Climate Change -
Inputs-Outputs Needed from Economists

Presentation to 14th International Input-Output Techniques Conference,
Montreal, 11 October 2002

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Climate change has focused the concerns of many about prospects for long-term environmental sustainability, and the evidence that humans and their activities are changing the face of the planet continues to increase. The purpose of this paper is to offer some indication as to what areas of socio-economic study would provide policy makers with relevant data to improve the quality of their information. Similarly, climate scientists' understanding of the atmosphere continues to improve, and this examination will begin by briefly reviewing relevant atmospheric data and trends, as well as related political developments. Governments' roles and policy options are examined next, with market-oriented, sector specific regulation recommended for further study. Finally, questions and issues for economic experts will be identified as potential areas for future study.

The global human population, after slowly increasing for thousands of years, has increased exponentially over the past century and now exceeds six billion people. At what level will it stabilize is an important question. The number of plant and animal species that have become extinct per decade has about doubled from the 1700s to the present. At the same time, the percentage of pasture land has also doubled, and the global forest coverage, which was approximately 50 per cent of the global land mass before 1700, has decreased to about one-half that amount. Nitrogen fixation is a fundamental process of plant growth, and has experienced an important milestone: approximately 25 years ago, the amount of nitrogen that has been "fixed" due to human use of fertilizers exceeded, for the first time, that which was "fixed" by natural processes. And, as human activities caused emissions of carbon dioxide into the atmosphere due to land clearing (deforestation) and consumption of fossil fuels, the atmospheric concentration of carbon dioxide has increased from about 280 ppm (parts per million), where it had been for several thousand years, to the present value of about 370 ppm. Although direct measurements of atmospheric concentrations have only been taken for less than the past 50 years, data from ice core samples provide CO_2 concentrations for the last 400,000 years and show that atmospheric concentrations varied between about 180 ppm and 310 ppm, so present values far exceed any value in that period (and probably over 20 million years). Similar increases in greenhouse gases methane (CH_4) and nitrous oxide (N_2O) have also been identified. The human imprint on the planet is clearly evident.[i]

Throughout most of the twentieth century, the focus of people and their governments was on economic growth, and despite an environmental ethos which emerged during the 1970s, the environment and economy were largely disconnected issues. In the 1980s, however, a more balanced approach was sought by the World Commission on Environment and Development[ii], sometimes called the Bruntland Commission, which published its findings in 1987. The Commission coined and defined the term "sustainable development," and the most succinct definition is as follows:

"Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."

The report was optimistic, and served as a general guide to future development based on a balance between economic development and the protection of the planet's natural environment, with a long-term

vision of sustaining both systems. By identifying the importance of meeting future needs, it introduced a long-term perspective as a basis for analyzing strategies in the present. In 1992, approximately 180 nations gathered in Rio de Janeiro for the United Nations Conference on Environment and Development and agreed to Agenda 21[iii] which laid out a roadmap for achieving sustainable development. In late summer of 2002, most of the same countries gathered for the World Summit on Sustainable Development in Johannesburg and compared notes on how they had done. Many participants and observers were of the view that the report card should not be a good one.

Also in Rio, the same governments signed the United Nations Framework Convention on Climate Change (UNFCCC) which states in Article 2 its objective:

"... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure food production is not threatened and to enable economic development to proceed in a sustainable manner."

Note that the objective is "stabilization" to "prevent dangerous anthropogenic interference." "Dangerous" has not yet been defined but it is clear that what is dangerous to some societies or ecosystems is not dangerous to others. The concepts of "time-frame" for adaptation, "[ensuring] food production," and "sustainable economic development" are important, but ill-defined, phrases. This far-reaching objective is very ambitious, and it is certainly questionable whether or not it can be achieved.

The Convention was also considers principles which form the basis of the text (contained in Article 3), such as recognition that states have *"their common but differentiated responsibilities,"* and that precautionary measures are appropriate (*" ... lack of full scientific certainty should not used as a reason for postponing ..."*). The Convention was also to be implemented in a way that supports an open economic system and provides no restrictions on international trade.

Particularly important in the assessment of climate change has been the Intergovernmental Panel on Climate Change (IPCC)[iv], which was established in 1988 by two United Nations specialized agencies, the World Meteorological Organization and the United Nations Environment Programme, to undertake scientific assessments of what is known and not known and the relationships between future emissions, future climate change and potential impacts, as well as possible mitigation strategies. The first IPCC Assessment in 1990 could be described as hesitant in its conclusions, but it was important to governments in considering ratification of the UNFCCC. The IPCC Second Assessment Report (1995) was more specific and prudent and provided input to the debate at Kyoto in 1997.

The Kyoto Protocol of the UNFCCC, negotiated in 1997, calls upon developed countries to collectively reduce emissions of greenhouse gases by 5.2 per cent relative to 1990 levels by the period 2008-2012.[v] In this Protocol, assumed to the first of several, only developed countries have obligations recognizing the "common but differentiated responsibilities" and the reality that most of the present additional atmospheric is due to developed countries. The Kyoto Protocol addresses six GHGs, and among these, carbon dioxide (CO_2) is particularly important because it is the largest contributor to the additional (anthropogenic) greenhouse gas effect. The Protocol also sets out a series of policies and measures for Annex I Parties (developed countries), targets and timetables, and deals with specific methodologies. Given that atmospheric greenhouse gas concentrations are the net result of emissions (sources) and removals (sinks) of gases, credits for removing gases already in the atmosphere by enhancing sinks should be treated in a similar manner to credits for reducing emissions to the atmosphere. Further, since emissions anywhere in the world contribute essentially equally to the atmospheric concentration, the Protocol also recognizes that mechanisms or agreements between countries can be used to meet the 5.2 per cent target.

The Kyoto Protocol mechanisms can be grouped into three types:

- International Emissions Trading which is allowed among developed countries;

- Joint Implementation which gives credits for investing in developed countries; and
- The Clean Development Mechanism which gives credits to Annex I countries for investing in developing countries.

The Third Assessment Report of 2001 was affirmative in terms of the human influence on the climate system and concluded:

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

"Human influences will continue to change atmospheric composition throughout the 21st century. Global average temperature and sea level are projected to rise under all IPCC SRES scenarios."

"Anthropogenic climate change will persist for many centuries."

A key issue for the consideration in the dealing with the climate system and the implementation of a protocol is the relative times scales of response. Although carbon dioxide takes only 2-4 years to mix through the global atmosphere, the time for 50 per cent of a pulse change in CO_2 to disappear would be 50 to 200 years[vi]; the corresponding time period for methane is 8 to 12 years. The climate system will, in turn, respond more slowly still to changing CO_2 concentrations: the air temperature would respond in 120 to 150 years while the sea level would follow on a time scale of thousands of years. Therefore, in simple terms, we can think of the atmospheric concentration responding to a change in methane emissions in about a decade and a change in CO_2 emissions in about a century while the actual climate system is lagging further behind, particularly for the oceans and the ice sheets. The ecosystems will respond to this climatic change on time scales of less than a year to a century or more. By comparison, the characteristic time scales for the socio-economic system are estimated to be: change in energy end-use technologies, 1-10 years; energy-supply technologies, 10-50 years; infrastructure, 30-100 years; and social norms and governance, 30-100 years. These characteristic time scales need to be considered in our decision making process.

At times, the debate about climate change becomes plagued with considerations of uncertainty. In his address to the Sixth Conference of the Parties under the UN Framework Convention on Climate Change, the Chair of the IPCC, Dr. R. Watson made the following statement:

"The overwhelming majority of scientific experts, whilst recognizing that scientific uncertainties exist, nonetheless believe that human-induced climate change is inevitable. Indeed, during the last few years, many parts of the world have suffered major heat waves, floods, droughts, fires and extreme weather events leading to significant economic losses and loss of life. While individual events cannot be directly linked to human-induced climate change, the frequency and magnitude of these types of events are predicted to increase in warmer world. One of the major challenges facing humankind is to provide an equitable standard of living for this and future generations: adequate food, water and energy, safe shelter and a healthy environment (e.g., clean air and water). Unfortunately, human-induced climate change, as well as other global environmental issues such as land degradation, loss of biological diversity and stratospheric ozone depletion, threatens our ability to meet these basic human needs." [vii]

In December 2001, 110 Nobel Laureates signed a declaration which included the following excerpt:

"The most profound danger to world peace in the coming years will stem not from the irrational acts of states or individuals but from the legitimate demands of the world's dispossessed. Of these poor and disenfranchised the majority live a marginal existence in equatorial climates. Global warming, not of their making but originating with the wealthy few, will affect their fragile ecologies most…

We must persist in the quest for united action to counter both global warming and a weaponized world.. As never before, the future of each depends on the good of all." [viii]

As an increasing number of states ratify the Kyoto Protocol to the United Nations Framework Convention on Climate Change, social scientists, economists, natural scientists, politicians, and policy makers are confronted with a set of complex and dynamic issues. Since the Brundtland World Commission on Sustainable Development, there has been a great deal of discussion, largely theoretical, about how to mitigate or even reverse environmental degradation without arresting economic development. There have been many successful initiatives, but these have tended to be regional or have affected a sector of the economy. In contrast, the Kyoto Protocol, as the first real step in implementing the UNFCCC, represents a large-scale, comprehensive initiative which will impact most economic sectors, in addition to anticipated effects on states which are non-signatories as well as those which have signed and ratified their commitment. Such a far-reaching international agreement is required because of the nature of the problem:

"It will not help, the way it sometimes does, to break the problem into smaller, more manageable, pieces. Only a comprehensive global approach to managing environmental resources and coordinating sustainable development will work."[ix]

Analyses of anthropogenic climate change are improved by modelling which approximates as closely as possible actual scenarios, and a complex interplay of climatic and human factors requires detailed identification of inputs and outputs with appropriate feedback mechanisms. The IPCC[x] provides a simple but useful model which provides a framework for integrated assessment of causal relationships. The model is circular, with feedbacks, and is comprised of four quadrants. We can start with the paths for socio-economic development (1), which includes economic growth, technology, population, and governance issues. Our collective, global development path will determine future emissions and , hence, atmospheric concentrations (2). As discussed above, these concentrations, in turn, produce climatic changes (3), evidenced by both variances in temperature and sea level and by more extreme weather events. The result will be impacts on human and natural systems (4), including food and water resources, ecosystems, human settlements, and human health. These impacts will be moderated (or enhanced) by the natural and human-managed adaptations to the climate changes imposed on them. The cycle is completed by human and natural systems' dynamic effects on socio-economic paths, and feedback from the socio-economic realm to the human and natural systems. The model is limited in that it presents causes and effects on a macro scale and its description of relationships is qualitative, but it provides an important overview of a multi-disciplinary approach to climate change.

Humans can respond to this climate change issue in two ways: mitigation (emission reductions) to reduce the burden of human activities on the atmosphere and hence the climate system; and adaptation, to reduce the negative impacts and enhance the positive impacts, of climate change (and variability). These responses should be considered complementary. Mitigation is desirable to reduce the stressor as a fundamental action. Adaptation is appropriate where and when mitigation cannot reduce the stressor (and hence impacts) to acceptable levels. It is important to use a prediction and analysis system to validate the mitigation and adaptation strategies. What might seem to be the most obvious response may not be the best when feedbacks and other processes are included. This needs to be done in a systematic way. It is when we fail to respond that we have the worst disasters.

Although the Kyoto Protocol includes both mitigative and adaptive measures, the focus of the discussion and analysis has largely been on mitigation and only recently have some countries started to shift their attention to adaptation. Reduction targets for greenhouse gas (GHG) emissions have ensured that countries, in consideration of ratification, examine environmental and socio-economic developments. The challenge of reducing GHG emissions brings the environment and economy debate into sharp focus as researchers and policy makers struggle to find an appropriate balance between the sometimes conflicting priorities. A key challenge posed by the Kyoto Protocol concerns the interdisciplinary nature of the research needed to identify economic, environmental, and social impact scenarios, their effects on reduction and mitigation of GHG emissions, and policy options. A multi-disciplinary research program

provides an opportunity for traditional areas of study to integrate their theories, models, and findings with those of other academic disciplines.

From an overview of atmospheric trends, climate change, and identification of issues, we turn from the scientific perspective to policy and socio-economic considerations. The role of government will be examined in the context of public policy, and options for government action will be considered. Economists' expertise is particularly relevant as national governments grapple with questions about how to reduce anthropogenic GHG emissions, which mitigatory and adaptive strategies ought to be adopted, and what information policy makers require from social scientists, particularly economists.

Why do the national governments of the Conference of the Parties to the Kyoto Protocol need to be involved, beyond committing their states to the Protocol? There are three key reasons why strong and sustained leadership and participation is required. The Kyoto Protocol is a complex issue involving many areas of study, but it is fundamentally an environmental issue, and belongs the government arena because of its "public good" nature. Voluntary efforts aimed at reduction of GHG emissions are largely ineffective. Finally, a long-term view is necessary, and governments, more than other actors in society, possess the capacity to think and act based on intergenerational equity.

First, the Kyoto Protocol and the United Nations Framework Convention on Climate Change are aimed at improving a social good which, if substantive results are achieved by the Protocol's 2008 to 2012 time frame, would benefit the health of all citizens. The involvement of national governments is needed because the issue of climate change is, as the Minister of the Environment for Canada has said, "*the ultimate common property challenge,*" and is a problem which cannot be addressed in piecemeal fashion.[xi] Nor can it be addressed by corporate interests, which have been the primary drivers of innovation – particularly technological development – but whose fundamental concern is chiefly wealth creation. Members of "civil society," such as non-government organizations and international organizations, are concerned with social justice issues but lack authority to compel others to act; their effectiveness results from their research, advocacy, and advisory roles. The Secretary General of the United Nations describes the relationship between civil society and government: *"democracy is ultimately the product, not the creator, of civil society… A strong civil society promotes responsible citizenship and makes democratic forms of government work. A weak civil society supports authoritarian rule, which keeps society weak."* [xii]

Most governments, unlike corporate interests or non-government organizations, have as part of their mandate the provision of social goods in the interests of citizens. As state sovereignty is the highest level of governance in the international system, cooperation among governments is a prerequisite for addressing transboundary issues. National governments vary considerably in their ideologies and structures, but each has an opportunity to be part of a long term solution to climate change, and the Kyoto Protocol is a first step toward reduction of GHG emissions, as well as adaptive strategies. Few government structures are monolithic, and signatories to the Protocol must consider how to implement its provisions domestically. Given the scope of the Protocol, its flexible provisions which give states a variety of ways to meet their targets (e.g. reductions at source points of emissions, tradable permits with other signatories, clean development mechanism), and its capacity to effect fundamental economic changes, its implementation ought to cut across most, if not all, governments' departments. Just as sustainable development represented a new way of thinking about economic and environmental issues, implementation of the Protocol will affect most functions of national governments, and its pervasiveness will require a government-wide effort to implement its provisions.

The magnitude of the task of meeting the seemingly small Kyoto target can be illustrated using a Canadian example. Canada's target is to reduce national GHG emissions by 2010 to 6 per cent below its 1990 levels. However, based on current projections of growth, a business-as-usual trend to 2010, this is actually about a 30 per cent reduction, to be accomplished now in less than 10 years.

In considering the magnitude of reducing emissions once economic growth is factored in, Jaccard and Bataille note that

"We require a business-as-usual forecast. If this forecast shows society naturally evolving to a lower GHG intensity, it will estimate much lower costs of reaching a given reduction target than if it shows the opposite. Over the last decade, each new forecast of Canada's GHG emissions in 2010 has projected them to be higher than the previous forecast. In 1999, for example, the government projected that its Kyoto target required a GHG reduction of 180 MT CO_2e per year by 2010, but this was revised upward just two years later to 240 MT CO_2e. Costs estimates have risen accordingly."[xiii]

An important role for economists is not only to prepare credible projections of economic growth but to provide some quantification of their uncertainty.

Second, the effect of voluntary measures indicates that they are either insufficient or their effect on reducing emissions is unknown, despite the potential to mine the corporate landscape for environmentally conscious organizations to volunteer to reduce their emissions, and the political attractiveness of this option, especially for democratically-elected governments. One voluntary program in Canada is Partners for Climate Protection (PCP), initiated by the Canadian Federation of Municipalities and the International Council for Local Environmental Initiatives, which provides technical support. Municipalities must agree to five milestones: taking stock of local GHG emissions, setting a reduction target for municipal operations (preferably, a 20 per cent reduction to be achieved within ten years of joining the PCP), developing a local action plan, implementing it, and monitoring progress.[xiv] To date, 96 Canadian municipalities have joined, but it is too early to assess members' progress or their collective impact on national emissions.

Another Canadian example is the Voluntary Challenge and Registry (VCR) program was established in 1997 as part of the federal government's National Action Program on Climate Change. Now a stand-alone corporation, its goal is to encourage organizations across all economic sectors to voluntarily accept greater accountability for their production of GHG emissions. Its mandate is to "provide through leadership, the means for promoting, assessing, and recognizing the effectiveness of the voluntary approach in addressing climate change."[xv] To date, the VCR program has 895 registered organizations, and one estimate from the government of Canada's National Climate Change Process suggests that the VCR program and related initiatives have reduced national emissions by slightly less than 5 per cent.[xvi] However, an analysis conducted by the Pembina Institute, an independent not-for-profit organization, indicates that the VCR program, which is the most extensive voluntary measures program in Canada, has been ineffective: "the VCR has utterly failed to bring about the kinds of emissions reductions that Canada will need to meet its Kyoto commitment" and that "there is widespread double counting of emissions among companies reporting emissions to the VCR."[xvii]

By itself, voluntarism as a main strategy for reducing emissions is highly unlikely to meet reduction requirements. Note, however, that voluntarism may be encouraged in concert with other, more coercive programs to maximize the potential for reductions by employing a variety of means.

Third, leadership by governments is essential at this point because this international convention and protocol represent a beginning point in GHG emissions reduction, as well as mitigation of, and adaptation to, climatic changes. The most optimistic prediction for the Kyoto Protocol assumes that its goal will be achieved; that is, that signatories will individually or jointly achieve a 5 per cent reduction of emissions below 1990 levels by the 2008-2012 time frame.[xviii] If this goal is realized, it cannot be assumed that the problem has been solved, and governments should be prepared to demonstrate sustained leadership as reductions are realized and more atmospheric data is collected. Recall that the target (Objective 2) of the UNFCCC is "*stabilization of greenhouse gas concentrations*". The scientific estimates[xix] are that to stabilize the atmospheric concentration at any value less than 4 times pre-industrial GHG concentrations will require global emissions to less than 50 per cent of 1990 values. Thus we are looking at a long-term

issue with major reductions in the future; the Kyoto Protocol is simply a small first step, presumably in the right direction.

When climate change first became a political issue at the 1988 Conference on the Changing Atmosphere in Toronto, many scientists felt that the initial reduction target should be 60 per cent, instead of the more politically feasible "Toronto Target" of a 20 per cent reduction of CO_2 emissions from 1988 levels by 2005.[xx] It is difficult to predict an atmospheric response to this first, small step, and there is a wide range of opinion among experts about climate change scenarios without the input of human-induced mitigative measures; with anthropogenic GHG reductions, the number of possible scenarios increases, and prediction becomes even more difficult. As scientific understanding continues to evolve, governments' ongoing leadership is critical because climate change is a multi-decadal issue, and cannot be collapsed into a more convenient time frame. Implementation of the Kyoto Protocol represents a crucial first step, but governments' commitment to a long-term, intergenerational perspective that is not sacrificed to short-term exigencies is an essential component of their leadership on climate change.

It is clear, then, that governments have a critical role to play in the implementation of the Kyoto Protocol, and that leadership ought to include an understanding of the long-term nature of climate change as a policy issue. The policy options available are as varied as the structures of government, and it is useful to consider policy options in terms of their degree of coercion, as Kathryn Harrison and George Hoberg, among others, have done. They have located policy instruments on a continuum based on coercive capacity, with public enterprise at one extreme, and moral suasion as the least coercive at the other extreme. In between are broadly defined policy categories which are increasingly coercive, such as financial incentives or subsidies, taxation to promote environmental goals, financial disincentives, direct spending, and traditional ("command-and-control") regulation. This is a rather facile theoretical framework, but as Harrison and Hoberg note, "Despite its simplicity, this insight has proven to be a powerful predictor of government behaviour."[xxi] Selection of policy instruments is also constrained by constitutional limits, legal decisions, past policy choices, and ideology, and in democratic systems, elected officials prefer policies which have diffuse costs and confer concentrated benefits.[xxii]

In an era of sustainable development, in which environmental issues are placed in an economic context of neo-liberalism, policies which fit this paradigm are more likely to be selected and implemented than those which do not. Steven Bernstein and Benjamin Cashore describe the relationship between the environment and the economy:

" ...an international norm-complex, which became entrenched in the 1990s, [that] embraces economic expansion, free trade, and market forces and incentives as a means to address global environmental issues. Norms of liberal environmentalism predicate environmental protection on the promotion and maintenance of a liberal economic order."[xxiii]

Prior to the emergence of this paradigm, environmental issues were widely regarded as wholly separate from economic interests; now, as with most social justice issues, they are located within an economic framework. Deliberation about which kinds of policies are likely to be both effective and politically successful has led many to embrace market-oriented regulation, wherein outcomes are compulsory but the means are determined by the subjects of regulation. Regulatory measures that allow corporations to select their own process for achieving compliance fit close to the centre of the policy continuum, and offer several economic advantages while environmental goals are pursued.

One such advantage of market-oriented regulation is that it encourages technological innovation by making long-term research and development more attractive to producers of goods and services. Strong financial penalties must be in place before producers are willing to commit to research which may lead to environmentally sustainable innovation; otherwise, the risks associated with emerging technologies may be regarded as too great to justify the costs. Government intervention need not be limited to penalties; incentives can be used to help achieve policy goals, by linking a policy to an environmental goal. An example is the renewable portfolio standard (RPS), used in Denmark and the Netherlands, which requires

energy producers to ensure a percentage of the energy produced is from government-approved renewable sources. No price for renewable energy is set, so that the market determines rewards and penalties and competitive pressure is sustained; for example, if a corporation finds a cheaper method of producing renewable electricity, it will find itself with a greater market share.[xxiv] Corporate competitors can reduce their costs by trading "green certificates," or permits, among themselves, similar to the Kyoto Protocol's provision for interstate trade of emissions reductions units. The RPS has been implemented in some parts of North America and Australia, but its effect on GHG emissions has not been determined. Energy costs, however, are expected to drop under the RPS regime.[xxv]

The vehicle emissions standard (VES) originated in California in 1990 and is a well-known form of a market-oriented regulatory scheme. Under the VES, automanufacturers must guarantee a minimum percentage of new sales for low emissions vehicles after a long phase-in period, and failure to do so will cost a manufacturer $5000 per vehicle. There are four classifications of low-emissions vehicles which are all below the federal standard, and stricter standards which will include regulations for SUVs and mini-vans, to be phased in between 2004 and 2009. There are twenty-four automanufacturers that produce low-emissions vehicles, and they are expected to be sold in forty-five states before 2003.[xxvi] The VES was designed to improve air quality, but could be modified to achieve GHG emissions.

The RPS and VES are both sector-specific programs, which is a beneficial feature because it allows policy makers the flexibility to respond to market signals after the policy comes into effect; for example, if technology costs are higher than anticipated, or an entire sector is experiencing difficulties devising a reliable technology which meets the government's criteria, the government can extend the phase-in period, or adjust its requirements. A potential drawback to sectoralized policies is that some sectors may find that their costs for compliance are higher than those of other sectors. Policy makers could avoid this problem by conducting an assessment before a policy is implemented, to ensure that costs of reducing GHG emissions are not borne by certain sectors while others incur a relatively small portion of costs.

If market-oriented, sector-specific policies were adopted, economists' expertise would play a crucial role in identifying costs of research and development at the pre-implementation stage. If some sectors traditionally incur greater risk associated with technological innovation, this information would be useful to policy makers (in Canada, political leaders have endorsed a principle that no region should bear an unreasonable burden; presumably, the same principle would apply to economic sectors). Finally, new technologies will experience different rates of market penetration, with high rates of commercialization causing costs to decrease more quickly, and anticipation of shifting consumer preferences toward "greener" products would assist in estimates of the rate of declining costs of production.

Economic information is also needed to meet the Kyoto Protocol's requirement described in Article 10:

"Formulate, where relevant and to the extent possible, cost-effective national and, where appropriate, regional programmes to improve the quality of local emission factors, activity data and/or models which reflect the socio-economic conditions of each Party for the preparation and periodic updating of national inventories of anthropogenic emissions by sources…"

Related to this requirement is the IPCC's observation that regions and communities which are vulnerable to climatic changes tend to be under pressure from forces such as resource depletion, poverty, and population growth, and that improvements in one issue area can strengthen the quality of other social and environmental issues.[xxvii]

The Protocol also requires signatories to report and regularly update their domestic strategies aimed at mitigation and adaptation. This reporting requirement concerns the energy, transport, industrial, agriculture, forestry, and waste management sectors. The economic implications of mitigation and adaptation are difficult to identify; however, economic analyses ought to include approximations of these considerations to more closely model "real world" experiences.

Other issues that arise due to the Kyoto Protocol include the system of international trade in carbon credits under the Kyoto mechanisms. How will these trading schemes affect international trading rules such as those established under the World Trade Organization? Does Kyoto and UNFCCC in a sense establish a new and independent trading regime? For Canada, a very important consideration is the reality that, if it ratifies Kyoto, it will be part of the a trading regime (the North American Free Trade Agreement) of which it is the only member that is constrained by the Kyoto Protocol. Canada has argued that this relationship with the United States and the large exports of "cleaner" energy to the United States should be given recognition in implementing the Protocol.

Economic modelling relies heavily on assumptions and principles, but these have not been fully articulated, and policy makers and social scientists must debate these fundamental questions so that economists may incorporate them as parameters into socio-economic scenarios based on climatic change. Fairness is a key principle, but does it translate into fairness across all sectors and regions? How might a region or sector which has historically contributed little to anthropogenic GHG emission be treated? Would it assume partial responsibility, or be compensated in recognition of its traditionally low emissions production? How does its prospects for future emissions factor in, if at all? In a federal state, the roles of provincial (as in Canada) or state governments and their economic considerations can be an important factor. In Canada, a meeting of the heads of the federal, provincial and territorial governments (First Ministers) agreed that:

"Some approaches to achieving our climate change objectives could result in some regions of our country bearing differential burdens. However, First Ministers have agreed that no region of the country should be asked to bear an unreasonable burden and any workable plan must respect that condition."[xxviii]

The Canadian approach to meeting its Kyoto commitments will be based on three main policy instruments: 1) domestic emissions trading; 2) targeted measures; and 3) government purchases of international permits. Although considerable analysis has been done, it is clear that further analysis needs is required before agreement can be reached on the right combination of these instruments and how to apply them. There are additional considerations that have not been mentioned; namely, the co-benefits of whatever approach is taking to meeting the Kyoto targets. One is the potential of reducing urban and regional smog, which largely results from fossil fuel consumption, so that the health and other benefits can be achieved. Another "co-benefit" is the need to start the industrial and social transformations needed to achieve the next sets of commitments that will be need to meet the long-term UNFCCC target of stabilization. These co-benefits (cleaner air, improved human health, and the emergence of new economic opportunities) are worthy of further study to assist economists in determining the true costs associated with climate change initiatives.

Economic modelling relies heavily on assumptions and principles, but these have not been fully articulated, and policy makers and social scientists must debate these fundamental questions so that economists may incorporate them as parameters into socio-economic scenarios based on climatic change. Fairness is a key principle, but does it translate into fairness across all sectors and regions? How might a region or sector which has historically contributed little to anthropogenic GHG emission be treated? Would it assume partial responsibility, or be compensated in recognition of its traditionally low emissions production? Should future projections for its emission levels be considered, and how might this variable be factored into a model, if at all? Fairness may also be applied to the apportionment of costs to business and citizens: bearing in mind that business will, as much as possible, pass on costs associated with reducing GHG emissions to consumers, should consumers assume part of the burden of increased costs in the form of increased prices for goods and services? Another option would be to implement a "green tax," but this may unduly dampen economic growth prospects, as many have suggested. Should consumers have a larger role, apart from incurring point-of-sale price increases?

Similarly, the "polluter pays" principle seems intuitively fair, but upon examination, it raises questions about how a region which generates economic wealth for a state ought to be considered under the Kyoto Protocol. If a state has sufficient financial resources, it may purchase permits from other signatories to the Protocol as the sole means of achieving compliance. These normative questions regarding the values which underpin policy and economic arrangements are outside the scope of the Protocol, but which nonetheless must be addressed in order to maximize the value of economists' input into planning for GHG emissions reduction, as well as preparations for mitigative and adaptive measures.

One assumption worthy of inclusion in economic analyses concerns consumers' recognition of technologies as imperfect substitutes; that is, consumers will differentiate between competing products and in order to change purchasing behaviour, a financial inducement or penalty may be required. Failure to recognize "consumers' surplus" – the extra value attributed to preferred technologies – is a problem often associated with bottom-up modelling, and may lead to an underestimation of costs of GHG emissions reduction.[xxix]

Climate scientists recognize that normal weather and climate activities are easier to forecast and model than natural disasters. Disasters continue to occur, however, and as climate change effects become more pronounced, certain kinds of disasters increase in frequency (e.g. flooding and drought), but are no more predictable than those which occur in the absence of climate change. As costs associated with each disaster continue to increase, there are opportunities for economic models to incorporate a risk factor apportioned over a multi-year or decadal time frame.

Many climate change-related issues to which economic experts may contribute valuable insight, or issues which non-economists may help clarify to improve the work of economists, have already been undertaken. A great deal of study lies ahead, however, due not only to the complexities inherent in a multi-disciplinary study, but to an area of study which is dynamic, and as our understanding of climate change continues to grow, so do opportunities to act in the interest of stabilizing GHG emissions at sustainable levels. The costs of reduction sooner (i.e. to meet the Protocol's 2008 – 2012 implementation period), rather than over a longer period, are unavoidably higher, but delaying implementation is even less tenable: full implementation of the terms of the Kyoto Protocol will delay by about a decade a doubling of CO2 concentrations in the atmosphere.[xxx] The Kyoto Protocol is a first step.

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[i] An excellent presentation on these matters is "Challenges of a Changing Earth" by Professor B. Moore which can be downloaded from www.sciconf.igbp.kva.se/fr.html

[ii] World Commission on Environment and Development, 1987: *Our Common Future*. Oxford University Press, 400 pp.

[iii] See www.un.org/esa/sustdev/agenda21.htm for further information.

[iv] See J.P. Bruce "Intergovernmental Panel on Climate Change and the Role of Science in Policy". *Isuma*, 2, pp 11-15. and IPCC website www.ipcc.org

[vv] See S. Bernstein and C. Gore, 2001: Policy implications of the Kyoto Protocol for Canada. Isuma, 2, 26-36. and P. Le Prestre et E. Dufault, 2001: Le Canada et le Protocole de Kyoto. Isuma, 2, 37-44. Available at www.isuma.net

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