CLIMATE ENGINEERING: CONCEPTS, EXAMPLES, AND RISKS

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Summary

Essentially all major societal activities contribute to existing or perceived environmental risks, from local to regional to international to global levels. Currently, the broad categories of existing or suggested technology responses to the "risk stream" include: expansion of nuclear technology programmes; development of resource-efficient systems; solar-based systems for providing low-polluting energy as well as greenhouse-gas sinks. However, it is less well known that a science, technology, and policy debate also exists in another response category involving very large-scale manipulations of ecological systems, even the climate regimes of the biosphere, aimed to offset the impacts of traditional technology. This article briefly reviews the geo-engineering approach to managing natural resources, and provides a platform for analysing the approach from the perspectives of science, technology, institutions, and environmental ethics

1. Introductory Examples and Concepts

Could, and should, large-scale natural systems be manipulated and controlled? For instance, would a well-timed detonation of an atom bomb in the Atlantic Ocean, close to Africas west coast, improve the poor climate of the Sahel countries? John Von Neumann, a renowned mathematician, suggested exactly this at the beginning of the 1950s. This is among the first known examples of modern scientific speculation on the ways and means to transform large-scale meteorological patterns on Earth, and conveys an image of what enormous powers as well as risks would be involved.

Von Neumann, a member of the United States Atomic Energy Commission, had been engaged in developing digital computers to be used as tools to predict the behavior of the weather machine. He must have been well aware of the physicist von Karman's findings in the 1930s, with respect to the surprising character of turbulence, but could not foresee the deepening understanding of its underlying patterns that was to come in 1960 when Edward Lorenz developed the theory of physical chaos. It seems that Von Neumann believed that large-scale (weather) systems might be controllable.

Indeed, several branches of science, including meteorology, ecology, and econometrics, experienced the "computer boom" in the 1960s and 1970s, leading many researchers to put much faith in large-scale, top-down models as a panacea, not only for the understanding complex systems (which is quite a respectable scientific stance), but also for controlling and manipulating such systems (which is an issue with ramifications far beyond mere science).

In fact, the battle between alternative interpretations of what systems complexity means – stabilization or surprise – has been going on for several decades. Important developments have taken place recently in bio-geophysical and ecological systems research. Moreover, differing interpretations of the implications of biogeochemical and bio-geophysical complexity manifest themselves in differing policy perceptions of anthropogenically driven climatic change. Is such change merely a process to which society can fairly easily adapt, or is it a threat that needs immediate preventative measures – perhaps even as drastic as exemplified at the outset of this paper, through worldwide concerted effort?

From the cultural and democratic perspectives of natural resources management, it is relevant to analyze whether strong technocratic elites could form that would aim at controlling and manipulating ecological systems, i.e., life-supporting systems, on a wholly unprecedented scale of magnitude. After all, long before Von Neumann speculated about large-scale manipulations of climate, there were many scholars raising concerns about the manipulation principle *per se*. Among worried voices was that of George Perkins Marsh, concerned about the effects of, for instance, connecting two huge water bodies, the Atlantic and the Pacific Oceans, directly via the Panama Canal project. As is also known, concerns of that kind were often not the primary matter for analysis in large-scale engineering ideas (some of which were developed and implemented) with respect to, for instance, the reversal of the flow of northern rivers in Russia to improve climate and irrigation schemes; the creating of a "Siberian Sea" with water from the Caspian Sea and the Aral Sea areas; and the river-diversion projects for the Aral Sea. The Chinese Three Gorges Project might provide additional examples of large-scale ecological-technological engineering. This project, formally approved by China's National People's Congress in April 1992, has many aspects tied to it, some of which relate to preventing the flooding that is a periodic threat to residents, and to improving navigation on the river. However, 19 towns, 238 km^2 of farmland, and 50 km^2 of orange groves, would be overflowed by the project, and over 1 million people are expected to have to leave the area by the year 2008.

The question becomes: even if science and technology are, or will be, able to provide the fundamental knowledge for planetary-scale engineering, would applying such knowledge be consistent with seeking out sustainable paths towards a sustainable future?

2. Concerns About Climate Change

Although climate science has a long history, involving, *inter alia,* the research of Svante Arrhenius in the late 19th century, the climate-change questions were raised and clearly defined in current scientific terms for the first time in 1971. Since then, the arena of climate change science and, eventually, also climate-change policy, has witnessed an enormous number of activities: conferences, negotiations, recommendations and/or framework conventions, scientific controversies, political and ideological conflicts, among which only a very small selection can be the basis for discussion in this article.

The science that underpins the activities in the climate change arena provides examples of very rapid processes of chemical and physical climatic alterations that can manifest themselves within less than a few decades, a very short time-span in view of technological response rates. Feedbacks between major and large-scale environmental problems, such as between stratospheric ozone depletion, global warming, and acidification including ground-near ozone and smog formation, add particular complexity to the characteristics of change. Environmental science, empirical as well as theoretical findings, points increasingly to the need to reject simplistic perceptions of the state of the world environment. The likelihood is growing that the business-as-usual environmental policies and technological strategies will redirect stabilizing biospheric feedbacks into destabilizing behavior. Global average temperature is still on the rise; the frequency of extreme climate events seems to be increasing; increases in greenhouse gas concentrations, aerosols, and UV-B radiation from stratospheric-ozone depletion are all occurring simultaneously. In addition, a new dimension was introduced by observations that suggest "a discernible human influence on global climate" (IPCC, Intergovernmental Panel on Climate Change, 1996), a statement recently substantially strengthened by IPCC’s updated reports, and in the IPCC Third Assessment including the statement: “Most of the warming observed over the last 50 years is attributable to human activities”. This influence, however, is inadvertent, an unintended side-effect of the rapidly increasing anthropogenic emissions to the atmosphere of a wide range of greenhouse gases, and of large-scale changes in land use over the globe.

3. Categories of Responses to Climate Change Risks

Analyses of "the problem stream", or "risk stream", of global bio-geophysical problems outlined above show that virtually all major societal activities contribute to perceived environmental risks, not in the least, in addition to the obvious sectors of energy use, transportation, and industry, forestry, agriculture and waste management. Current categories of existing or suggested technological response ("the response stream") to the "problem stream" include expansion of nuclear technology programs, solar-based systems for providing low-polluting energy, as well as greenhouse-gas sinks, and various versions of small-scale or medium-scale ecological engineering, including the use of GMO’s, genetically modified organisms.

Alongside these long-debated policy-response types, however, a scientific discussion also exists on "futuristic" technologies to offset the impacts of traditional technology, such as the category of global ecological engineering, also termed geo-engineering, and projects dealing with mass migration to space (such as the Japanese Mombusho, and New Earth 2100, projects). Whereas von Neumann was concerned with the possibilities of altering a naturally established climatic regime, today's discourse on climate engineering addresses the problems of whether man-induced changes to climate could, and should, be counteracted with measures other than those related to technologies and policies that are aimed at reducing climate-forcing emissions and activities.

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Biographical Sketch

Bo L.B. Wiman, after an M.Sc. in Electrical Engineering in 1973, added a few years of training in ecological and earth sciences, and in 1985 received a Ph.D. in ecology. Appointments since the 1970s include advisory and specialist functions to the Swedish Ministry of Industry, the Ministry of Agriculture, and the Institute for Futures Studies. He was acting Professor in 1988 and 1989 at the Natural Resources Management Institute (NRMI), Stockholm University, and a member of the NRMI senior scientist staff 1988-1995. He has served as Associate Professor (environmental systems) at the Department of Environmental and Energy Systems Studies (IMES), Lund Institute of Technology at Lund University, and has been acting Professor (energy systems) at IMES. He has been a member of numerous Ph.D. thesis committees, and has published in the fields of atmospheric aerosols and of natural-resources management, including aspects of biogeography, theoretical ecology, and climate-change policy response, and has also published several books, on subjects such as natural resources management;

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