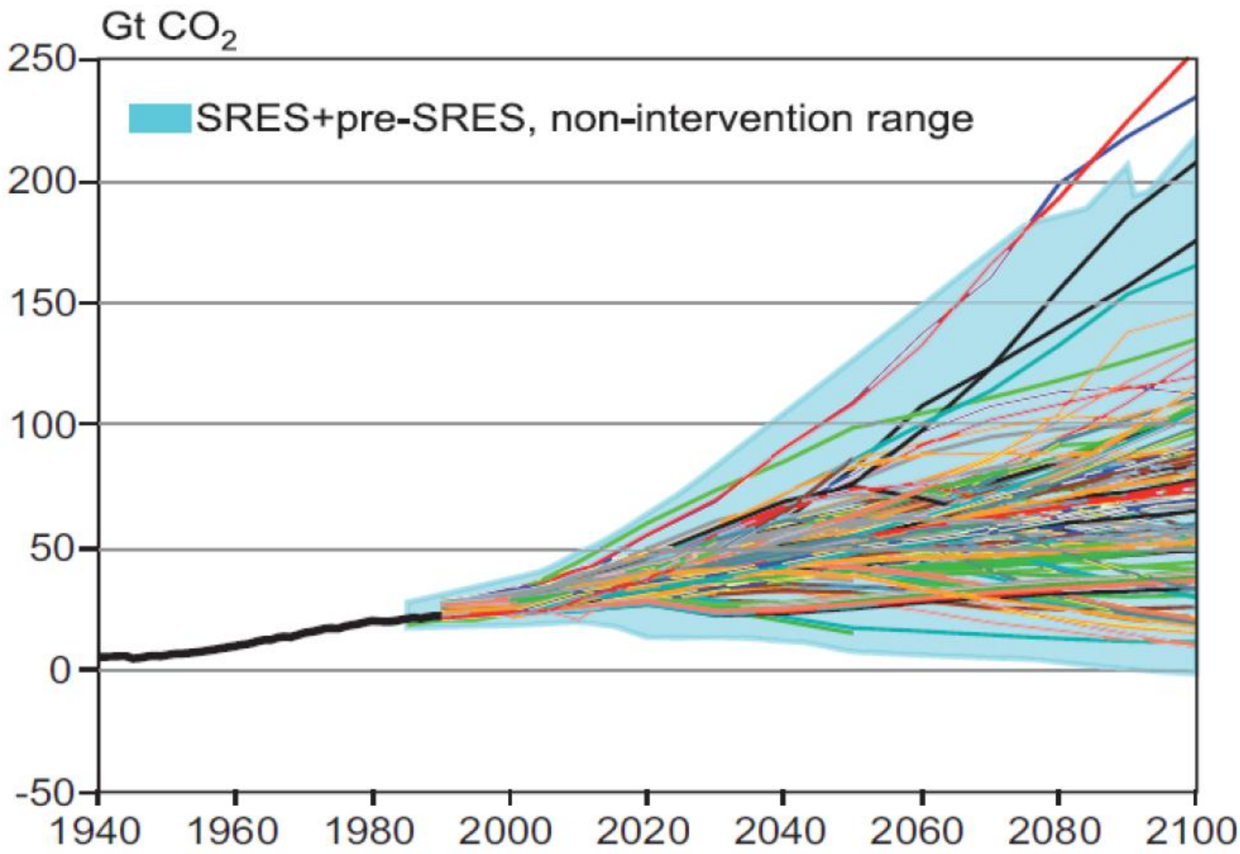

Figure 12: Comparison of the SRES and pre-SRES energy-related and industrial CO_2 emission scenarios in the literature with the post-SRES scenarios (SRES is the 2000 IPCC Special Report on Emission Scenarios) (Source: IPCC)

Nuclear waste disposal and climate engineering are technical attempts to bury the risks or manipulate the consequences of nuclear technology and climate change.

The long-term risks of nuclear energy become obvious at the end of the nuclear fuel chain. Nuclear waste disposal (whether from nuclear power production, nuclear weapons programs or nuclear disarmament) will remain a problem over thousands of years, and many future generations will have to bear this load without having the short-term "benefit" of the current generation. To decay half of the amount of plutonium 239, which is the primary fissile isotope used for the production of nuclear weapons, it takes around 24000 years or 1000 human generations, much longer than the known history of homo sapiens. After decades of nuclear energy production, the pile of nuclear waste is still growing, even though worldwide not a single site for final disposal of spent fuels is operating and temporary storage is continuously being extended. It is uncertain whether and when a responsible solution to the long-term disposal of radioactive waste can be found (Macfarlane/Ewing 2006).

All the solution concepts on the table are burdened with problems: dropping the nuclear waste into the deep ocean, storing it in the ice of Antarctica, launching it into outer space, injecting liquid waste under groundwater bearing layers and different variants of underground storage have all been taken into consideration. In the 1970s the concept of "safe" disposal in deep geological formations was explored. This would provide long-term isolation and containment without any future maintenance. While many governments and international organizations prefer this approach, others want to keep the waste in a retrievable and controlled form, combined with long-term surveillance. In any case, it is highly uncertain whether the evidence for a final repository can ever be proven to sufficiently guarantee long-term safety and security.

Geoengineering is offered as a solution for reducing dangerous climate change by deliberately modifying the Earth System. Suggested measures of "climate engineering" (CE) include carbon capture and sequestration in biomass, soil, underground or in the ocean; aerosol emissions to absorb sunlight in higher layers of the atmosphere (similar to volcano eruptions); and other means of changing the Earth's radiation balance by reflecting sunlight, e.g. through large mirrors in outer space. To varying degrees, these measures have unknown costs and risks. Moving from involuntarily changing the atmosphere through emissions to the intentional manipulation of the climate system and the regulation of global temperature (like in a "global air conditioning system") opens a Pandora's Box of competing actions between countries.

The assessment of climate engineering should not focus only on the technical and economic dimensions, but consider the political and social implications as well. Related policies should not become a playground for capital interests and power games or increase the barriers between North and South and between rich and poor. If these developments are not avoided, CE measures could turn into security risks or trigger conflicts for current and future generations. What appears to be a remote possibility may turn into a real danger if the atmospheric manipulation by one state severely affects the interests of other states.

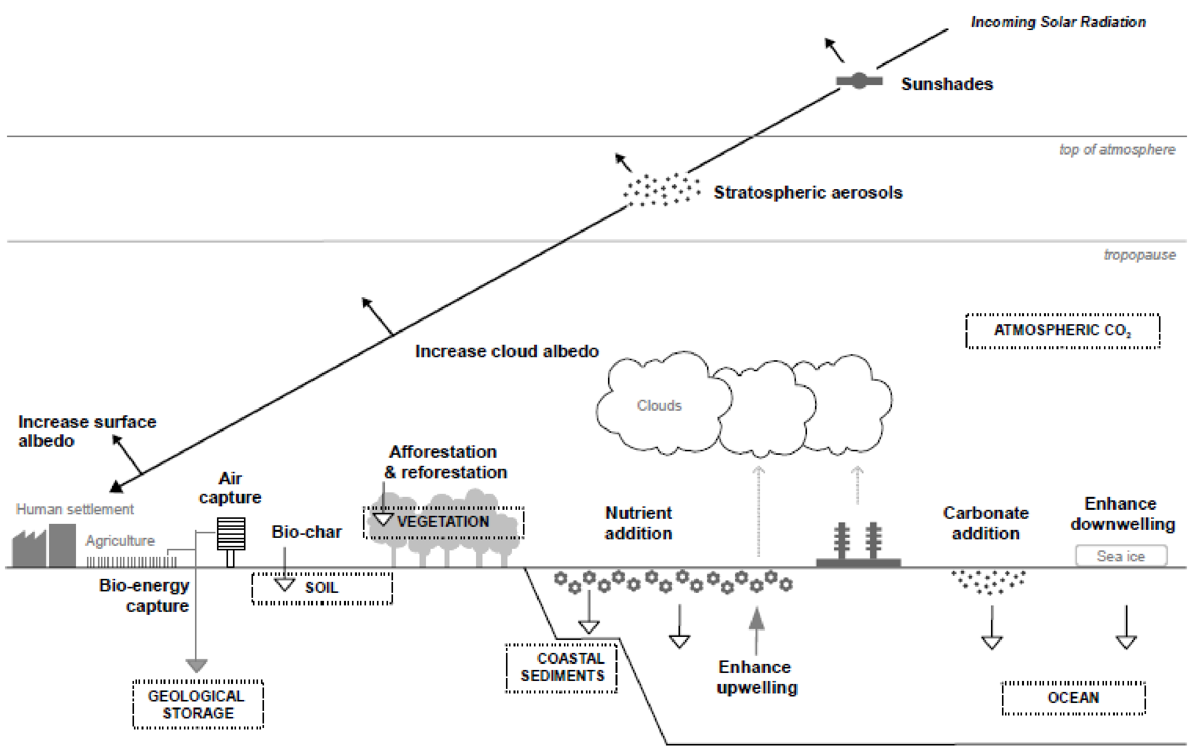

Figure 13: Schematic overview of the climate geoengineering proposals considered. Black arrowheads indicate short-wave radiation, white arrowheads indicate enhancement of natural flows of carbon, grey downward arrow indicates engineered flow of carbon, grey upward arrows indicate engineered flow of water, dotted vertical arrows illustrate sources of cloud condensation nuclei, and dashed boxes indicate carbon stores (Source: Lenton/Vaughan 2009).

CE techniques should not create more risks than they avoid. As long as there are large uncertainties about the consequences of CE measures, they should not be pursued. It is important to differentiate between CE techniques with relative low risk (such as afforestation and carbon storage in biomass) and those with a high potential risk (such as large scale manipulation of the atmosphere and the earth's radiation balance). Preference should be given to preventive mitigation measures, followed by practical adaptation measures against unavoidable climate consequences. CE should only be considered as a strategy of last resort if other measures have been used to the maximum possible degree. In comparing the options, the costs, benefits and risks of the alternatives need to be considered, as well as uncertainties, perceptions and complexities. Research can help to reduce the uncertainty, make risks more assessable and provide a better understanding of the alternatives. Currently there is no reason for hasty or premature decisions since climate change can still be contained in other ways and CE is not a full-fledged solution. Rather than expanding carbon emissions and burying or correcting the consequences through geoengineering, it is more appropriate to avoid the problems in the first place by mitigation measures (Robock 2008). To this end, it is essential to establish a nuclear-free, carbon-free and sustainable energy system (Makhijani 2007). Because of the adverse linkages between nuclear and climate risks, it is time to develop a new thinking that synergizes solutions in both nuclear security and climate policy with an integrated framework of sustainable peace.

From Conflict to Cooperation: Towards Sustainable Peace

The discrepancy between long-term goals and concrete steps undermines the conditions for international cooperation in security and climate policy.

Whether nuclear risks and climate change will lead to more conflict or cooperation will depend on how human beings and their societies respond to these challenges. In the 1992 United Nations Framework Convention on Climate Change (UNFCCC), countries agreed to prevent dangerous anthropogenic interference with the climate system. In the 2009 Copenhagen Accord, most nations supported the goal of limiting global temperature change to 2 degrees Celsius by the end of the century, but failed to define concrete steps toward that goal. During his election campaign in 2008, candidate Barack Obama committed to an 80 percent reduction of CO_2 emissions by the middle of the century, a goal that has not been further pursued during his presidency. Throughout 2010, progress in climate policy was blocked by Republican resistance in the US Congress; meanwhile, carbon emissions have continued to rise. The agreement of Cancun in December 2010 offers a path forward, but requires determined efforts by the major polluters.

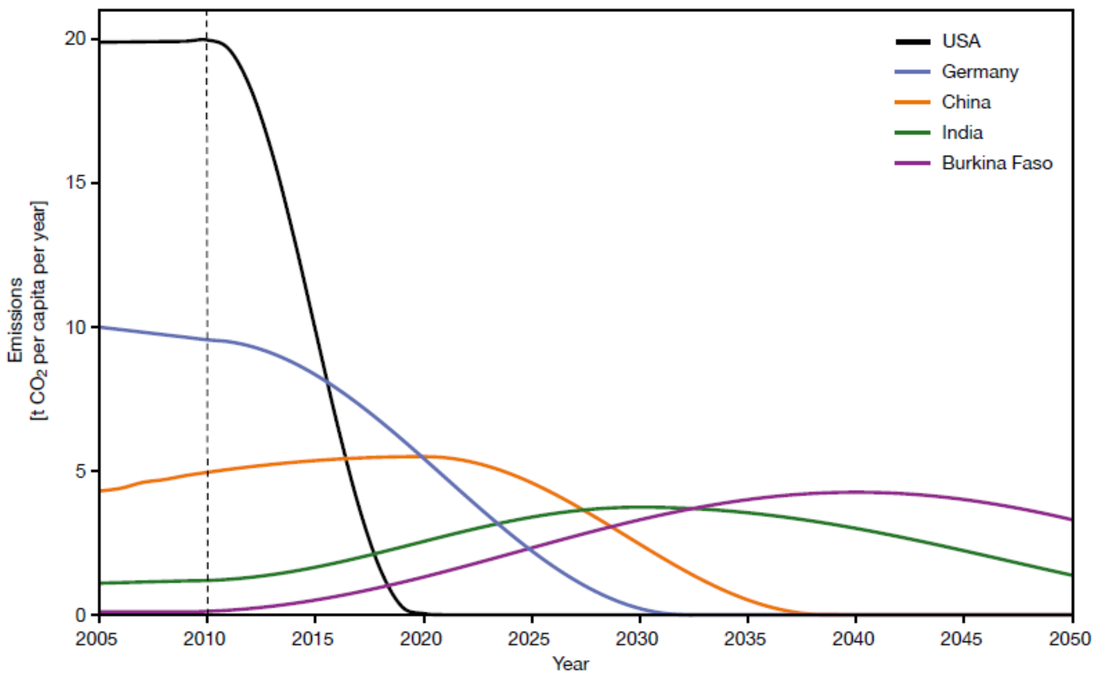

Figure 14: Theoretical paths of per-capita emissions of selected countries under the budget approach of the German Advisory Council on Global Change. Each country is entitled to a total of 110 t CO_2 emissions per capita over the period from 2010 to 2050, based on population data for 2010 (source: WBGU 2009).

Obama also spoke in favour of a nuclear weapon-free world in Berlin in 2007 and in Prague in 2009, but so far concrete measures have lagged behind rhetoric. While the 2010 Nuclear Posture Review offers some promising language, more concrete is the decision of the Obama administration to increase the budget for nuclear weapons development. The New Strategic Arms Reduction Treaty (New START) is a moderate and important step towards further reduction of the US and Russian nuclear arsenals. Its ratification in the US Senate in December 2010 demonstrates that the strong resistance at the domestic front can be overcome, albeit at the cost of meeting the Republican Party's demands for a modernization of the nuclear arsenals.

On the international level, the goal of nuclear abolition has found wide support, in particular in recent resolutions in the UN General Assembly and a vote by the UN Security Council in 2009. A focal point of activities was the NPT Review Conference in May 2010 where a number of NGOs and countries expressed their support for a Nuclear Weapons Convention (NWC) that would implement the comprehensive goal of a world without nuclear weapons (ICAN 2010). The final document of the conference noted UN Secretary-General Ban Ki-moon's five-point proposal for nuclear disarmament of 24 October 2008, "which proposes, inter alia, consideration of negotiations on a nuclear weapons convention or agreement on a framework of separate mutually reinforcing instruments, backed by a strong system of verification" (NPT 2010). Many states and anti-nuclear civil society groups see negotiation of a NWC as politically feasible and necessary to move beyond the current disarmament stalemate (Scheffran 2010a, Ware 2010). So far, major progress has not been achieved due to resistance from the nuclear weapon states.

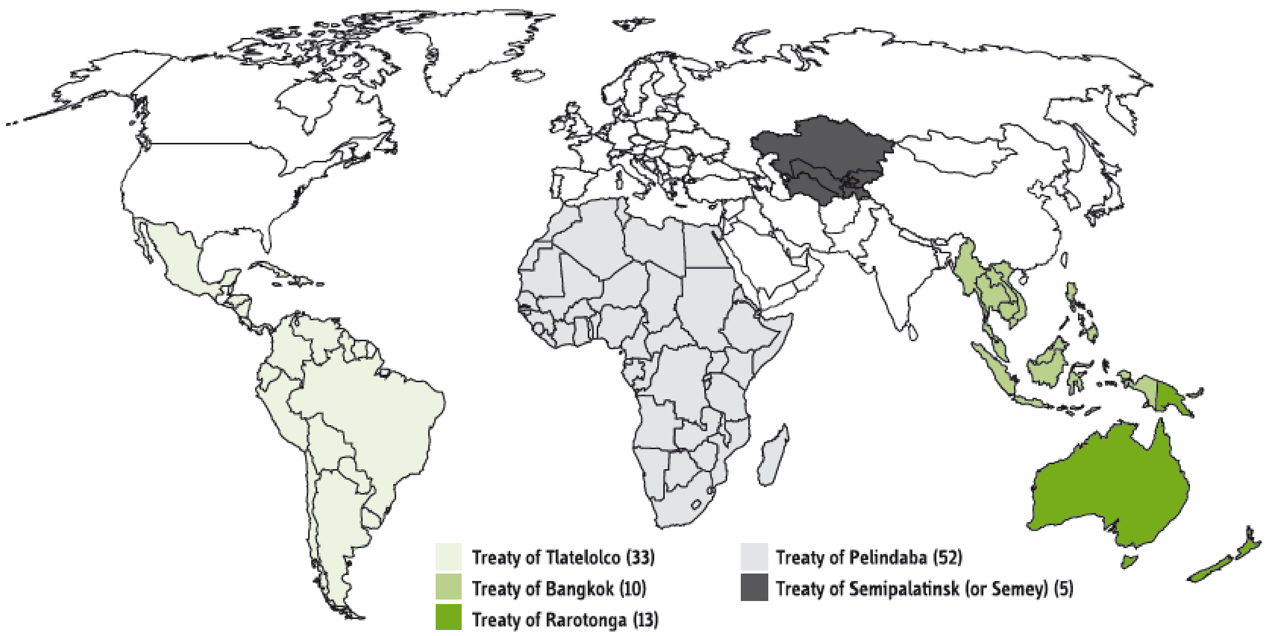

Figure 15: Nuclear Weapon-Free Zones in 2009. There are now five nuclear weapon-free zones, covering over 110 countries, including all countries in the Southern hemisphere (Source: IPFM 2009)

If the nuclear and climate problems are not tackled comprehensively but remain stuck in piecemeal approaches, one problem could impede solving the other. As long as countries acquire nuclear power and nuclear weapons, arms races and threat perceptions could spoil international relations, which in turn could undermine the conditions for cooperative climate policies. On the other hand, progressing climate change could undermine human and international security, causing incentives to use violent means to protect resources and interests. To avoid such a doomsday scenario, it is essential to strengthen the positive linkages between both policy areas. Negotiations on roadmaps for nuclear disarmament and carbon emission reduction could overcome the stalemate in both areas. Regional approaches could help to trigger global solutions, such as establishing Nuclear Weapon-Free Zones (NWFZ) in the Middle East, Northeast Asia and the Arctic (see figure 15 for existing NWFZs). Regional partnerships in environmental security could prevent disasters in climate hot spots and support the capacity building of societies against the risks of climate change. In a win-win scenario, nuclear disarmament would improve the conditions for climate cooperation which, in turn, would support an international political climate that would make nuclear weapons increasingly obsolete.

International law offers an effective framework to prevent the risks of nuclear war and climate change through a double-zero approach for nuclear disarmament and carbon emission reduction.

While nuclear arsenals have declined since the end of the Cold War, carbon emissions are still going up and it is not clear when or if a peak will be reached. Since the early 1960s, a number of arms control agreements have been achieved: INF (Intermediate-Range Nuclear Forces) and START Treaties, Moscow Treaty (SORT), Comprehensive Test Ban Treaty (CTBT), Nuclear Weapons Free Zones, Conventional Forces in Europe (CFE) Treaty, Chemical Weapons Convention, Biological Weapons Convention, Anti-Personnel Mine Ban Convention and the Convention on Cluster Munitions. With the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, international law was extended to the atmosphere. While the goal of the United Nations Framework Convention on Climate Change's to stabilize carbon concentrations in the atmosphere at non-dangerous levels is far from being achieved, the 1997 Kyoto Protocol specified short-term emission goals for industrialized countries and introduced several instruments. However, most countries failed to reduce greenhouse gas (GHG) emissions to the 1990 levels. For many experts, a maximum temperature change of two degrees Celsius above pre-industrial levels and an 80 percent emission reduction by the middle of the century is essential. While this does not exclude a number of risks, it is meant as a barrier against the potentially more dramatic risks at higher temperatures. To act on a global level, the international community has to agree on a maximum carbon budget for the whole planet that does not exceed the temperature ceiling, and then allocate admissible emission pathways to individual countries within the budget limit according to principles of justice. What justice means in this context is heavily contested.

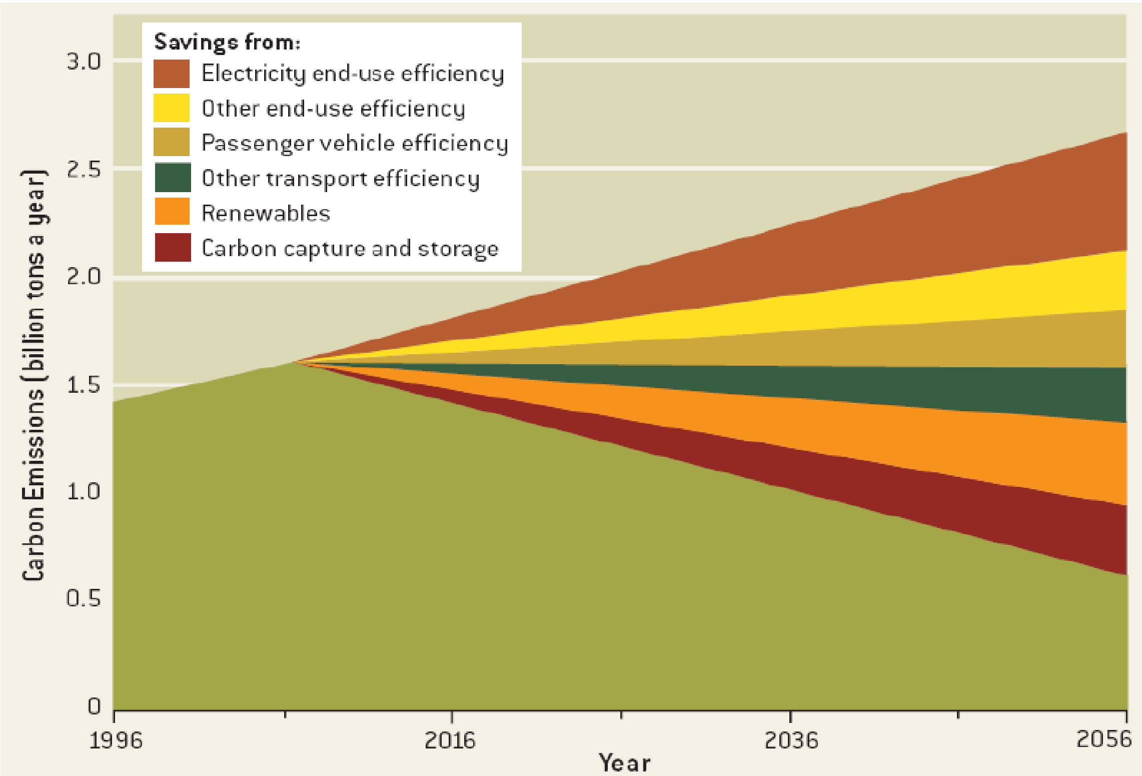

Figure 16: Pathways towards a low-carbon world, based on wedges of emission reduction in the United States (Source: Scientific American)

Among the short-term steps for nuclear arms control is cooperation with Russia on strategic arms reductions and an international Fissile Material Cut-Off treaty on nuclear weapons materials. Similarly, a number of adaptation and mitigation measures have been proposed for reductions of GHG emissions which need to be implemented. However, an incremental approach alone will not solve the problems in either field in the foreseeable future. An integrated framework is required that combines various steps in a coherent approach to move toward a "double zero" of nuclear weapons and carbon emissions (Scheffran/Schilling 2009).

To turn rhetoric into concrete actions, non-governmental organizations have made specific proposals for comprehensive solutions in both the nuclear and climate fields. The Model Nuclear Weapons Convention, drafted in 1997 and updated in 2007 by an international group of experts, outlines a path to Global Zero (MNWC 1997, Datan et al. 2007). It does not include a ban on nuclear power, although it is recognized that the goal of nuclear abolition would be easier to achieve and verify with such a ban than in a world where nuclear power continues to be pursued (Scheffran 2010b). A model treaty for drastic emission reductions was presented by NGOs in preparation of the 2009 climate summit in Copenhagen, but unfortunately did little in influencing the outcome. To make progress, it is the major powers that have to commit to drastic reductions in emissions and nuclear weapons. Without their serious involvement, a world free of both these scourges will remain elusive.

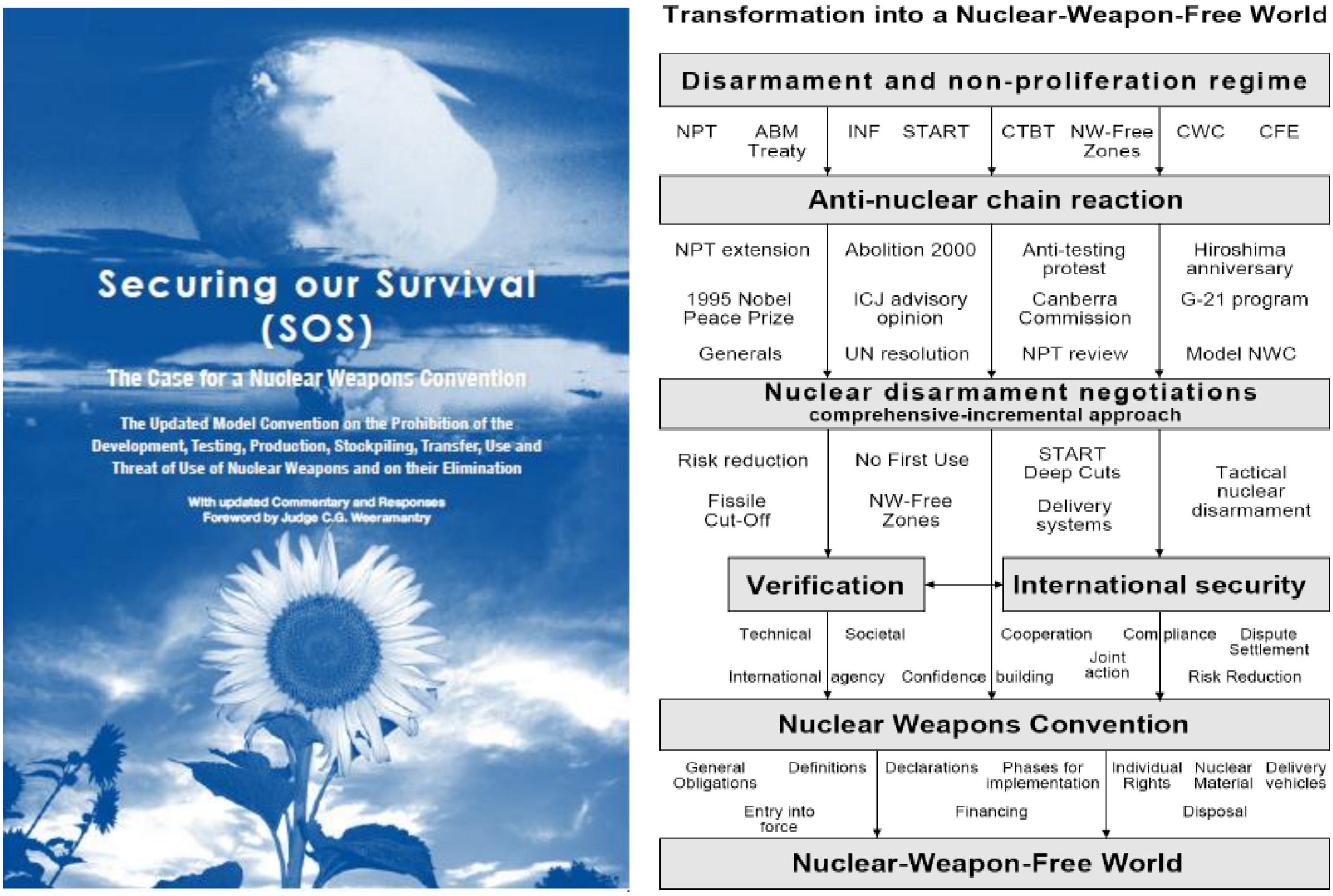

Figure 17: Cover of *Securing Our Survival* and roadmap towards a nuclear-weapon-free world

Scientists have a special responsibility for eliminating the risks of fossil energy and nuclear power.

Since scientists and engineers invented the technologies to exploit fossil energy and nuclear power, they have a special responsibility in abolishing both. With the advent of nuclear weapons, physicists took the responsibility in calling for nuclear disarmament. As the Russell-Einstein Manifesto notes: "In view of the fact that in any future world war nuclear weapons will certainly be employed, and that such weapons threaten the continued existence of mankind, we urge the governments of the world to realize, and to acknowledge publicly, that their purpose cannot be furthered by a world war, and we urge them, consequently, to find peaceful means for the settlement of all matters of dispute between them."

Joseph Rotblat refused to continue working on the Manhattan Project to build the atomic bomb when he learned that the bomb was no longer needed against Hitler. He called for the moral responsibility of scientists: "The time has come to formulate guidelines for the ethical conduct of scientists, perhaps in the form of a voluntary Hippocratic Oath. This would be particularly valuable for young scientists when they embark on a scientific career ... I appeal to my fellow scientists to remember their responsibility to humanity." In conjunction with the Pugwash Conferences, he was awarded the Nobel Peace Prize in 1995 for his efforts towards nuclear disarmament. The Intergovernmental Panel on Climate Change, together with Al Gore, received the Nobel Peace Prize in 2007 for their efforts in studying and educating on man-made climate change.

Because of their expertise, scientists and engineers can make major contributions to abolishing the nuclear arsenals (e.g., by verifying the disarmament process), as well as develop the technologies necessary for a sustainable energy transition that would avoid further human-induced global warming. The challenge to avoid dangerous climate change could foster the readiness for cooperation, on local and global levels. And a push toward nuclear disarmament could help transform the international security landscape into a more peaceful and sustainable world order.

To establish a foundation for peace that prevents climate change and nuclear war, it is crucial to develop and establish the concepts of cooperative security and sustainable peace.

Preventing the dangers of climate change and nuclear war in the long run requires an integrated set of strategies that address the causes as well as the impacts on the natural and social environment. New concepts of security could serve as building blocks for a more peaceful world, including *common security* (pursuing common responses to common threats), *ecological security* (preventing environmental problems from turning into security risks) and *human security* (shielding and empowering people against acute threats) (Scheffran 2011). Satisfying human needs and harnessing human capabilities makes societies more resistant to climate change and allows them to implement low-carbon energy alternatives and conflict-resolution mechanisms. Both require the creation of institutions that ensure the benefits of cooperation via establishing and enforcing common rules and regulations. Reducing poverty and implementing human rights would significantly strengthen human security and build problem-solving capabilities. Less wealthy countries need development cooperation and international financial assistance, e.g., by effectively using microfinance. A "Green New Deal" would provide the framework for the financial and technology transfer required to build a low-carbon society that tackles the challenges of energy security, climate change and human development at the same time.

To face both nuclear risks and climate change, it is important to create sustainable lifecycles and livelihoods that respect the capabilities of the living world. It is crucial to evade the vicious cycle of unsustainable economic growth, unchecked accumulation of political power and escalation of violence that for too long have contributed to environmental destruction, underdevelopment and war. Instead, a "virtuous cycle" needs to be built that transforms the current world disorder into a more peaceful and sustainable world order. To avoid conflicts related to the scarcity of natural resources, or at least reduce their destructive effects, a bundle of measures is required that is not limited to the traditional means of conflict management, such as military intervention, arms control, refugee support and disaster operations.

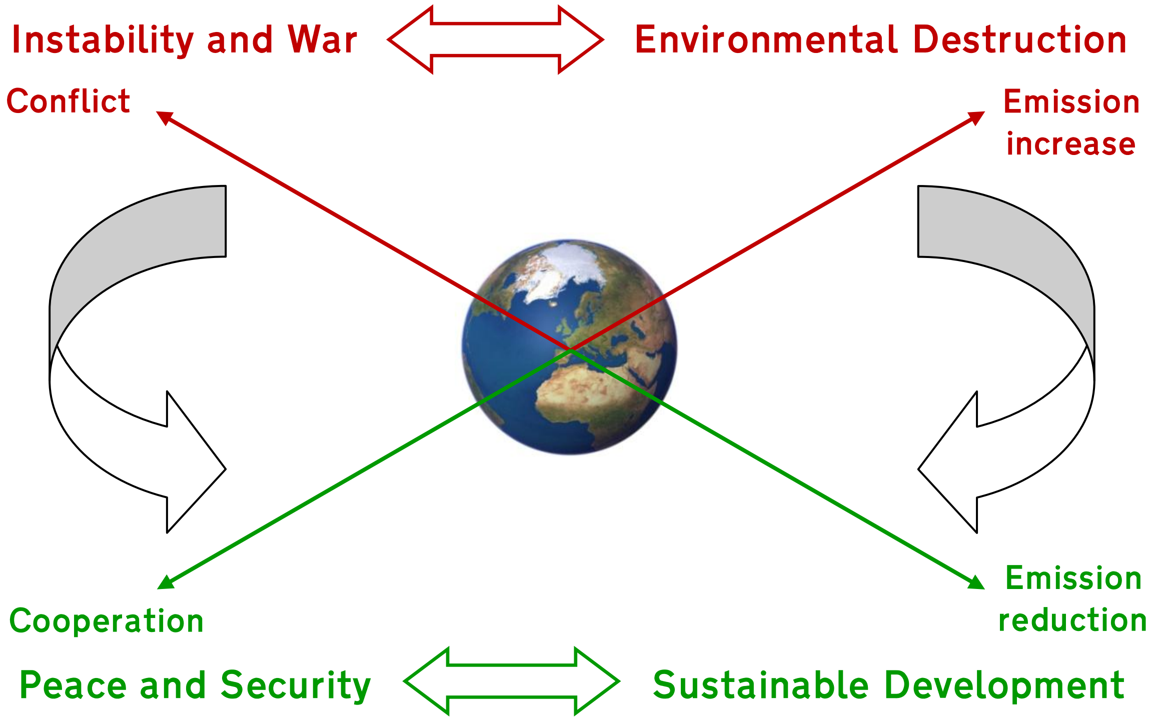

Figure 18: World at the crossroads: From climate conflict to sustainable peace

A world that is violent and unpeaceful is at the same time unsustainable und unjust, and vice versa. Strategies for preventing the causes of violent conflict integrate a set of measures, including the preservation and efficient use of natural resources, implementing principles of equity and justice, strengthening cooperation and changing lifestyles. Accordingly, concepts of peace that rely on avoiding dangerous conflict, on preventive arms control, the reduction of violence and the abolition of nuclear weapons, and on compliance with human rights and cooperation, will improve the conditions for the cooperative implementation of sustainable development. The inherent linkages need to be further developed in a mutually stimulating way to an integrated concept of sustainable peace (Scheffran 1998).

There will be no role for nuclear weapons in a peaceful and sustainable world. On the contrary: they prevent it because they are based on principles fundamentally violating the conditions for peace and sustainable development. The world should eliminate and prohibit these weapons that symbolize so badly the last century of violence. They belong to the past, not to the future.

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