

**The Role of Adaptation  
in Dealing With  
Climate Change<sup>1</sup>**

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## Why is Climate Change Important?

Because climate determines the biological productivity of our food systems, health, and the abundance and distribution of natural resources such as water, forests, fish, wildlife and other biological resources, it affects the well-being of all living things. If climate were to change but not have any significant physical, biological or socio-economic impacts, climate change would be nothing more than a scientific curiosity not worthy of being elevated to a public policy issue. Thus, whether or not climate changes is not as important as what its' effects are. Therefore, establishing that climate will change is a necessary, but not a sufficient, condition for policy changes which could have significant socio-economic impacts. A sufficient condition would be that the socio-economic (including environmental) consequences of action would be, on the net, more beneficial than inaction, and that the costs of action would be the best and highest use of society's resources.

## Factors Influencing Natural Resources in the Future.

Climate change, whether human-induced or because of natural variability, is only one of several factors determining future natural resource use and management. Other factors which may play an even more significant role include:

- o **Population growth** which will inevitably increase the pressures and demands on resources of all kinds. Over the next century, the world's population is expected to increase from the current 5 billion to between 11 and 14 billion.
- o **Economic growth.** This can stimulate demand even as it makes resource and environmental protection more affordable. Poverty, it should be noted, has been identified as one of the major causes of environmental degradation.
- o **Technological progress** which could increase demand for some resources while reducing it for others. For example, introduction of synthetic fibers have reduced the demand for fiber crops and livestock. This may have increased pressures on landfills, while reducing the amount of land devoted to agriculture and grazing. Similarly, the widespread use of plastics has been to a large extent at the expense of timber and metals such as iron and steel. This too has resulted in trading-off one set of risks to the environment and to natural resources for another. The increases in life spans and living standards, particularly in the developed world, attest to the fact that these trade-offs have on the net benefitted society.

It is quite conceivable that the impacts of human-induced climate changes could be a "relatively small perturbation" compared to these other factors.

## **Effects of Climate Change on Natural Resources.**

### Critical Climatic Factors

While much of the public policy debate on climate change has focussed on one or, at most, two parameters (temperature and global mean sea level rise) other climatic parameters are just as, if not more, critical to the health, abundance, distribution and well-being of human beings and other species. Water and its availability (measured in terms of both soil moisture and water available for irrigation) is probably more important for determining crop productivity and food security. Water is also critical for all other vegetation, habitats and life-forms that depend directly or indirectly upon vegetation for sustenance. Equally important are the climatic variability (on annual, seasonal and diurnal scales) and how that may change in the future, the predictability of climate, and changes in the frequency and magnitude of extreme events (droughts and floods).

### Projection of Changes in Critical Climatic Factors.

There is indeed a greenhouse effect. Naturally-occurring greenhouse gases warm the earth by about 33° C. Without such warming, the earth would be much less hospitable to human beings and many other species.

Greenhouse gas concentrations have increased measurably since pre-industrial times. Continued increases will change the climate but, except for a few aspects, in ways that can not, by and large, be currently estimated.

One aspect of which we are relatively certain is that globally-averaged mean temperature would, if anything, increase. Temperatures would increase more toward the poles than toward equator, more in winter than in summer and more at night than in the day. However, the rates and magnitude of surface temperature increase are uncertain. Nevertheless, using the best available general circulation models (GCMs), which because of several shortcomings have significant uncertainties associated with them, the Intergovernmental Panel on Climate Change's Science Work Group estimates that the global mean surface temperature would increase about 1° C by 2025 and 3° C by 2100 (relative to today's "means"). Corresponding sea level increases are about 18 cm. ( $\pm$  9cm.) and 65 cm. ( $\pm$  35 cm.).

The uncertainties regarding the rate and magnitude of surface temperature increases are magnified as the geographical area of interest is reduced in scale to continents, regions, watersheds and river-basins. However, impact analysis must necessarily first be done at these smaller watershed and river-basin scales; then they may be aggregated to higher levels.

Moreover with respect to the other climatic factors: the seasonal and diurnal variability of temperature is expected to decline and the IPCC's Science Work Group notes

that there is no reason to believe that the magnitude and frequencies of storms will vary. Notably, we cannot be confident of even the **direction** of change of many of these critical climatic factors at the regional level. Will they be positive or negative?

### **Direct Effects of Changes in Atmospheric Concentrations of Greenhouse Gases**

Because any human-induced climate change will be a consequence of changes in the atmospheric concentrations of carbon dioxide (CO<sub>2</sub>), chlorofluorocarbons (CFCs), halons, methane (CH<sub>4</sub>) and other radiatively-active gases, the non-climate impacts of these gases must necessarily also be considered in estimating impacts of such climate change and in developing and analyzing policies. In particular, the direct effects of CO<sub>2</sub> and CFCs must be considered. CO<sub>2</sub> can stimulate photosynthesis in vegetation (including crops), increase its water use efficiency and its tolerance to drought, salinity and air pollution. On the other hand, CFCs by depleting the ozone layer and allowing more ultraviolet-b to reach the earth's surface, can only have negative impacts. However, assessments of the impacts of increasing greenhouse gases rarely, if ever, account for these direct effects.

### **Estimates of the Impacts of Climate Change**

Our understanding of impacts of changes in atmospheric centralization of greenhouse gases is, at best, poor because:

- We lack credible projections of the type and level of economic activities in the energy, agriculture, forestry and other sectors which would determine future emissions of greenhouse gases. Projections beyond 20-30 years are, at best, conjecture. Just as no one could have forecasted today's world a 100 (or even 50) years ago, it is equally unlikely that anyone will be able to forecast the world 50 to 100 years from now.
- We lack credible regional estimates of changes in critical climatic factors. This would be true even if we knew future emissions rates precisely.
- Of uncertainties regarding how to translate changes in concentrations of greenhouse gases and associated changes in critical climatic factors into biological and/or physical effects on natural resources.
- Of uncertainties in translating biological/physical effects into socioeconomic impacts.
- Of the usual, but invalid, assumption of a static world, i.e., the assumption that there is no technological innovation or adaptation that will take place over the 50-100 year (+) time frames that are selected for analysis to illustrate "impacts". This is particularly important for highly managed sectors and activities such as agriculture, forestry, public health and water resources where there is a long and successful history of technical and management innovation. Moreover, farmers and water resource

managers are constantly upgrading their expectations of the weather, climate and frequency and magnitude of extreme events based upon prior experience i.e., upon recent climate change. Thus, it should be expected that they would automatically adapt their management to steady changes in the climate.

Many impacts will be positive, while others will be negative. However, it is not yet possible to know whether the net impact will be in one direction or another. Nevertheless, some general features emerge:

- It is unlikely that **global food security** will be harder to attain were climate to change. Climate change per se will alter the productive potential of each area: however, whether production potential would be increased or decreased in particular areas can not now, in general, be foretold. Warmer temperatures would tend to increase productivity in currently cold areas. In the mid-latitude interiors of continents, lower soil moistures would tend to reduce productivity. The direct effects of CO<sub>2</sub> -- increased photosynthetic rates, higher water use efficiency and increased tolerance to drought, air pollution and salinity -- which benefit productivity would be in addition to the effects of climate change per se. Because of the decade(s)-long time-lag between the build-up of atmospheric concentrations and associated climate change, the benefits of the direct effects of CO<sub>2</sub> would be manifested that much in advance of any effects, positive or negative, of climate change alone.
- Sea level rise** will have a net negative impact. A Dutch study for the IPCC indicates that protecting the world's coastlines against a 1-meter sea level rise (the upper limit according to the IPCC's estimate for 2100) would cost \$500 billion. This is the cumulative, undiscounted cost over the 110-year period. It is estimated to be about 0.04% of cumulative world GDP. Such an expenditure would help protect human settlements and associated infrastructure, but not necessarily environmental values associated with the coasts.
- Natural ecosystems** would be affected in ways we cannot now forecast. Increases in greenhouse gas concentrations and associated climate change would cause such ecosystems, which are constantly evolving, to evolve along a different path. It is unlikely that whole ecosystems would be translocated. Instead, each species would react differently, forming new assemblies and relationships. Changes in gas concentrations and climate would affect each species directly, and indirectly by modifying its competitive advantage relative to other species. The magnitude of impact will depend upon the rate of change in greenhouse gas concentrations and in critical climatic factors. Some fear too rapid a change could cause species die-back and/or species extinctions. On the other hand, other species may thrive. The net effect on primary productivity is unknown.

--Both **water supply and demand** will be affected by climate change. However, it is not possible to predict with confidence whether a particular area will be better, or worse, off.

### **The Role of Adaptation**

The ultimate **goal of public policy** is to deal with problems so that the net social and economic (including environmental) consequences are minimized. Thus, prior to any actions that go beyond the "no-regrets" stage we must be able to show that they will result in net social, economic and environmental benefits, even while taking into consideration the scientific, technical and economic uncertainties.

To assure that social, economic and environmental disruptions are minimized, as the IPCC WG3 report points out, both **adaptation** and **limitation** must be considered as an integrated package. The lower the costs of adaptation, the less the need for limitations. Conversely, the greater the costs of adaptation, the greater the need for limitations.

While the public policy debate has concentrated on limitations, it should be noted that adaptations are unavoidable because:

- oClimate will change due to natural variability, whether or not there is human-induced climate change.
- oIf there is any human-induced climate change, the inertia of the climate system dictates further climate change even if atmospheric greenhouse gas concentrations were to be stabilized immediately.
- oThe least-social-cost strategy must necessarily consider adaptation. First, no rational analysis of limitation options can proceed without estimating whether, and to what extent, the options reduce the net negative social, economic and environmental consequences of climate change. However, as noted above, estimates of the impacts of climate change must necessarily factor in adaptation and technological change (which is inherent to adaptation) that will occur automatically -- whether or not there are new government programs that would further aid adaptation. Second, limitations and adaptations should be compatible (see below). It is also essential to assure that the marginal costs of one do not exceed that of the other or the marginal benefits.

### **The Ability to Adapt**

The IPCC's Resource Use and Management Subgroup notes that there is considerable ability to adapt to climate change because:

- o Human beings and other species have an intrinsic ability to adapt to some degree of climate change because climate is inherently variable at all time scales. Through the ages they have developed the capability, and a suite of responses, to adapt -- in many instances, successfully -- to extreme events (e.g., floods, droughts). Human beings should be significantly more adaptable than other species. The greater the rate of climate change, the greater their vulnerability.
- o Economic and technological progress has made it easier to cope with climatic variability and extreme events through earlier warning systems, better infrastructure and greater financial resources. Continued economic and technological progress will further reduce society's vulnerability to climate change. Because the ability to adapt varies with the amount of economic resources societies can muster and their degree of technical sophistication, one would expect developing countries to be less able to adapt (assuming the degree of impacts are the same). Nevertheless, as the RUMS report indicates, the efficiency with which many countries have adopted new technology in these sectors, albeit often without adequate environmental assessment, suggests a considerable ability to adapt to new circumstances whatever their cause; however, the closer farming is to subsistence farming the less the likelihood that it would adapt without assistance and "appropriate design".
- o Climate varies tremendously around the world from place to place. Yet human beings have cultivated crops, and managed livestock, forests, water and other natural resources under all these myriad conditions. This wide variation in current climate means that there already exists a fund of knowledge that will help us adapt to future climate change. Thus, one should expect that an area would attempt to draw upon experiences and practices from area(s) whose present climatic conditions most closely approximate its future expected conditions. The degree of success in using analogues would depend not only upon the correspondence of the climatic and physical conditions, but also on legal, economic, cultural and other institutional factors which may reduce (or aggravate) barriers to translocating practices from one locale to another.

Finally, some sectors have a greater ability to adapt; history bears this out. This is particularly true for the heavily-managed sectors: agriculture, forestry, public health and water resources. In fact, for agriculture, forestry and public health, this ability to adapt is likely to accelerate with the introduction of biotechnology, genetic engineering and the information revolution which speeds up the dissemination of knowledge. Because agriculture is in most nations, the major user of water, introduction of more drought tolerant species via these techniques will also help society cope with future water resource problems.

### **Compatibility of Limitation and Adaptation Responses**

Limitation and adaptation strategies may or may not be compatible with each other.

Examples of potential non-compatibility between adaptation and limitations (and their respective goals) include:

- Monoculture plantation forests. Such forests may be the most efficient sinks for CO<sub>2</sub>, yet widespread reliance on them could have potential negative impacts on biodiversity.
- CO<sub>2</sub> controls may not only reduce any potential climate change but may also reduce many of the positive impacts on water supply and availability, agriculture and forests due to direct effects of CO<sub>2</sub>; thus, CO<sub>2</sub> limitations would reduce the adaptability of human and natural systems.

The trade-offs between the opposing outcomes must be based upon more complete analysis of the social, environmental and economic analysis of limitation options prior to any decisions.

Adaptation and limitation options that would reinforce each other include increasing the productivity (or efficiency) per unit of land used for agriculture, timber and forest products and human settlements, consistent with environmental safeguards; elimination of agricultural subsidies (see below); afforestation, reforestation and reductions in deforestation; and reductions in tropospheric ozone concentrations.

### **Criteria for Selection of Options**

Each nation should decide the precise mix of response options that would maximize its net socio-economic (including environmental) well-being based upon its specific social, environmental and economic situation. This will inevitably involve determining the necessary balance between various competing societal objectives (of which dealing with climate change is but one) and allocating limited financial, technical and human resources between them. Given the uncertainties regarding the socio-economic impacts of climate change, and the several competing demands on society's resources including the vast backlog of society's unmet needs for, e.g., better public health and safety, it would be irrational to select policies solely because of climate change. Nevertheless, it would be prudent to take those actions now which are economically justifiable in their own right and which would, incidentally, help society adapt to future climate change. To ensure this, each option should be evaluated based on the following criteria:

- o Flexibility, i.e., it should be adjustable at relatively low cost in light of new knowledge as science improves and uncertainties are reduced. The option should be successful whether or not climate changes.
- o Timeliness, considering how long it takes to formulate and effectively implement the options, as well as how long before effects on natural resources become evident.

o Feasibility, considering the various institutional, economic, legal and cultural barriers to successful implementation and the degree of difficulty in overcoming them.

o Compatibility with other climate-related responses and socio-economic objectives.

o Economic justifiability, on grounds other than climate change. This includes ensuring cost-effectiveness and economic efficiency, and consideration of opportunity costs - aspects that are likely to be met if it provides other non-climate-related benefits.

In most instances, adaptation options would have to be analyzed and implemented at the subnational levels since what may be sauce for the goose may not be sauce for the gander because impacts of climate change, the ability to adapt and the consequences of adaptation will all vary considerably from place to place. In other instances, such options analysis would need to be done on a national or even on a bi- or multi-national basis (e.g., for rivers crossing international boundaries).

### **Options for Adaptation**

Options that could be implemented in the short-term include:

o Improving the knowledge base to allow reasoned judgments to be made on natural resource use and management. This includes:

--developing inventories, data bases, and monitoring systems of the current state of resources;

--cataloguing current management and use practices across the wide range of climates existing on the globe;

--improving methodological tools for assessing the impacts of increasing greenhouse gas concentrations and associated climate change;

--estimating the sensitivity and adaptability of natural resources to different scenarios of climate change;

--estimating the sensitivity and adaptability of natural resources to different scenarios of greenhouse gas controls.

o Increasing the efficiency of the use of all natural resources by increased productivity and fuller utilization of the "harvested" component of resources and by waste reduction. Such measures include the development and adoption of technologies which would increase the productivity or efficiency (per unit of land and water) of crops, forests, livestock, fisheries and human settlements consistent with the principles of sustainable developments. It would alleviate the major causes of conversion of

natural ecosystems and loss of biological diversity. In addition to alleviating pressures on land, such measures would also help reduce emissions of greenhouse gases. On the other hand, in areas where carrying capacities are strained or extended, appropriate measures to expand carrying capacities should be considered, e.g., by implementing pollution control measures, improving access to potable water or transportation infrastructure. Examples of options to increase efficiency include more efficient milk and meat production per unit product; development of drought resistant crop varieties; improved food storage and distribution; and better irrigation water management practices and drainage which would allow water supplies to serve greater areas.

- oAcceleration of economic development efforts in developing countries. Because these countries have largely resource-based economies, efforts improving agriculture and natural resource use would be beneficial. Such efforts, would help formation of such capital as may be necessary to adapt to climate change, and generally make sustainable growth and development more feasible.
- oReviewing and, where appropriate, removing subsidies for inefficient use of land, agriculture, forests, water and other natural resources. This would reduce inappropriate exploitation of marginal lands and other resources, as well as their over-exploitation in other (non-marginal) areas. World-wide reduction in such subsidies would particularly benefit developing countries. The direct environmental benefits would be accompanied by a strengthening of their economies which are heavily dependent upon natural resources. In turn, stronger economies would make both adaptation and sustainable development more affordable and further reduce environmental degradation. Finally, this would also decrease greenhouse gas emissions by limiting land conversion that would otherwise result from excessive land clearing, livestock and agriculture.
- oPromoting and strengthening of resource conservation and sustainable resource use in those highly vulnerable areas where climate change may further exacerbate conditions. Assessments of the potential impacts of climate change might help identify which are likely to be further stressed. Various initiatives could be explored for conserving the most sensitive and valuable resources including strengthening conservation measures, managing development of highly vulnerable resources, and promoting reforestation and afforestation.
- oDeveloping methods whereby local populations and resource users gain a stake in conservation and sustainable resource use, e.g., by investing resource users with clear property rights and long-term tenure, and allowing voluntary water transfer or other market mechanisms.

- oDecentralizing, as practicable, decision-making on resource use and management, while assuring coordination with adjacent jurisdictions and incorporating mechanisms whereby interests of the broader society are also considered;
- oContinuing and improving national and international agricultural and natural resource research/extension institutions;
- oStrengthening mechanisms for technology transfer and development.

## Conclusion

More attention needs to be paid to adaptation than has heretofore been given it in the public policy debate on climate change. First, because there can be no credible estimates of the impacts of climate change that do not incorporate the ability of human beings (and other species) to adapt. This ability to adapt is particularly high for the heavily-managed sectors such as agriculture, forestry, public health and water resources. These sectors are also the most sensitive to climate. They have a long history of successful and rapid adoption of technological and management innovation. In fact, the pace of such innovations is expected to accelerate over the next several years due to breakthroughs in biotechnology, genetic engineering and in information dissemination.

Second, the least-social-cost strategies of dealing with climate change must necessarily consider limitations and adaptations as an integrated package.

Development and analysis of limitation and adaptation strategies must be harmonized. There is a relationship between the timing and costs of limitation and adaptation: the slower the rate of climate change, the easier it would be to adapt, and vice versa. Limitation measures should be compatible with adaptation goals, where possible. Thus, analysis of monoculture plantations to absorb CO<sub>2</sub> should consider their potential negative impact on biological diversity. Moreover, analysis of the relative merits of various limitations strategies should consider other non-warming consequences of controlling the various gases (either individually or together) including, e.g., direct effects of CO<sub>2</sub> and CFC on the biosphere. Thus a truly comprehensive approach towards human-induced climate change should recognize that controlling the different gases will have different effects on the adaptive capacity of natural resources.

By contrast, some adaptive and limitation strategies are compatible with each others goals. In particular, these include increasing the productivity or efficiency (per unit of land or water) of crops, livestock, forests, fisheries and human settlements consistent with the principles of sustainable development; elimination of subsidies for agriculture and, where appropriate, other natural resources; and reforestation, afforestation and reduced deforestation. Clearly, such strategies, which do double-duty, should be emphasized.

Adaptive strategies must, in general, be tailored to national or sub-national situations. These strategies should focus primarily on addressing current problems that seem likely to be intensified by climate change. In considering the options listed previously, particular attention and support should be given to those developing nations which appear to be most vulnerable to the impact of climate change but the least able -- in financial and human capital terms -- of responding to them.

In this context, world-wide elimination of subsidies on agriculture and, where appropriate, other natural resources, in addition to having direct environmental benefits, would also foster economic growth in developing nations (because these sectors contribute

heavily to their economies). Such economic growth will reduce poverty, one of the main causes of environmental degradation, and improve their future ability to adopt. This further strengthens the case for elimination of agricultural subsidies.