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Keynote speech

Facing Future Challenges: Assessing the Role of Science and Technology in Climate Change Mitigation and Adaptation

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It is 2016, and climate change has become a dramatic and often bitter reality in many places. The years 2011-2015 were the warmest five-year period on record. Over the last months, anthropogenic climate change combined with a strong El Niño – the weather anomaly that originates in the Pacific – has driven up temperatures worldwide. According to the WMO, the world has now reached a symbolic 1°C above the mean temperatures of the pre-industrial age.

The warming of the planet translates into disaster in many locales: In May and June 2015, India and Pakistan were struck by heat waves. The Californian mega-drought had reached historic proportion. Brazil was also confronted with extreme drought conditions that plunged the 20-million megapolis, the city of São Paulo, into the worst water crisis in 80 years. At the same time, heavy precipitation and flooding posed serious problems to many societies and their economies. In January 2015, Malawi in South East Africa was hit by heavy floods, while in late July, Myanmar and Bangladesh suffered from flooding and landslides. Apart from the direct loss of human lives, these extreme-weather conditions manifest as increased poverty, temporary displacement, and the heightened likeliness of the outbreak of epidemics.

It is known that anthropogenic climate change and weather extremes are closely connected. This means that the extreme weather events the world has seen in the last few years may just be a preview of future catastrophes.
There should be no doubt: Anthropogenic climate change is among the greatest challenges that humanity faces in the 21st century. The looming climate catastrophe is reminiscent of the threat of nuclear apocalypse in the era of the Cold War. In a business-as-usual-scenario, continuing greenhouse gas emissions at present levels will lead to a situation where large parts of the planet may become virtually inhabitable by the end of the century. Even more worrying, scenarios based on state-of-the-art computer modelling indicate that with current emission levels, it will be very hard to keep mean

temperatures below 2°C above pre-industrial times, as is the stated goal since the 2009 Copenhagen conference on climate change (UNFCCC COP15). Not only would climate change devastate whole regions, but, according to a host of geographers, economists and political scientists, it would increase the conflicts over vital resources like water or arable land by large degrees.

It takes political will to reverse these trends. The good news seems to be that the international community has understood the dangers of climate change. At the COP 21 climate summit in Paris in December 2015, the nations of the world have agreed to a new treaty for climate change, effective from 2020. The Paris Agreement has both met harsh criticism and enthusiastic support. The former is directed against the fact that the emission targets set in the agreement are voluntarily and that the pathway to the new 1.5°C goal remains relatively vague. The latter celebrates the decisiveness and unity that the Paris agreement is supposed to embody.

Whatever the opinion on the outcome of COP 21 may be, it is clear that science and technology have a key role in paving the way. Both the decarbonizing of our industries, economies and lifestyles, and the adaptation to inevitable climatic changes that are already on the way, require great efforts in terms of research and technological innovation.

Without these, the battle against climate change is already lost. The scientific community must be wholeheartedly devoted to the mission of decarbonizing modernity and adapting to climate change. This is a magnificent and urgent task, however, it has many pitfalls. If scientists and engineers lose track of the human scale, they will not solve the vast problems associated with dangerous climate change. I will elaborate what I mean by this in the following.

Human beings use technology to alter and shape natural landscapes. This has happened at least since the advent of sedentary farming in prehistoric times. But even in the paleolithic age, when hunter and gatherer societies used advanced weapons for hunting, they at least contributed to the extinction of the dominant large mammal species, and ecosystems where altered forever.

The political ecology approach is based on one essential question: Who profits and who loses out from interactions between humans and nature? This question is also extremely relevant when talking about climate change mitigation and adaptation, and the technologies that are used for these purposes. From the critical theoretical perspective of political ecology, it has to be acknowledged that most technologies are not, and can never be, politically neutral.

As mentioned above, a number of scholars worry about the potential of climate change to destabilize societies and cause conflicts over natural resources. There is a heated debate in the conflict and peace studies community whether the link between climate change and conflict is valid and straightforward, and which factors play into the equation. Nevertheless, one aspect is mostly missing: That climate change mitigation and adaptation measures also have the potential to cause conflict on a massive scale. I will provide a number of examples, namely hydroelectric mega-dams, nuclear power, carbon capture and storage (CCS), biofuels, and genetically modified organisms.

Hydroelectricity is promoted as a source of “clean” energy in order to justify the large-scale impacts that mega-dams have on the environment. The 20th century was marked by a construction boom of large dams, many in developing countries like India and China, that followed a developmentalist modernization agenda. Construction of dams was often associated with displacement and forced resettlements of local populations, which made them highly conflictual to begin with. While it is true that the operation of hydroelectric power plants, unlike coal plants, does not require the emission of carbon dioxide, large dams are not carbon-neutral. First of all, the gigantic dimensions involved in the construction process use up huge amounts of greenhouse gas emissions. What is more, the flooding of forests lead to anaerobic processes and eventually, large amounts of methane are released, which itself is an extremely potent greenhouse gas. The most prominent example of a controversial dam construction site is Bela Monte at the Xingu River in Pará state, Brazil, which is designed to be the third-largest dam on Earth. The construction of the Belo Monte Dam faces fierce resistance by environmentalists and indigenous people, who live on the land which is to be flooded. To date, Belo Monte’s construction is not finished; it is scheduled to start operation in 2019.

Recent research emphasizes that construction of large dams may not only have socio-economic and environmental side-effects; the endeavours are at times also not economically feasible, for example in the earthquake-prone regions of Nepal. Also, dams tend to become subject to sedimentation after some decades, which heavily obstructs their functionality. Finally, the above-mentioned droughts impair the operation of large dams, as rivers run dry.

Another, equally controversial large-scale technology is nuclear power. To many, even to dedicated environmentalists, climate change provides a strong argument for the resurgence of nuclear power. Nuclear power is able to produce large quantities of energy without emitting significant amounts of carbon dioxide. Therefore, some hail it as a future technology; the Obama Administration has made it a dedicated part of its plan to combat climate change. However, there are several reasons why nuclear energy is not the way out. First of all, the operation of nuclear power plants is associated with unforeseeable risks. The nuclear disasters of Chernobyl in 1986 and Fukushima in 2011 have shown that accidents do occur, and they may result in the radioactive contamination of large areas, extremely heightened cancer risks to neighbouring populations, and radioactive poisoning of water resources. The second big problem is waste disposal, as the storage of highly radioactive waste is a problem that is to be taken very serious. After usage, fuel rods are emitting radiation not for decades or centuries, but for many thousands of years; therefore, nuclear waste has to be stored safely, a technological puzzle that has not been solved yet. The third problem is the security dimension; civilian nuclear power always holds the potential of being a smokescreen for the acquisition of nuclear weaponry, as the prolonged controversy over Iran's nuclear ambitions have illustrated. Proliferation of nuclear material is an issue. A fourth issue is the high, often runaway costs associated with the construction of nuclear power plants. Without massive state investments and subsidies, nuclear power plants cannot be built. This illustrates that nuclear power is hardly an option for Least Developed Countries, which are in dear need of cheap and reliable energy. Finally, the mining of uranium is a dirty business, with immense potential of negative impacts on ecosystem, local populations and worker's health. Also, some uranium mines are in fragile states, which heightens the potential of violent resource conflicts.

The world's most important source of energy, and the single biggest contributor to climate change, is the burning of coal. It produces around one third of the world's primary energy supply. It fuels most of China's economic boom, and is equally important to most industrial countries. Coal resources are abundant and may last for some more centuries. However, apart from the dramatic effects on the global climate, coal mining and coal burning cause water pollution, air pollution and health hazards for urban populations. Carbon capture and storage (CCS) is a pilot technology that aims to offset the negative sides of burning coal. Carbon dioxide is captured from emissions and then pressed underground in deepgeologicalformations. Again, this technology is extremely costly. Also, there is an unknown danger of leakages. The IPCC points towards knowledge gaps in the understanding of the implementation of CCS technology. If the stored carbon dioxide escapes and reaches the atmosphere, it could even speed up global warming. The main political problem is that the promises of "clean coal" by ways of CSS allow the coal industry to further operate on their current model, while there is an urgent need to discontinue the widespread use of coal-fired power plants in the near future.

Biofuels have been promoted as a possible alternative to fossil fuels, as fuels made from plants – mostly Biodiesel and Bioethanol - are supposed to be carbon-neutral. For some time, USA, Brazilian and EU policies have actively promoted the use of biofuels in order to reduce energy dependencies on oil-producing nations. However, over the last few years, biofuel production has been subject to heavy criticism from environmentalists and advocacy groups. Investments in arable land for the purpose of biofuel production has been associated with forced evictions of local, often indigenous populations, and in consequence, with land conflicts. Under the current agribusiness production model based on mechanization, chemical fertilizers and potentially hazardous pest controls, even the carbon neutrality of biofuels is in question. There also is an ethical question, since biofuel has very likely driven up food prices during the 2008-11 food price crisis. There seems to be some promising research into second-generation biofuels – fuel made from waste and other non-foods – but this technology is not ready for mass production yet.

Luring are the promises of agribusiness and life sciences companies to end world hunger through genetically modified organisms (GMO). However, the chances that GMO could provide a universal adaptation mechanism to climate change in agriculture are quite low. First, today's GMO, like Roundup-ready Soy, are associated with the dramatic and potentially harmful use of pesticides such as glyphosate. Also, resistances are a problem. Secondly, GMO are expensively developed; small-scale farmers in many places will not be able to afford GMO seed. Thirdly, environmentalists still worry about unforeseeable consequences of GMO to human health, ecosystems and biodiversity; in the EU, under the precautionary principle, large-scale production of GMO food remains strictly controlled. Overall, GMO can be assessed as a very expensive technology with many associated problems; alternative models of climate-smart food production are preferable.

Nuclear power, large dams, biofuels: Like fossil fuel, these technologies are part of an out-dated economic model. They symbolize the pathways of accelerated modernity that created the situation the world is in today. It is preferable to phase out the use of these technologies instead of presenting slightly modified, newer versions as solutions to climate change.

The alternative, however, is not a deindustrialization, an end to technological development. There is no going back to an allegedly better past. Without the progress humanity has made in agriculture, medicine, engineering, and transportation technology over the last centuries, the world would be a much bleaker place, and many millions more would be threatened by death through starvation and disease.

Humanity must shed thoughtless megalomania. What is called for are more locally adapted, smart technologies. These technologies must be cost-effective and energy-effective, they must be easy to maintain, to repair and to deconstruct, and they must be built to scale. Climate change urges humanity to a new culture of innovation – one that favours sustainability over profitability.