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ADDENDUM
NOVEMBER 21, 2007

To be added to SECTION 1, in response to
"THE CHALLENGE OF GLOBAL CLIMATE CHANGE: THE POST-KYOTO POLICY AGENDA"
Richard Stewart, New York University

New submissions from:
Louise O. Fresco, University of Amsterdam
Klaus Lackner, Columbia University

To be added to SECTION 2, in response to
"GLOBAL CLIMATE CHANGE AND THE ROLE OF UNIVERSITIES"
John Sexton, New York University

New submission from:
Dazhong Wang, Tsinghua University

From Kyoto to Sustainability: new challenges for the 21st century

Louise O. Fresco[i]

The issues

The last decade has seen an increasing focus on climate change as a prime preoccupation of scientists and politicians alike. Indeed, the scope of climate change science is breathtaking, as the detailed and thorough analysis of Professor Richard Stewart confirms. Yet there are several puzzling aspects to climate issues that suggest that we may need to rethink this focus. There is the lack of success of the implementation of the Kyoto Protocol, notwithstanding the overwhelming national and international efforts that have gone into it. There are also convincing figures on the unrelenting growth of energy use, with world energy needs in 2030 50% higher than today[ii], that should make us think again. And there is the nagging question of how the final goal – a stabilized level of, say, 600 ppm of CO_2[iii] - can be traced back reliably to scenarios for economic development and emissions reductions.

But, most importantly, evidence abounds that climate change is a facet of wider environmental and global change, and that some of these changes act on geological time scales, as reflected in the Millennium Ecosystems Assessment and preceding studies[iv], including the large body of work represented by twenty years of research by the IGBP (International Geosphere Biosphere Programme). Global environmental change includes human impacts on the biosphere, the hydrosphere and the atmosphere, for example extensive conversion of natural vegetation into agricultural and urban areas, high nitrogen and phosphate loads due to fertilizer use, or the release of aerosols. Nearly all of these changes are linked through multiple feedback loops to other parts of the anthroposphere[v] and the earth system as a whole. Many of these changes are a direct function of the economic development pathways that mankind has – consciously or unwittingly – followed so far. And many of the fastest changes take place in what we used to call developing countries, while at the same time some of the poorer of these countries will be the first to suffer. The relationship between climate, global environmental change and economic development is of great complexity and poorly understood yet crucial to any understanding of climate or global change. The fact that due to population growth and changing dietary patterns demand for most food products, and especially animal proteins, will increase by 50% up to 2030, with nearly all of this growth in developing countries, or that India and China energy use is set to more than double by the same year, cannot be emphasized enough. Climate is first and foremost a development issue.

The scientific challenges

There is nearly unanimous agreement that human activities cause effects that are of the same order of magnitude and even exceed the natural forces that regulate the earth system. Climate, as a set of variables influenced by human action as well a as driver of many other processes, is only one of the subsystems of the earth system, albeit a very important one. As a consequence, climate should not be seen as a subject on its own, nor only in relation to the energy agenda or limited to reducing CO_2 and GHG levels[vi]. Our efforts to understand, mitigate and adapt to climate change must be an integral part of our move towards a sustainable society (this is perhaps not reflected sufficiently in Professor Stewart's paper). If we put it this way, the old dichotomy between adaptation and mitigation becomes obsolete, as we must aim towards a new set of parameters that bring human action in balance with other driving forces of the earth system, including measures to curb emissions as well as measures to adapt to new temperature and CO_2 levels[vii].

While we could argue endlessly about the definition of sustainability, we can probably find common ground in the thought that sustainability does not exist in an absolute sense and that it is always a matter of trade offs between various alternatives with divergent long term and short term, and geographically explicit effects. Hence, sustainability is both about being able to react to unexpected fluctuations and to deal adequately with negative effects, where they occur. Sustainable development aims to minimize human effects on the environment, to reduce our dependence on the ever scarcer natural resources and to close material and energy cycles in production processes. Many approaches have been developed, with more or less scientific justification, to do this and to change public attitudes, such as the cradle-to-

cradle approach or the environmental foot prints. At a meta-level the quest for sustainability questions our very concept of economic growth, its quantitative versus its qualitative nature and how we measure it.
To put it differently, resilience[viii] and sustainability, in terms of natural drivers and social factors, are closely linked. They both refer to a wide ranging set of phenomena beyond climate such as the loss of biodiversity, veterinary public health (avian flu epidemics for example), excessive monsoon rains or energy price volatility, rural poverty (leading to erosion) and many others. Although these phenomena may seem wide apart, they are linked by the fact that they are the result of market failure and that they usually are transboundary in nature, i.e. having effects beyond the location where they take place. Sustainability, in other words, requires that we set global as well as local policies to resolve current market failures, nationally and internationally and that we develop a baseline against which to monitor overall progress as well as scenarios and approaches of human behavioral change. Although this is not mentioned very explicitly in the UN Millennium Development Goals, the relationship between sustainability and development should be at the heart of our concerns.
It can be argued that humans are unable to deal with the long term perspective that sustainable development requires because hundreds of thousands of years of biological and cultural selection have predisposed us to react to our current affluence as if we were still living lives determined by scarcity. We continue to consume and accumulate and pollute because we lack the instruments to restrain ourselves. Sustainability, therefore, involves moral choices which are not in the realm of science, but science should provide the understanding of the earth system and of the effects of our choices.
While there is an abundance of sectoral and disciplinary work, time has come for a certain unification of the scientific research that forms the basis of the 'big questions' referred to above. All these 'big questions' require new modes of scientific thinking linking the natural and the social sciences in a quantitative and spatially explicit manner. The overall approach must be to avoid a simplistic, even if sometimes effective, approach to developing technological solutions in favor of an integrated set of human and natural models aiming at behavioral change. Again, this diverges from the Stewart paper, which seems to suggest too strongly that top down technological solutions, including geo-engineering, ought to be the starting point. An exhaustive list of these big questions does not exist, and we would be well advised as an international university community to develop a common understanding of truly global priorities. These range from improving our understanding of the earth system (such as albedo, ocean acidification or land degradation) to resource use efficiency and new economic, social and fiscal instruments.

International cooperation

Climate research has led to the creation of numerous international partnerships, often of a dual (scientific and political nature), with the IPCC as the most well known among them. To a lesser extent this is also true for global environmental change and earth system research, although that area tends to be far more fragmented. For sustainability no clear science partnership exists, although innumerable research and development organizations claim to be contributing towards a more sustainable world. In any case, we lack a strong body to promote a science based transition towards sustainability, be it an equivalent to the IPCC or the IGBP or something entirely different. Some tentative efforts are under way to think about such a future, possibly growing out of the IGBP and the IHDP[ix].
In recent years the private sector as well NGOs have progressed substantially in dialogues about sustainability, leading to a host of voluntary agreements (to cite just one example: the code of conduct on pesticides) and major innovations in areas of energy savings, water quality and water use efficiency and responsible consumer behavior. It goes without saying that the complexity of the issues requires long term international collaboration, if only to exchange experiences on best practices, such as new technology and successful policies.
So far, with a few noticeable exceptions, most developing countries have participated in a piecemeal fashion in the international arena and capacity building is still in its infancy, although initiatives like START[x] are making an impact. Any future collaboration mechanisms should remediate this omission.

Leadership for our universities

This then ought to be the prime focus of our universities: to put science and education at the service of the transition towards a sustainable mode of interaction with the natural biophysical environment of our planet. Not how do we adapt to or mitigate climate change, but how to move to a sustainable world society – that is the central question. Universities have a special role to play in this because they are not only centers of excellent research but also train young people, i.e. those who will invent and implement ideas for a sustainable future.

It would be a sign of true forward looking leadership if the universities present at the Secretary-General's Colloquium would launch a working group, together with the UN, the private sector and NGOs, to explore ways and means by which universities, and including university students, could contribute in a meaningful way to a more sustainable world. An appeal should also be made to countries to move beyond the current paralysis of the post-Kyoto negotiations in order to establish mechanisms to deal with the wider context of sustainability of which climate change is one of the pillars.

The University of Amsterdam

Like many universities, our interest in climate and global change has evolved out of the initiatives and networks of individual researchers and has led to a wealth of course elements and research projects, many of them of a highly interdisciplinary nature, undertaken by numerous groups in nearly all faculties, with many academic partners. We are currently considering whether the subjects of climate, global environmental change and sustainability ought to become more visible in our strategic plan, in particular because they appeal to Dutch and foreign students alike. In the area of climate change, the work on the legal aspects of mitigation and adaptation to climate change, or coastal resource management, as well as paleo-ecology may serve as examples. Among the many activities, several go beyond climate science. In the social sciences extensive work is undertaken on sustainable business management and corporate responsibility, livelihoods in developing countries, consumer behavior and ethics and economic modeling. Graduate work exists on various sustainable technologies. We offer undergraduate courses on Earth and Mankind, Earth and the Environment and are elaborating a new program on Future Planet Studies. One of the university's spin offs is a company (IVAM) focusing on energy transition[xi]. The involvement of many disciplines in research and education is a tribute to our long standing tradition of interdisciplinary thinking on environmental issues, resulting perhaps from our location in a truly progressive town in terms of its environmental management and from the long Dutch struggle to create a resilient, prosperous and sustainable country in a highly vulnerable river delta against all environmental odds.

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[ii] World Energy Outlook 2007, IEA Paris 2007.

[iii] A fixed goal of temperature increase, as proposed by some political bodies, say to a maximum of 2 degrees C, would be even more fraught with difficulties.

[iv] See www.**millenniumassessment**.org and also seminal publications like Clark, W. C., B. L. Turner, R. W. Kates, J. Richards, J. T. Mathews, and W. Meyer, eds., 1990. *The Earth as Transformed by Human Action*. Cambridge, UK: Cambridge University Press.

[v] Loosely defined as the part of the earth system directly influenced by human action.

[vi] It is worth noting that although CO_2 and other greenhouse gases are important, CO_2 is not a direct driver of climate system per se (these drivers are solar radiation and hence atmospheric and oceanic circulation) – as non-specialists often may think.

[vii] The latter is of particular importance because of CO_2 fertilisation effects promoting plant growth.

[viii] As is its mirror image, vulnerability.

[ix] International Human Dimensions of Global Change Programme, the social science equivalent of the IGBP. For views on the latter see its 20th anniversary symposium at

http://www.igbp.kva.se/page.php?pid=396. These comments are based on recent personal conversations with various key people in the field.

[x] SysTem for Analysis Research and Training of IGBP and ESSP, START.

[xi] For a full list of teaching activities see annex I.

Climate Change: Something Must Be *Done*

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Current public discourse on climate change remains marooned between the embellishment of doomsday scenarios and hyper-critical skepticism. Although it is true that there still exist some uncertainties regarding the full impact of climate change, a convincing case for the necessity of controlling carbon dioxide in the atmosphere has already been made, and this case cannot be ignored. The time to act on the threat of climate change has come. Climate change has been observed, and in broad outlines, the phenomena associated with it are understood. Skeptics occasionally refute exaggerated claims of alarmists, but to date, they have been unable to provide a coherent alternative explanation of observed climate change. Some skeptics cling to the unlikely notion that those aspects of climate dynamics that are not yet understood are finely tuned to cancel out those aspects that are well understood.

Panic will not solve the problem of climate change; neither will a wait-and-see approach that could delay the search for solutions until is too late. Something must be *done*. Something can be done.

The way to stop climate change is to halt the rise in the concentration of carbon dioxide in the atmosphere. This requires new energy technologies that can avoid emissions of carbon dioxide to the atmosphere and institutional changes that make it possible to implement worldwide carbon management programs. A better understanding of the climate would inform the debate of how much time we have to stop greenhouse gas emissions, but considering the inertia of the world's energy infrastructures, any reasonable stabilization level requires immediate and drastic actions.

Unfortunately, energy use and economic development grow together. In a world that strives for rapid economic growth and that has vast resources of fossil fuels in the form of coal, tars and shales, moving the energy infrastructure away from fossil fuels is a nearly impossible task. Rather than abandoning aspirations for a higher standard of living, a more palatable approach to solving the climate problem would make it possible to harness fossil fuels without raising the carbon dioxide content of the atmosphere. In such a scenario, for every ton of carbon extracted from the ground, another ton of carbon will have to be disposed of safely and permanently. Such a strategy would be akin to solving previous environmental problems that were of similar urgency but could be addressed on local or regional scales.

Many human activities result in pollution. At first these pollutants seem to be ignored. Then, as the scale of emissions increases, efforts are undertaken to accelerate their dilution into the environment at large. It is only when it becomes clear that dilution is not a solution, that the problem is addressed in earnest. The big cities of the nineteenth century had to develop large and sophisticated sewer systems to protect the health of their citizenry. In the twentieth century, active steps were taken to reduce pollution in rivers and lakes and to improve local air quality. Acid rain increased the scale of the control areas. By controlling the ozone destroying substances in the atmosphere, environmental management reached global scales. Today, concern over climate change will force a global restructuring of the energy infrastructure.

Stabilization of greenhouse gases in the atmosphere requires a reduction in carbon dioxide emissions by at least a factor of three below those of today. This leaves a per capita emission allowance for the world which is approximately thirty times smaller than the actual per capita emission in the United States today. Thus, the world will have to adopt a net zero carbon energy infrastructure. Either the world will abandon fossil fuels, or it will develop technologies for carbon dioxide capture and storage. Alternatives to fossil fuels are limited, only nuclear energy and solar energy provide sufficient resources; and neither one is able to compete on an economic level with fossil fuels.

Hence, there is a strong motivation to explore the opportunities for closing the carbon cycle, i.e., for capturing the carbon dioxide that is produced in the combustion of fossil fuels and keeping it out of the atmosphere. This can be done, probably by increasing the cost of energy by about one third. Solar energy and nuclear energy would still need to improve to compete, and the total cost to the world economy would be small enough to be absorbed.

Three new technologies are needed to close the anthropogenic carbon cycle: Capture of carbon dioxide at concentrated sources like electric power plants, future hydrogen production plants and steel and cement plants; capture of carbon dioxide from the air; and the safe and permanent storage of carbon dioxide away from the atmosphere.

Technologies for carbon dioxide capture at large concentrated sources already exist. In in scrubbing carbon dioxide out of the flue stacks of power plants, energy efficiency would suffer by about 20 to 40%. Recent developments suggest that even retrofitting old plants is a real possibility. However, a concerted effort in technology development would likely lead to new power plant designs without any air emissions but with greatly improved energy conversion efficiency. Similar strategies for the designs of zero emission cement, steel and fertilizer plants would eventually lead to the capture of nearly all carbon dioxide emissions from concentrated sources.

However, one half of the current emissions would still remain unchanged as they stem from small, distributed and often mobile sources. Airplanes and cars, in particular, represent a large fraction of these emissions. They could be addressed by collecting carbon dioxide directly from the air. While it has been generally considered difficult to extract carbon dioxide at such low concentrations, trees and other photosynthesizing organisms perform this task routinely. Industrial processes, i.e., “synthetic trees, ” can capture carbon dioxide much more efficiently than natural processes. Air capture devices and windmills have in common that both extract something from the air. Air capture devices are much more compact than windmills: removing the carbon dioxide from a given volume of air allows for a gasoline consumption that releases several hundred times as much energy as a wind mill can collect from the same volume of air.

Once captured, carbon dioxide can be disposed of safely and permanently. Today carbon dioxide is already injected into in oil wells operating under tertiary recovery. As these reservoirs fill up, there are many more reservoirs, mainly saline aquifers that could be tapped for carbon dioxide storage. Formation of stable carbonate minerals in above-ground industrial processes would guarantee permanence of carbon dioxide disposal and virtually unlimited storage capacity, even if safe geological reservoirs were to prove too small in capacity. At present the cost of mineral carbonation is still too expensive by about a factor of three to five.

Engineering advances alone cannot solve the problem. A regulatory framework needs to be found that will encourage carbon dioxide capture and storage. Carbon dioxide emissions pose a conceptually simpler problem than acid rain as the natural cap on carbon dioxide emissions is zero. By controlling emissions at the point where carbon comes out of the ground – the mobilization of carbon – and by certifying sequestration at the point where carbon dioxide is stored – the immobilization of carbon, it becomes possible to create a trading scheme where carbon dioxide storage would offset fossil fuel production. In the short run, governments may auction off permits that trade like certificates without actually immobilizing carbon. However, eventually these permits will be phased out, and the world will approach a net-zero carbon economy. In such a scheme the price of carbon will internalize the cost of avoiding climate change. Therefore, economic forces will decide whether fossil carbon or other carbon free forms of energy are preferred. Based on technology options that have become apparent over the last decade it appears that solutions to greenhouse gas warming will be affordable. They might add one or two cents to the price of a kilowatt-hour of electricity or twenty-five cents to the price of a gallon of gasoline.

Rather than prolonging the debate over what disasters may or may not befall us, we should develop practical solutions, just as in the past when we built sewer systems for cities, sulfur scrubbers for power plants, and catalytic converters for cars. There is no question that carbon dioxide emissions will have to stop eventually. The sooner we succeed in stopping the carbon dioxide increase in the atmosphere, the smaller the risk of irrevocable and severe damage. In hindsight, the worst outcome of swift action would be that we succeeded in halting carbon dioxide emissions a couple of decades before it was absolutely necessary.

Global Climate Changes and the Unique Role of Research Universities

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Climate change is a major global issue of common concern to the international community. It is an issue involving both environment and development, but it is ultimately an issue of development. As noted by the *United Nations Framework Convention on Climate Change*, the largest share of historical and current global emissions of greenhouse gases has originated from developed countries, while per capita emissions in developing countries are relatively low and the share of global emissions originating from developing countries will grow to meet their social and development needs.

1. Post Kyoto Protocol Agenda

(1) As a responsible developing country, China attaches great importance to the issue of global climate change. Since 1992, a series of technical and legal policies and measures have been taken in accordance with national situation, making positive contributions to the mitigation of climate change. According to IEA, China's emission intensity dropped to 2.76 kgCO2/US$ (constant 2000 U.S. dollar) in 2004, as compared to 5.47 kgCO2/US$ in 1990, a 49.5% decrease. For the same period, emission intensity of the world average dropped only 12.6% and that of the OECD countries dropped 16.1%.

(2) In June 2007, the Chinese government formulated China's National Climate Change Program, outlining specific objectives, basic principles, key areas of actions, as well as policies and measures to address climate change for the period up to 2010. By 2010, the energy consumption per unit GDP is supposed to be reduced by about 20％, and the proportion of renewable energy (including large-scale hydropower) in primary energy supply will be increased by 10%. In order to accomplish this objective, the government has also worked out the plan of *China's Scientific and Technological Actions on Climate Change*.

(3) In recent years, guided by scientific outlook on development, China has implemented the basic national policies concerning the construction of harmonious society, resource conservation and environmental protection, striving to build recycling and sustainable national economic system with low input and emissions as well as a resource conservative and environment-friendly society. In consistent with future development objectives of China, national capacity to mitigate emissions of greenhouse gases will make substantive contribution to the protection of the global climate system.

(4) In terms of selecting global target for the control of greenhouse gases concentration and sharing obligations of emission reduction, it is important to balance the relationship among adaptation, mitigation and development, and pay more attention to the characteristics and change trends of energy consumption in countries at different stages of development. While dealing with negotiations and initiatives on addressing climate change, we should make endeavors to avoid the phenomenon of "stressing climate issue, but diluting development issue; stressing mitigation of climate change, but neglecting adaptation to climate change; stressing common responsibility, but ignoring separate responsibilities; stressing other multilateral consultation channels, but weakening the main channel under Convention and Protocol; stressing market mechanism of emission reduction, but paying less attention to financial support and technology transfer".

(5) Currently, we should first review the completion of emission reduction targets for Annex I country Parties for the period from 2008 to 2012 regulated in *Kyoto Protocol*, analyze national causes for unfulfilled commitment, sum up experience, and then discuss further measures.

2. Role of Universities toward Climate Change

With important functions in talent cultivation, scientific research, technical development and academic exchange, universities, especially the high-level research universities, have been playing a unique role in addressing climate change.

I Talent Cultivation

Cultivating related talents, especially senior and decision-making talents, to address climate change is the contribution that high-level research universities should make in priority. As in China, Zeng Peiyan, vice premier in charge of the issue of climate change, and Xie Zhenhua, deputy director of State Development and Reform Commission, were graduated from Tsinghua University; In addition, a lot of Tsinghua alumni are serving in key departments handling climate change issues such as National Climate Coordination Committee of State Development and Reform Commission, Ministry of Science and Technology, State Environmental Protection Administration and Development Research Center of State Council. Currently, in order to cultivate innovative talents with knowledge and concept of resources preservation, environmental protection and sustainable development, Tsinghua has carried out "green university plan", set up Demonstrational Ultra-Low Energy Consumption Building and Sino—Italy Ecological and Energy Efficient Building in campus successively, and opened the course of *Introduction to Sustainable Development and Environmental Protection* to all undergraduates and graduates of the university.

II Technology Development

Providing relevant scientific knowledge and conducting research for adaptation to and mitigation of global climate change are the core contribution that high-level research universities should make. Tsinghua University has been engaged in conducting a lot of innovative researches on such fields as clean coal technology for power generation, advanced nuclear energy technology, new and renewable energy, advanced transmission and power network security, and energy-saving construction technology, greatly promoting China's energy use in the way to high efficiency and low emission.

III Policy Studies

Carrying out studies on strategies and policies related to climate change is the significant contribution that high-level research universities should make. As the first institution in China to start energy system analysis and climate change issue studies, research team of Tsinghua provides key technical support for Chinese government's formulation of related policies to climate change, by means of successively establishing such organizations as "3E Institute" and "Research Center for Climate Change", conducting studies on such research topics as "technical support for mitigating climate change research", "evaluation on socio-economic impact of climate change" and "interaction between climate change and development of human society", as well as participating in studies and formulation of *Renewable Energy Law*, recycling economic development strategy, national energy development strategy, development strategy for China's West and national energy-saving and emission-reduction strategy.