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Executive Summary

Introduction to
Confronting Climate Change

Three years ago, Sigma Xi was invited by the United Nations Department of Economic and Social Affairs to convene an international panel of scientists to prepare a report outlining the best measures for mitigating and adapting to global climate change. Chaired by Sigma Xi Past-President Peter H. Raven, director of the Missouri Botanical Garden, the 18-member Scientific Expert Group on Climate Change and Sustainable Development held its first meeting at the Sigma Xi Center in Research Triangle Park, North Carolina, in December of 2004 and presented its final report in New York on February 27, 2007. The non-profit United Nations Foundation co-sponsored the study. "This report gives very clear recommendations," Raven said, "for what the international community and nations themselves must do to mitigate and adapt to climate change." The following is an executive summary, and the full report can be found at **www.sigmaxi.org.**

CONFRONTING CLIMATE CHANGE:
AVOIDING THE UNMANAGEABLE AND MANAGING THE UNAVOIDABLE

Executive Summary. Scientific Expert Group Report on Climate Change and Sustainable Development.
Prepared for the 15th Session of the Commission on Sustainable Development.

Global climate change, driven largely by the combustion of fossil fuels and by deforestation, is a growing threat to human well-being in developing and industrialized nations alike. Significant harm from climate change is already occurring, and further damages are a certainty. The challenge now is to keep climate change from becoming a catastrophe. There is still a good chance of succeeding in this, and of doing so by means that create economic opportunities that are greater than the costs and that advance rather than impede other societal goals. But seizing this chance requires an immediate and major acceleration of efforts on two fronts: mitigation measures (such as reductions in emissions of greenhouse gases and black soot) to prevent the degree of climate change from becoming unmanageable; and adaptation measures (such as building dikes and adjusting agricultural practices) to reduce the harm from climate change that proves unavoidable.

Avoiding the Unmanageable

Human activities have changed the climate of the Earth, with significant impacts on ecosystems and human society, and the pace of change is increasing. The global-average surface temperature is now about 0.8°C[1] above its level in 1750, with most of the increase having occurred in the 20th century and the most rapid rise occurring since 1970. Temperature changes over the continents have been greater than the global average and the changes over the continents at high latitudes have been greater still.

The pattern of the observed changes matches closely what climate science predicts from the buildup in the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and other greenhouse gases (GHGs), taking into account other known influences on the temperature. The largest of all of the human and natural influences on climate over the past 250 years has been the increase in the atmospheric CO_2 concentration resulting from deforestation and fossil-fuel burning. The CO_2 emissions in recent decades (Figure ES.1), which have been responsible for the largest part of this buildup, have come 75% to 85% from fossil fuels (largely in the industrialized countries) and 15% to 25% from deforestation and other land-cover change (largely from developing countries in the tropics).

The seemingly modest changes in average temperature experienced over the 20th century have been accompanied by significant increases in the incidence of floods, droughts, heat waves, and wildfires, particularly since 1970. It now appears that the intensity of tropical storms has been increasing as well. There have also been large reductions in the extent of summer sea ice in the Arctic, large increases in summer melting on the Greenland Ice Sheet, signs of instability in the West Antarctic Ice Sheet, and movement in the geographic and altitudinal ranges of large numbers of plant and animal species.

Even if human emissions could be instantaneously stopped, the world would not escape further climatic change. The slow equilibration of the oceans with changes in atmospheric composition means that a further 0.4°C to 0.5°C rise in global-average surface temperature will take place as a result of the current atmospheric concentrations of greenhouse gases and particles.

If CO_2 emissions and concentrations grow according to mid-range projections, moreover, the global average surface temperature is expected to rise by 0.2°C to 0.4°C per decade throughout

1 A given temperature change in degrees Celsius (°C) can be converted into a change in degrees Fahrenheit (°F) by multiplying by 1.8. Thus, a change of 0.8°C corresponds to a change of 0.8 x 1.8 = 1.44°F.

the 21st century and would continue to rise thereafter. The cumulative warming by 2100 would be approximately 3°C to 5°C over preindustrial conditions. Accumulating scientific evidence suggests that changes in the average temperature of this magnitude are likely to be associated with large and perhaps abrupt changes in climatic patterns that, far more than average temperature alone, will adversely impact agriculture, forestry, fisheries, the availability of fresh water, the geography of disease, the livability of human settlements, and more (see Figure ES.2). Even over the next decade, the growing impacts of climate change will make it difficult to meet the UN's Millennium Development Goals (MDGs).

No one can yet say for certain what increase in global-average surface temperature above the 1750 value is "too much," in the sense that the consequences become truly unmanageable. In our judgment and that of a growing number of other analysts and groups, however, increases beyond 2°C to 2.5°C above the 1750 level will entail sharply rising risks of crossing a climate "tipping point" that could lead to intolerable impacts on human well-being, in spite of all feasible attempts at adaptation.

Ramping up mitigation efforts quickly enough to avoid an increase of 2°C to 2.5°C would not be easy. Doing so would require very rapid success in reducing emissions of CH_4 and black soot worldwide, and it would require that global CO_2 emissions level off by 2015 or 2020 at not much above their current amount, before beginning a decline to no more than a third of that level by 2100. (The stringency of this trajectory and the difficulty of getting onto it are consequences, above all, of the emission levels already attained, the long time scale for removal of CO_2 from the atmosphere by natural processes, and the long operating lifetimes of CO_2-emitting energy technologies that today are being deployed around the world at an increasing pace.)

But the challenge of halting climate change is one to which civilization must rise. Given what is currently known and suspected about how the impacts of climate change are likely to grow as the global-average surface temperature increases, we conclude that the goal of society's mitigation efforts should be to hold the increase to 2°C if possible and in no event more than 2.5°C.

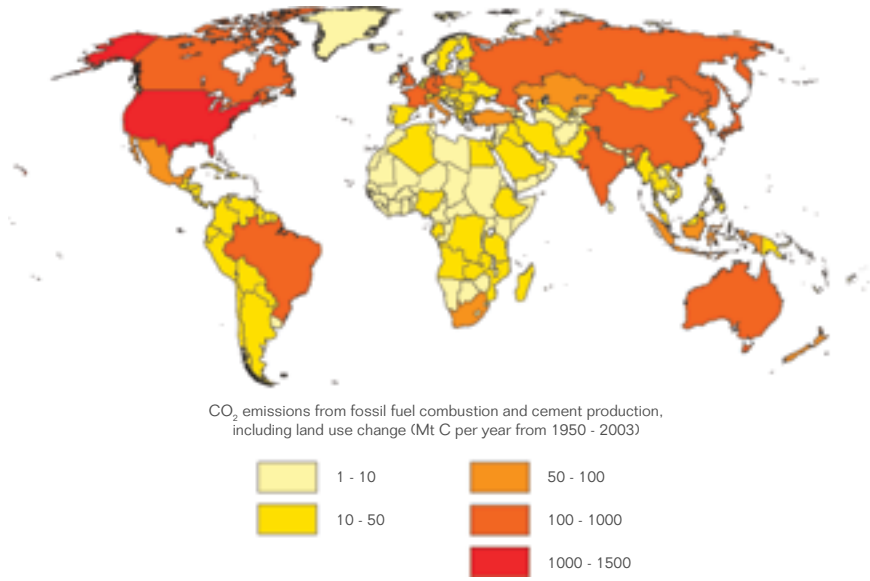

Figure ES.1. The annual emissions of CO_2 by country, averaged over the period 1950 to 2003, in millions of tonnes of carbon per year (MtC/year).

Managing the Unavoidable

Even with greatly increased efforts to mitigate future changes in climate, the magnitude of local, regional, and global changes in climatic patterns experienced in the 21st century will be substantial.

- A 2°C increase in the global-average surface temperature above its 1750 value is likely, for example, to result in up to a 4°C warming in the middle of large continents and even larger increases in the polar regions. Regional changes will be even more extreme if global average temperatures rise by 3°C or higher.

- Climate change during the 21st century is likely to entail increased frequency and intensity of extreme weather, increases in sea level and the acidity of the oceans that will not be reversible for centuries to millennia, large-scale shifts in vegetation that cause major losses of sensitive plant and animal species, and significant shifts in the geographic ranges of disease vectors and pathogens.

- These changes have the potential to lead to large local-to-regional disruptions in ecosystems and to adverse impacts on food security, fresh water resources, human health, and settlements, resulting in increased loss of life and property.

- Some sectors in some locations may benefit from the initial changes in climate. Most impacts are expected to be negative, however, with the social and economic consequences disproportionately affecting the poorest nations, those in water-scarce regions, and vulnerable coastal communities in affluent countries.

Managing the unavoidable changes in climate, both by promoting adaptation and by building capacity for recovery from extreme events, will be a challenge. International, national, and regional institutions are, in many senses, ill prepared to cope with current weather-related disasters, let alone potential problems such as an increasing number of refugees fleeing environmental damages spawned by climate change. Society will need to improve management of natural resources and preparedness/response strategies to cope with future climatic conditions that will be fundamentally different from those experienced for the last 100 years.

Integrating Adaptation and Mitigation to Achieve Multiple Benefits

The simultaneous tasks of starting to drastically reduce GHG emissions, continuing to adapt to intensifying climate change, and

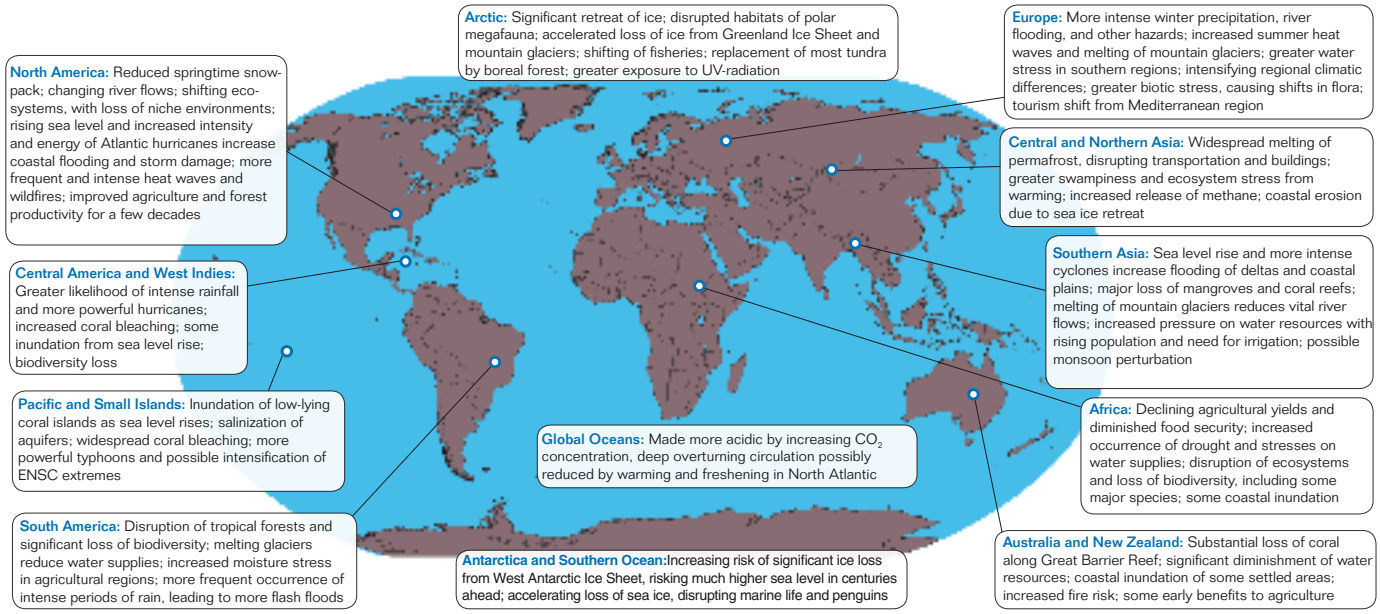

Figure ES.2. Significant impacts of climate change that will likely occur across the globe in the 21st century.

achieving the MDGs will require skillful planning and implementation, all the more so because of the interaction of these aims.

For example, clean and affordable energy supplies are essential for achieving the MDGs in the developing countries and for expanding and sustaining well-being in the developed ones. Energy's multiple roles in these issues provide "win-win" opportunities as well as challenges, including:

- Utilizing the most advanced building designs, which can provide emissions-free space conditioning (cooling and heating) in ways that greatly reduce energy and water demands and that promote improved health and worker performance.

- Implementing carbon capture and storage from fossil-fueled power plants, which reduce impacts on climate while making available concentrated CO_2 that can be used in enhanced natural gas and oil recovery and in agricultural applications.

- Replacing traditional uses of biomass fuels for cooking and heating (including agricultural residues and animal dung burned in inefficient cookstoves) with modern energy supplies that can reduce production of black soot and other aerosols, improve the health of women and children otherwise exposed to high indoor air pollution from traditional uses of biomass, and reduce deforestation and land degradation.

- Combining the sustainable use of biomass for energy (renewable sources of biomass to produce electricity, liquid fuels, and gaseous fuels) with carbon capture and sequestration, which can power development and remove CO_2 already emitted to the atmosphere.

In addition, reversing the unsustainable land-use practices that lead to deforestation and degradation of soil fertility will help limit the release of CO_2 and CH_4 into the atmosphere from the soil. Improving sanitation in rural areas can reduce emissions of CH_4 and provide a renewable fuel to help reduce dependence on coal, petroleum, and natural gas.

Projects and programs from around the world have demonstrated that much progress can be made on climate-change mitigation and adaptation in ways that save money rather than add to costs. Some of the measures that will ultimately be required are likely to have significant net costs—albeit much less, in all likelihood, than the climate-change damages averted—but a clear way forward for immediate application is to promote much wider adoption of "win-win" approaches, such as those described above, that reduce climate-change risks while saving money, or that produce immediate co-benefits outweighing the costs of the measures.

To move further, government leadership is required to establish policy frameworks that create incentives for energy-system change and establish public-private partnerships for energy-technology development, deployment, and diffusion. Leaders in the private sector also need to seize opportunities to develop, commercialize, and deploy low-emitting energy technologies that will also create jobs and enable economic development. Individuals, especially in affluent societies, must also show leadership by consuming responsibly.

The Elements of a Roadmap

Avoiding the unmanageable and managing the unavoidable will require an immediate and major acceleration of efforts to both mitigate and adapt to climate change. The following are our recommendations for immediate attention by the United Nations (UN) system and governments worldwide.

1. Accelerate implementation of win-win solutions that can moderate climate change while also moving the world toward a more sustainable future energy path and making progress on attaining the MDGs. Key steps must include measures to:

- Improve efficiency in the transportation sector through measures such as

vehicle efficiency standards, fuel taxes, and registration fees/rebates that favor purchase of efficient and alternative fuel vehicles, government procurement standards, and expansion and strengthening of public transportation and regional planning.

- Improve the design and efficiency of commercial and residential buildings through building codes, standards for equipment and appliances, incentives for property developers and landlords to build and manage properties efficiently, and financing for energy-efficiency investments.

- Expand the use of biofuels, especially in the transportation sector, through energy portfolio standards and incentives to growers and consumers, with careful attention to environmental impacts, biodiversity concerns, and energy and water inputs.

- Promote reforestation, afforestation, and improved land-use practices in ways that enhance overall productivity and delivery of ecological services while simultaneously storing more carbon and reducing emissions of smoke and soot.

- Beginning immediately, design and deploy only coal-fired power plants that will be capable of cost-effective and environmentally sound retrofits for capture and sequestration of their carbon emissions.

2. Implement a new global policy framework for mitigation that results in significant emissions reductions, spurs development and deployment of clean energy technologies, and allocates burdens and benefits fairly. Such a framework needs to be in place before the end of the Kyoto Protocol's first commitment period in 2012. Elements of the framework should include:

- An agreed goal of preventing a global-average temperature increase of more than 2°C to 2.5°C above the 1750 value—accompanied by multi-decade emission-reduction targets compatible with this aim.

- Metrics of performance that enable monitoring of progress towards reductions in energy and emissions intensity at a national level.

- Flexibility in the types of policies, measures, and approaches adopted that reflect different national levels of development, needs, and capabilities.

- Mechanisms that establish a price for carbon, such as taxes or "cap and trade" systems. A carbon price will help provide incentives to increase energy efficiency, encourage use of low-carbon energy-supply options, and stimulate research into alternative technologies. Markets for trading emission allocations will increase economic efficiency.

- A mechanism to finance incremental costs of more efficient and lower-emitting energy technologies in low-income countries.

3. Develop strategies to adapt to ongoing and future changes in climate by integrating the implications of climate change into resource management and infrastructure development, and by committing to help the poorest nations and most vulnerable communities cope with increasing climate-change damages. Taking serious action to protect people, communities, and essential natural systems will involve commitments to:

- Undertake detailed regional assessments to identify important vulnerabilities and establish priorities for increasing the adaptive capacity of communities, infrastructure, and economic activities. For example, governments should commit to incorporate adaptation into local Agenda 21 action plans and national sustainable-development strategies.

- Develop technologies and adaptive-management and disaster-mitigation strategies for water resources, coastal infrastructure, human health, agriculture, and ecosystems/biodiversity, which are expected to be challenged in virtually every region of the globe, and define a new category of "environmental refugee" to better anticipate support requirements for those fleeing environmental disasters.

- Avoid new development on coastal land that is less than one meter above present high tide, as well as within high-risk areas such as floodplains.

- Ensure that the effects of climate change are considered in the design of protected areas and efforts to maintain biodiversity.

- Enhance early-warning systems to provide improved prediction of weather extremes, especially to the most vulnerable countries and regions.

- Bolster existing financial mechanisms (such as the Global Environment Facility)— and create additional ones—for helping the most vulnerable countries cope with unavoidable impacts, possibly using revenues generated from carbon pricing, as planned in the Adaptation Fund of the Clean Development Mechanism.

- Strengthen adaptation-relevant institutions and build capacity to respond to climate change at both national and international levels. The UN Commission on Sustainable Development (CSD) should request that the UN system evaluate the adequacy of, and improve coordination among, existing organizations such as the CSD, the Framework Convention on Climate Change, the World Health Organization, the Food and Agriculture Organization, the UN Refugee Agency, the World Bank, and others to more effectively support achievement of the MDGs and adaptation to climate change.

4. Create and rebuild cities to be climate resilient and GHG-friendly, taking advantage of the most advanced technologies and approaches for using land, fresh water, and marine, terrestrial, and energy resources. Crucial action items include the following elements:

- Modernize cities and plan land-use and transportation systems, including

greater use of public transit, to reduce energy use and GHG intensity and increase the quality of life and economic success of a region's inhabitants.

- Construct all new buildings using designs appropriate to local climate.
- Upgrade existing buildings to reduce energy demand and slow the need for additional power generation.
- Promote lifestyles, adaptations, and choices that require less energy and demand for non-renewable resources.

5. Increase investments and cooperation in energy-technology innovation to develop the new systems and practices that are needed to avoid the most damaging consequences of climate change. Current levels of public and private investment in energy-technology research, development, demonstration, and pre-commercial deployment are not even close to commensurate with the size of the challenge and the extent of the opportunities. We recommend that national governments and the UN system:

- Advocate and achieve a tripling to quadrupling of global public and private investments in energy-technology research, emphasizing energy efficiency in transportation, buildings, and the industrial sector; biofuels, solar, wind, and other renewable technologies; and advanced technologies for carbon capture and sequestration.
- Promote a comparable increase in public and private investments—with particular emphasis on public-private partnerships—focused on demonstration and accelerated commercial deployment of energy technologies with large mitigation benefits.
- Use UN institutions and other specialized organizations to promote public-private partnerships that increase private-sector financing for energy-efficiency and renewable-energy investments, drawing upon limited public resources to provide loan guarantees and interest rate buy-downs.
- Increase energy-technology research, development, and demonstration across the developing regions of the world. Potential options for achieving this goal include twinning arrangements between developed and developing countries and strengthening the network of regional centers for energy-technology research.
- Over the next two years, complete a study on how to better plan, finance, and deploy climate-friendly energy technologies using the resources of UN and other international agencies such as the UN Development Programme, the World Bank, and the Global Environment Facility.

6. Improve communication to accelerate adaptation and mitigation by increasing education efforts and creating forums for dialogue, technology assessment, and planning. The full range of public- and private-sector participants should be engaged to encourage partnerships across industrial and academic experts, the financial community, and public and private organizations. National governments and the UN system should take the following steps:

- Develop an international process to assess technologies and refine sectoral targets for mitigation that brings together experts from industry, nongovernmental organizations, the financial community, and government. The Technology and Economic Assessment Panel of the Montreal Protocol provides an effective model for assessing technological potential and effective, realistic sectoral mitigation targets.
- Enhance national programs for public and corporate education on the needs, paths, opportunities, and benefits of a transition to a low-emission energy future.
- Enlist the educational and capacity-building capabilities of UN institutions to provide information about climate change and the opportunities for adaptation and mitigation. Under the leadership of the Department of Economic and Social Affairs, the UN should complete an internal study to more effectively engage relevant UN agencies.

The Time for Collective Action is Now

Governments, corporations, and individuals must act now to forge a new path to a sustainable future with a stable climate and a robust environment. There are many opportunities for taking effective early action at little or no cost. Many of these opportunities also have other environmental or societal benefits. Even if some of the subsequent steps required are more difficult and expensive, their costs are virtually certain to be smaller than the costs of the climate-change damages these measures would avert.

Two starkly different futures diverge from this time forward. Society's current path leads to increasingly serious climate-change impacts, including potentially catastrophic changes in climate that will compromise efforts to achieve development objectives where there is poverty and will threaten standards of living where there is affluence. The other path leads to a transformation in the way society generates and uses energy as well as to improvements in management of the world's soils and forests. This path will reduce dangerous emissions, create economic opportunity, help to reduce global poverty, reduce degradation of and carbon emissions from ecosystems, and contribute to the sustainability of productive economies capable of meeting the needs of the world's growing population.

Humanity must act collectively and urgently to change course through leadership at all levels of society. There is no more time for delay.

UNITED NATIONS–SIGMA XI SCIENTIFIC EXPERT GROUP ON CLIMATE CHANGE

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