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Thematic Section

What Next? Climate change, technology and development

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ABSTRACT *Drawing on the* What Next project, *Niclas Hällström warns that the urgency of the climate crisis may open the door for new, untried and risky techno-fix solutions. He argues that society must find ways to ensure precaution, sustainability and equity when introducing new technologies. He raises concern that 'geo-engineering' and new converging technologies at the nano-scale as solutions to climate change could lead to new global problems and highlights the importance of civil society.*

KEYWORDS *climate change; livelihoods; techno-fix; precaution; geo-engineering; nanotechnology; synthetic biology; technology assessment*

Introduction

It seems that during the last year the debate on global warming has finally reached a stage where people are beginning to grasp the magnitude and urgency of the crisis. The strong consensus within the science community on the direct link between human-induced increase of greenhouse gases in the atmosphere and a changing and warming climate is hitting hard, and the denialists seem to be on the retreat. Alarmingly, we see prior projections as having been too conservative. The escalation of runaway feedback loops at even modest temperatures seems likely.

The issue is no longer whether global warming is a problem. In fact, a sense of emergency is beginning to hit the general public, decision-makers, researchers, corporate executives and the media. And with this sense of urgency, new primary battlefronts are opening up as to the choice of solutions and responses. Some of these 'responses' and 'solutions' may be dangerous illusions that may very well create new, global problems of a magnitude equal to global warming, and may not even tackle climate change as such.

The environment, democracy and local peoples' livelihoods are at stake . At the centre of this are the rapid emergence and promotion of a range of new powerful technologies and the promises of grand-scale 'techno-fix' solutions to 'geo-engineer' the planet back on track. Closely linked. to these are the issues of participation, precaution and our understanding of development.

The questions on the table are as follows:

- Should we allow geo-engineering through large-scale fertilization of the world's oceans with iron nanoparticles to stimulate plankton growth as a new CO_2 sink

- Is it sensible to geo-engineer the atmosphere by massively 'polluting' it with sulphur or metal nanoparticles to reflect incoming sunlight?
- What are the risks and ethics of creating entirely new life forms as new energy sources and CO_2 sinks?
- Is adaptation best served through corporate development of new, genetically modified crops with proprietary, patented 'climate-ready' genes?

While many spontaneously react with scepticism to such propositions, numerous influential voices are speaking out in favour. *Time* magazine, in its 24 March 2008 (Walsh, 2008: 47) issue, highlighted geo-engineering as one of the ten most important ideas that are changing the world and refers to Nobel laureate Paul Crutzen, who has argued that we need to release vast amounts of sulphur into the atmosphere.

Crutzen, who received the Nobel Prize for his work on the hole in the ozone layer, argued in August 2006 that, 'If sizable reductions in greenhouse gas emissions will not happen and temperatures rise rapidly, then climatic engineering, as presented here, is the only option available to rapidly reduce temperature rises and counteract other climatic effects. The very best would be if emissions of the greenhouse gases could be reduced. Currently, this looks like a pious wish' (Crutzen, 2006). While controversial, Crutzen has opened up a debate and legitimized geo-engineering as an option to be considered seriously.

Similarly, a *Financial Times* commentary on 4 February 2008 urged the next US president to take a global leadership role in tackling climate change by setting up a new Manhattan style project to develop new technological solutions such as carbon capture and geo-engineering – in close collaboration with Google, Microsoft and other big business companies (Rachman, 2008). In one go, the US could go from scapegoat to saviour, without even touching thorny issues such as gasoline taxes.

Converging technologies

Current technological developments, including proposed geo-engineering schemes, are situated in the context of a new industrial revolution. At the core of this revolution is 'nanotechnology', a conglomerate of different science applications and specific technologies that deal with matter at the atomic level. Nanotechnologies exploit the fact that materials change their properties (colour, electric conductivity, elasticity, strength, explosivity, toxicity, etc.) dramatically at this very small size.[1] The convergence of technologies at the nanoscale is producing unprecedented advancement of understanding and capability to manipulate matter and life. In fact, the boundaries between life and matter are increasingly blurred as nanotechnology, genetics, computer science and neural sciences integrate and give rise to whole new sets of applications. The National Science Foundation (NSF) in the US have dubbed the field NBIC (nano-bio-info-cogno) (Roco and Bainbridge, 2002). The European Union is talking about CTEKS (Converging Technologies for the European Knowledge Society) (European Commission, 2004). Almost every industrialized country, and many countries in the South, have set up National Nanotechnology Initiatives. The competition is fierce and the scramble for intellectual ownership through patents is intense. The market for nanotechnology-related products is predicted to increase exponentially. The US National Science Foundation in 2001 estimated that by the year 2015 this market would be worth US$ 1 trillion, while the market analysts of Lux Research in 2004 predicted it would be worth US$ 2.6 trillion by the year 2014. This implies that the nanotech market will become larger than the combined value of the whole informatics and telecommunications market and ten times larger than the future biotechnology market (Hullman, 2006).

More than 1,000 products made of the crudest form of nanotechnology – nanoparticles – are now in the market, ranging from tennis rackets to car tires to sunscreen protection. More advanced applications such as miniaturized computer chips and drug delivery devices made up of structures at the nanoscale are under development. Whole new fields are opening up, around the corner integrating machines, computers and living organisms with each other, including the creation of entirely new life forms.

In an investigation of the 1,300 largest corporations across all business sectors – the Global 1000 and Fortune 500 corporations – Lux Research estimated that although most companies would be affected, 18 percent (233 companies with a combined revenue of US$ 3.2 trillion) will be *highly* effected by nanotechnological development. The likely challenges for these would be of the magnitude that Kodak experienced due to the boom in digital photography (Bunger, 2008). The corporate map will be considerably redrawn as broad, key patents cut across sectors and the rationale for mergers escalate to yet another level.

The new high-tech solutions to global warming are thus only part of a larger matrix of technological development and corporate reconstitution of which neither government circles nor civil society are aware (nanoparticles are not yet subject to regulation or thorough risk assessment). Undoubtedly, a number of yet unforeseen hi-tech and even more grand large-scale 'solutions' to global warming will come out of this highly dynamic and competitive field.

For the time being, however, a number of new geo-engineering technologies are evidently already in the cards and are being considered in relation to climate change. The following are some examples:

Ocean fertilization

In spring 2008, the proposition of a moratorium on ocean fertilization was discussed at the negotiations of the Convention on Biological Diversity conference of the parties (COP) in Bonn. This highly controversial geo-engineering scheme gained considerable attention during 2007 as the first commercial attempt to dump iron nanoparticles in the ocean. It was stopped after action by civil society organizations and strong statements by intergovernmental scientific committees of the London Convention and London Protocol on ocean dumping (ETC Group, 2007a). A US corporation, Planktos Inc., was about to dump 100 tons of iron nanoparticles over an area of 10,000 km^2 close to the Galapagos islands, with the intention to spur massive growth – a bloom – of plankton (iron is a limiting nutrient in most ocean ecosystems). The CO_2 uptake of the plankton (and assumed eventual sedimentation at the bottom of the sea) was in turn assumed to generate carbon credits for the carbon trading market to offset the CO_2 emissions from fossil fuel use by emitters in the North.

The London Convention groups 'note with concern the potential for large-scale ocean iron fertilization to have negative impacts on the marine environment and human health' and that 'knowledge about the effectiveness and potential environmental impacts of ocean iron fertilization currently is insufficient to justify large-scale operations' (The International Maritime Organization, 2007). Critics, both scientists and environmentalists, point to the risks of altering the intricate ecological balance in the ocean and the shaky assumptions that there would really be a significant and lasting sequestration of carbon.

Yet, a considerable number of ocean fertilization experiments have already been undertaken. In early 2007 the ETC group, a civil society group monitoring the evolution of emerging technologies closely, noted that since 1993 at least ten experiments had taken place involving at least nine different countries (ETC Group, 2007b).

Modification of the atmosphere

As already mentioned, the idea of manipulating the atmosphere is being seriously considered. In his August 2006 intervention, Paul Crutzen proposed that sulphur, the main cause of acid rain at lower altitudes, be disseminated in the stratosphere (to be delivered through balloons or artillery). Based on the experiences from the volcanic eruption of Mount Pinatubo and its cooling effect on global temperatures, Crutzen estimated that for between US$ 25 and 50 billion, sufficient amounts of sulphur could be launched into the atmosphere to last for up to two years. This, he argued, would be less costly and more effective than the necessary and difficult mitigation of greenhouse gas emissions (Crutzen, 2006).

Other similar propositions include the spread of metal nanoparticles in the stratosphere. These particles, due to their small size, would fall down slowly and during their time in the atmosphere function as tiny reflectors of incoming sunlight. By constantly adding new particles to the atmosphere through commercial air transportation, for example, the offset effect would be maintained. Eventually, however, the particles would hit the ground with unknown effects on ecology and health.

Another proposal is to place a large set, perhaps trillions, of tiny lenses in space orbit, again to reflect incoming sunlight (Broad, 2006).

Other climate change adaptation measures consider for example, how to change directions of cyclones or how to induce rain in areas that experience droughts (National Science Foundation, 2003). Again, these manipulations would take place on large scales, with unpredictable implications on weather patterns and ecosystems, and could cause new kinds of conflict and even warfare (House *et al.*, 1996).

New designed life forms

In the last few years the new scientific field of 'synthetic biology' has emerged. This is a new, more precise level of genetic engineering with the capacity to redesign and create new life forms.[2] The field thrives from the convergence of different scientific disciplines providing the means to break new ground. Dr Craig Venter, the brilliant researcher who won the race to map the human genome, has claimed that he will be the first to create an entirely new life form by synthesizing a new genome from scratch – and has already filed a broad patent claim on the life-producing process (*The Economist*, 2007; Gibson *et al.*, 2008).

Increasingly, the justification and arguments for synthetic biology research are presented in terms of providing new solutions to the climate crisis. Venter's company Synthetic Genomics Inc., for example, states the following on its homepage:

> Imagine a future where clean, environmentally friendly microorganisms produce the bulk of industrial material that today are made from petrochemicals, where specifically tailored organisms harness the sun to create clean energy, when researchers can use a modular software-like product to design new microbial genomes which are manufactured on an industrial scale. At Synthetic Genomics Inc., we are developing novel genomic-driven strategies to address global energy and environmental challenges. Recent advances in the field of synthetic genomics present seemingly limitless applications that could revolutionize production of energy, chemicals and pharmaceuticals and enable carbon sequestration and environmental remediation (www.syntheticgenomics.com/index.htm, accessed 21 May 2008).

What was inconceivable and probably ethically unacceptable by most only a few years ago is now presented as a fact and a grand-scale vision of a utopian future where pressing problems will be solved through technology. Given the escalating sense of crisis, the temptation to go this way may be irresistible for both policymakers and others. However, from an ethics and systems ecology perspective, such inventions must be regarded with concern and precaution.

Genetic modification for adaptation

The long-standing battle around genetically modified organisms (GMOs) is also taking new twists in the face of the climate crisis, not least in the realm of adaptation. The ETC Group recently surveyed patent claims by the largest seed and agrochemical corporations for what are being labelled 'climate ready' genes, corresponding to traits likely to make plants withstand climate induced environmental stresses such as drought, heat, cold, floods and saline soils. They report that

> BASF, Monsanto, Bayer, Syngenta, Dupont and biotech partners have filed 532 patent documents (a total of 55 patent families) on so-called "climate ready" genes at patent offices around the world. In the face of climate chaos and a deepening world food crisis, the Gene Giants are gearing up for a PR offensive to rebrand themselves as climate saviours. The focus on so-called climate-ready genes is a golden opportunity to push genetically engineered crops as a silver bullet solution to climate change. But patented techno-fix seeds will not provide the adaptation strategies that small farmers need to cope with climate change. These proprietary technologies will ultimately concentrate corporate power, drive up costs, inhibit independent research, and further undermine the rights of farmers to save and exchange seeds' (ETC Group, 2008).

With the initiative for a 'second green revolution for Africa', heavily promoted by private philanthropic foundations such as the Rockefeller Foundation and the Gates Foundation, the pressure towards GM crops and further entrenchment of small-scale farmers into dependency on proprietary crops are likely to increase.

Other technologies

Other 'climate-saving' large-scale technologies include the resurgence of nuclear power, underground carbon sequestration and the prospects of massive expansion of export-oriented agrofuels plantations in the South. The latter is currently becoming one of the hottest issues in the international debate, where concerns about implications for food production, land rights and environmental impact are voiced as reasons for a moratorium on large-scale agrofuels (www.grain.org/agrofuels/?moratoriumen, accessed 23 May 2008). Directly connected with agrofuels are issues such as GM trees, terminator technology and the development of second-generation agrofuels through synthetic biology.

Taken together – What next?

Although there are reasons to scrutinize each of these technologies in their own right, there is also a pressing need to understand what is happening in the broader picture.

A few years ago, the Dag Hammarskjöld Foundation in collaboration with a number of scholars and activists set in motion the What Next project to reflect back on 30 years of work on alternative development – and to look ahead.[3] In its 30-year business-as-usual scenario of the future, What Next weaves a complex web of trends and interlinkages between climate, new technologies and corporate concentration. In the gloomy story of the future, geo-engineering is pursued as a major strategy to curb global warming, leading to escalating health and environmental problems, and also providing the rationale for new levels of corporate mergers and collusion between governments and big geo-engineering consortia. The technologies are considered too risky to be made available to everyone, and are too costly insurance-wise for the corporations; thus, governments must step in and guarantee liability. While the struggle against climate change unfolds through increasingly centralized and large-scale efforts, society is also becoming more closed and authoritarian – again considerably triggered by technological development. As synthetic biology and other new technologies are providing the means for easily producing massively destructive bioweapons, society must protect itself and democracy from terrorists and lunatics through prevention by surveillance. Surveillance, massively enhanced by new information technology, robotics and satellites, becomes the paradoxical imperative to protect democracy and freedom. As a way to adapt to a rapidly changing environment and succeed in an increasingly competitive society, more and more people see themselves obliged to enhance themselves in a range of ways, both physically and mentally, through new human performance enhancement drugs and therapy – if they can afford them.

The What Next business-as-usual scenario is of course not cast in stone, but realistic and logical enough to be taken seriously. In attempting to look at the whole picture, seemingly disparate trends come together and form patterns. In the scenario, one-dimensional responses to problems such as climate change lead to new problems elsewhere.

What if?

Evidently, technology is at the core of the climate debate. Appropriate technologies, both old and new, are clearly needed to solve the problems of global warming. There is no doubt that the world needs technological innovation – energy efficiency, renewable energy and smarter transportation systems. But it is also evident that we need a more nuanced debate on technology in a context of risk, scale, power, participation and democracy. Some technologies are inherently centralizing and risky, whereas others are more likely to be sustainable and of direct benefit to local communities. Technology is not only the high-tech versions developed in the North for global export; it is also, for example, intricate water management systems evolved in particular places over long periods of time, often invisible to the outsider and experts, but likely important elements of a sustainable future (Lohmann, 2008).

I do not propose an anti-technology, luddite approach, rather I ask that we deal with technologies in a careful, responsible and holistic manner. It is important that we thoroughly apply the precautionary principle so that truly sustainable and equitable technologies can evolve (and those already existing are recognized). We need to take the time necessary to ensure that undue risks are not taken. Even if there is a climate crisis desperately calling for urgent intervention.

Sir Martin Rees, President of The Royal Society, and one of the most eminent scientists in the UK, discusses in his book 'Our Final Hour' the challenges of science and the emergence of new technologies, including geo-engineering, synthetic biology and other climate change-related 'solutions'. He somberly concludes the following:

> I think the odds are no better than fifty-fifty that our present civilization on Earth will survive to the end of the present century... through malign intent, or through misadventure, twenty-first century technology could jeopardize life's potential, foreclosing its human and posthuman future (Rees, 2003: 8).

Left in the hands of technocrats and the scientists themselves, we are not likely to come to grips with climate change or emerging technologies. Civil society, through the ordinary public and social movements, is crucial in order to ensure transparency, critical inquiry, and open participation in debates and decision-making. Technology transfer is not a simple, value-free, technocratic matter. It is politics. As Rees states:

> Choices on how science is applied – to medicine, the environment, and so forth – should be debated far beyond the scientific community... the views of scientists should not have special weight in deciding questions that involve ethics or risks: indeed, such judgments are best left to broader and more dispassionate groups (Rees, 2003: 78).

As more positive, sustainable and equitable ways forward, the What Next project also outlines alternative scenarios by asking *what if* civil society in collaboration with other actors managed to change focus from large-scale techno-fixes to genuine equity-oriented, sustainable solutions? What if citizens and researchers would, for example, take initiative to set up a decentralized Wikipidea-style system – 'Technopedia' – to track and evaluate technology development and act as more efficient watchdogs and whistleblowers? And on an international level – how could UN conventions and institutions be called for to conduct forecasting and technology assessments that would genuinely engage the public and civil society and have the power to regulate and impose caution when justified? The What if scenarios weave a web of possibilities in trying to answer these questions. They also highlight the potential for communities to link up and increase resilience by preserving well-functioning, local systems of natural resource management while trying and embracing new, climate-friendly technologies on their own terms.

The climate crisis must be understood for what it is – an expression of a grossly inadequate development model. In solving the climate crisis, the deep problems of mainstream development thinking must be tackled at the core, including our very understanding of progress, markets, technology and growth (What Next project, 2005). Grandiose quick-fix technological solutions – as well as quick-fix economic solutions such as carbon trading – could very well exacerbate the crisis. They are expressions of the same kind of thinking that created the problems in the first place. What may seem hard, tedious and politically challenging routes that focus on equity, social movement building and structural change are in the end likely to be the most efficient, and probably the only viable and sustainable roads ahead.

The urgent imperative to tackle the climate crisis should be seen as a golden opportunity to ask fundamental questions and come to grips with many of the other pressing global problems. For technology to be part of the solution rather than adding new and even more pressing challenges, we need open debate on the crucial ethical and political questions accompanied by social mobilization and action.

Notes

1 Nanotechnology deals with materials ranging from 1 to 100 nanometres (a human hair is approximately 80,000 nm in diameter). For overviews and basic understanding of nanotechnology, see the following: The Royal Society, UK Nanoscience and nanotechnologies: opportunities and uncertainties report (2004); (www.nanotec.org.uk/finalreport.htm); US National Nanotechnology Initiative (www.nano.gov/facts/home_facts.html), The ETC Group (www.etcgroup.org) where the overview 'A Tiny Primer on nano-scale technologies and the little BANG theory' can be downloaded.
2 See for example www.synbiosafe.eu for background and overview of the field.
3 The What Next Report 2005–2035: Trendlines and alternatives (Mooney, 2006) is available in a pre-publication version at www.dhf.uu.se. It is the result of a collaborative effort initiated by the Dag Hammarskjöld Foundation with Pat Mooney, ETC group as the lead author and the author of this article as coordinator of the group process. See also www.whatnext.org

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