Adapting to Climate Change: The Challenges and Opportunities in an Uncertain Policy Environment

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Global climate is changing and the scientific community has concluded that the warming is unequivocal (IPCC, 2007) as seen in atmospheric and oceanographic temperatures, rising sea levels and the loss of sea and land ice (Zwiers, this volume[1]). By comparing the influences of natural processes in driving climate change with the combination of natural plus human processes, it can be concluded further that humans are the main cause of this warming. Based on knowledge of the climate system and its relationship to human-generated emissions of greenhouse gases, it is projected that the climate will continue to warm at about the same rate as over the past 25 years, for the next 20 to 40 years, as it adjusts to the already accumulated additional greenhouse gases in the atmosphere, plus those expected to be added over that time. Depending on the global emission-reduction strategies that are undertaken, the climate beyond about 2040 will become increasingly dependent on the emission scenario and the rate of warming will either decrease, a little or considerably, or slightly increase, for the range of likely future emissions. The climate will continue to change and the warming will continue for centuries to follow (Weaver, 2008).

Although Canada signed the Kyoto Protocol in 1997 and ratified it in 2002, our emissions of greenhouse gases have continued to rise (Environment Canada, 2008) such that, in 2007, they were 34% above the accepted Kyoto target of 7% below 1990 levels for the period 2008–2012. In 2007, energy-related emissions accounted for 81% of the total, and agriculture contributed 8.6%. The impact of agriculture on climate change through its emissions has been discussed by Desjardins (this volume[2]).

[1]Pages 19–26.
[2]Pages 29–38.

The impact of a changing climate on agriculture is the subject of the chapter by Mearns[3]. As the climate changes with overall warming, there will be significant regional variations, generally with winters warming more than summers, land areas more than oceans and coastal zones, and higher latitudes warming more than nearer-equatorial latitudes (Christensen *et al.*, 2007). Variations in future precipitation and resulting water supplies will be regionally and seasonally dependent with some areas of the world having reduced wintertime precipitation, some reduced summertime precipitation, and some both. The results will have implications for water availability, agricultural productivity and overall food supply.

This chapter is about adapting to climate change and its challenges and opportunities in an uncertain policy environment. Although climate-change adaptation is usually defined, as it will be later in this chapter, as (IPCC, 2007b):

> *...adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.*

I have chosen to define, for purposes of this chapter, adaptation to climate change as actions and adjustments taken both to reduce agriculture's vulnerability to a changing climate and its extremes and to reduce the impacts resulting from emission-reduction actions, responding in both cases to policies, regulations and other factors. Climate change is a multi-dimensional issue—it has cultural, social and economic values and is much beyond an environmental issue. Because of the multitude of perspectives and issues, there are fundamental disagreements on approach (Hulme, 2009), which lead to uncertainties. There is a need for improved communications from science to policymakers (McBean, 2009b). A focus in this paper will be on how can or will the implementation of climate-change adaptation take place in recognition of these uncertainties—uncertainties both in future climate and in the present and future policy environments.

The Policy Environment for Adapting to Climate Change

The international policy environment for agriculture's role in climate is based on the United Nations Framework Convention on Climate Change (Climate Convention) (UNFCCC, 2009). The Climate Convention's objective is, as stated in its Article 2:

> *…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 ensuring continuity of food production is one of the criteria.

Under the Climate Convention's Article 4 on Commitments, all parties are expected to undertake cooperative actions in the development of technologies to reduce anthropo-

[3]Pages 41–45.

genic emissions of greenhouse gases. Among the sectors specified are agriculture, forestry and waste management. The Climate Convention also includes actions on preparing for climate adaptation, including plans for water resources and agriculture.

The Climate Convention's Kyoto Protocol, as signed and ratified by Canada and most other states (but not the United States) has emissions-reduction targets that are usually the focus of policy considerations and national programmes that include strategies to "mitigate climate change" (Article 10). Under the Kyoto Protocol's Article 2, commitments include development and use of renewable forms of energy, which could include renewable energy from agriculture. In Annex A, which specifies the sectors/source categories for emissions and emission reductions, those for agriculture include:

- enteric fermentation;
- manure management;
- rice cultivation;
- agricultural soils;
- prescribed burning of savannas; and
- field burning of agricultural residues.

The Kyoto Protocol also includes commitments (under Article 2) to promote sustainable forms of agriculture and to "facilitate adequate adaptation to climate change" with agriculture, forestry and waste management among the sectors specified. Among the plans for adaptation are technologies and methods for improving spatial planning, which could be interpreted to include planning for different agricultural-production zones.

In late 2009, the 15th Conference of the Parties under the Climate Convention will be convened in Copenhagen. It will address the directions laid out in the Bali Action Plan that countries agreed to in 2007 at the 13th Conference of the Parties. The Action Plan specified steps to be taken to "enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012," which is after the end of the Kyoto Protocol commitment period. An agreed long-term global goal for emission reductions, to meet the Convention's objectives, is to be one outcome of the 15th Conference of the Parties, as well as interim targets. What those targets will be or even if there will be agreement on them, is uncertain at present. From an agriculture point of view, there will likely be important terminology, guidance and rules in the details. These details are even more difficult to predict.

Canada/United States Federal-Policy Environment

Now, in mid-2009, a rapid transition is occurring in Canadian and the United States climate-change policy, as a result of the change in the US administration with its proactive position on global warming [see McBean (2009a) for one commentary]. Correspondingly, there is a flurry of activity in Canada to develop policies on emissions reductions as well. Perhaps the most important new action is the American Clean Energy and Security Act (often referred to as the Waxman-Markey Bill), which is in negotiation in Congress at the time of writing. A broadly based (covering more than 80% of US emissions) regime

is expected, based on cap-and-trade principles, which may be in place as early as 2012. Downstream electricity emissions and upstream natural-gas liquid, petroleum and coal-based liquid fuel producers/importers are the focus of the first phase. By 2014, downstream industrial sources (including process emissions), but not including petroleum or biomass, will be brought into the system, with regulations for mid-stream natural-gas local-distribution companies coming in about two years later. Opinions on the Waxman-Markey Bill are widely varied, including conservative views that it will be a very costly and ineffective instrument and some environmental groups saying it has so many loopholes that it will not be effective in emission reductions. It is, in any case, a very complex bill—about 1,000 pages [see, for example, Wall Street Journal (2009)].

Until now, most of the action on greenhouse-gas emissions reductions in the United States has been at the state level. The Western Climate Initiative (WCI, 2009), which involves many western US states, differs in scope from, but uses the same thresholds as, Waxman-Markey. British Columbia, Manitoba, Ontario and Quebec are partners with seven US states in the WCI, and Saskatchewan and Nova Scotia are official observers.

The Canadian federal government, signalling a desire to align with the United States, has declared that its initial-phase policy will cover electricity and industry, and will be phased in in a similar way to the US/Canada's Climate Change approach (Environment Canada, 2009a). It aims to reduce total greenhouse-gas emissions by 20% from 2006 levels by 2020, and by 60 to 70% by 2050. These are slightly larger cuts than the US targets. The regulatory framework will impose mandatory emissions-reduction targets across the full spectrum of Canadian industry. Full details are yet to be released. From what is presently known, there is mixed alignment with the US bill. One difference is the emphasis on a Technology Fund as a compliance mechanism. The federal government has stated that it is open to provincial equivalency. The minister also laid out his principles for the Canadian position for the Copenhagen Conference of Parties in late 2009:

- balance environmental progress and economic progress;
- a long-term focus;
- technology (with a focus on carbon capture and storage); and
- a consensus at Copenhagen that has to involve both the developed world and the developing world.

With respect to the focus on carbon capture and storage, it is important to keep in perspective its limitations and costs (*e.g.* Economist, 2009)

On June 10, 2009, Minister Prentice announced *Canada's Offset System for Greenhouse Gases* (Environment Canada, 2009b), which is intended to provide Canadian firms and individuals with the opportunity to reduce or remove emissions from activities and sectors that will not be covered by planned greenhouse-gas regulations. Offset credits will be issued by the Offset System for eligible greenhouse-gas reductions or removals achieved from a specific project. One offset credit represents 1 tonne of carbon dioxide equivalent emissions reduced or removed. This will establish a price for carbon in Canada and the government will issue offset credits thereby creating a "currency," a means of exchange, which can be traded like commodities or stocks.

Canada's Carbon Offset Policy may be an opportunity for agriculture. The opportunities for offset projects include:

- capture and destruction of methane from landfills;
- reforestation and other forestry projects; and
- agricultural-soil management.

Biological sink projects, which either remove greenhouse gases from the atmosphere and store them in reservoirs (for example, in soil or trees) or avoid emitting greenhouse gases to the atmosphere from a reservoir (for example, avoided deforestation) will generally be relatively slow accumulations of carbon and it is possible that the results will not be permanent and greenhouse gases may be re-released. Agriculture sink projects could include the following types of land-management practices:

- reduce the intensity of tillage operations;
- adopt crop rotations and grazing-management practices that sequester more carbon in the soil; or
- increase the use of permanent cover.

There will also be other types of biological sink projects such as afforestation—creating a forest where none has existed since at least 1990—and reforestation.

Canadian agricultural soils have been a source of atmospheric carbon dioxide for the past century due to depletion of soil carbon through cultivation. A trend towards no tillage in western Canada, primarily for economic reasons, has helped return carbon to soils. It is now predicted that Canadian soils will soon become net sinks, but there is need for enhanced scientific understanding of the processes and improved means to quantify and verify emissions.

As yet, Canadian and American emission-reduction policies are neither fully clear nor enacted, so considerable uncertainty remains. Adaptation to these policies and evolving with them will be a challenge. Will the credits for changing agricultural practices to enhance carbon sequestration be sufficient to justify them? With the changing climate, how will mitigation (emission reductions and/or carbon withdrawal) regulations be compatible with changes in crops and other practices more appropriate to a future climate and a future market for food?

Climate Change and Food Security

The Climate Convention's objective was to avoid dangerous interference with the climate system. A fundamental question is, "What is dangerous?" The European Union and some states have adopted the target of 2°C warmer than pre-industrial global temperatures and the recent Climate Congress in Copenhagen (University of Copenhagen, 2009) reconfirmed this objective. The Congress concluded that:

> *Temperature rises above 2°C will be difficult for contemporary societies to cope with, and are likely to cause major societal and environmental disruptions through the rest of the century and beyond.*

Parry *et al.* (2008) analysed the impacts on various sectors from different levels of emission reductions. Although a 50% reduction by 2050, based on meeting the target of 2°C relative to pre-industrial temperatures (or 1.4°C compared to 1980–1999 values), seemed to avoid dangerous impacts, they noted two additional points. First, with the uncertainties involved in such projections, which are skewed towards larger changes, unacceptable impacts are possible. Second, because the climate system is still not in equilibrium with the emission reductions, one must really look at the impacts at 2100, with their associated uncertainties. Estimates of the overall costs and risks of climate change have been estimated by Stern (2007) to be equivalent to losing at least 5% of global GDP each year, now and forever. Taking a broader view of risks and impacts could raise that to 20% of GDP or more.

As we look towards the future it can be expected that, in the next few decades, there will be decreases in production for some cereals at low latitudes while there will be increases for some cereals at mid- to high latitudes (Parry *et al.*, 2008). In the latter half of this century, as the climate warms and changes further, there will be decreases in all cereal production at low latitudes and decreases as well in some regions in mid- to high latitudes (IPCC, 2007b) . The impact of climate change on global agricultural gross domestic production (GDP) by 2080 is estimated by the IPCC (2007b) as between –1.5% and +2.6%, with considerable regional variation. Overall, mid- to high-latitude agriculture stands to benefit, whereas agriculture in low latitudes will be adversely affected. Parry *et al.* (2008) further commented that:

> *We are now probably witnessing the first genuinely global effects of greenhouse gas warming. The steep increases in food prices around the world are the result of rising costs and demand aggravated by drought in food-producing regions—in the case of Australia, probably due in part to global warming and by a poorly conceived experiment in climate policy that has converted cropland to bio-fuel plantations. This should serve as a wake-up call: impacts of climate change can surprise us, especially when they act in combination with other pressures.*

Several countries have identified climate change as a security risk. For example, the German Advisory Council on Global Change (2008) identified what they termed a conflict constellation as climate-induced declines occurred in food production. They noted that, already, more than 850 million people are currently undernourished and this will worsen as a result of climate change. Their analysis led to the conclusion that for a 2°C increase in global mean temperature (relative to pre-industrial values—about 1.4°C more warming) there will be a food *insecurity* increase in many developing countries. For 2 to 4°C warming, there would be a drop in agricultural productivity worldwide, which would be reinforced by desertification, soil salinization and/or water scarcity. Food "hotspots," from a security point of view, were identified in several places around the world. The Canadian national climate assessment (Lemmen *et al.*, 2008) has also identified the implications of climate change for Canadian activities related to international development, aid and peace keeping.

The impacts of changing climate are already evident in every region of Canada (Lemmen *et al.*, 2008) and in North America in general (Field *et al.*, 2007), and climate

change will exacerbate many current climate risks, and present new risks and opportunities, with significant implications for communities, infrastructure and ecosystems. It has health implications (Séguin, 2008) and the impacts of recent extreme weather events have highlighted the vulnerability of Canadian communities and critical infrastructure (Berry *et al.*, 2008). Since climate change will have impacts elsewhere in the world, and, accordingly, these regions will take some adaptation measures, there will be implications for Canadian consumers, and the competitiveness of some Canadian industries, including agriculture.

Reducing Agriculture's Vulnerability to a Changing Climate and its Extremes

The national assessment (Lemmen *et al.*, 2008) concluded that general adaptive capacity in Canada is generally high, but is unevenly distributed. Resource-dependent and aboriginal communities are particularly vulnerable and this vulnerability is magnified in the Arctic. Some adaptation is occurring in Canada, both in response to, and in anticipation of, climate-change impacts. Examples of these adaptations are integrating climate change into existing planning processes, often using risk-management methods that are seen as an effective approach. There are, however, barriers to adaptation action that need to be addressed, including limitations in awareness and availability of information and decision-support tools. Although further research will help to address specific knowledge gaps and adaptation-planning needs, there is the knowledge necessary to start undertaking adaptation activities in most situations now. What is missing in most cases is a policy framework and national and/or provincial comprehensive adaptation strategies. When and how they will arise and what they will include are uncertain.

Adaptation strategies for a changing climate are necessary (Burton, 2008) and will need to be an ongoing process. The national assessment (Lemmen *et al.*, 2008) defines adaptation as:

> *…making adjustments in our decisions, activities and thinking because of observed or expected changes in climate, in order to moderate harm or take advantage of new opportunities.*

Although climate hazards pose a potential threat, their associated impacts are largely determined by a community's vulnerability, which is a function of its exposure to those hazards, its sensitivity to the stresses they impose and its capacity to adapt to these stresses, and the central goal of adaptation policy must be to reduce vulnerability (Burton *et al.*, 2002). The vulnerability of communities to extreme weather events is not a fixed condition, and can be reduced through actions that minimize exposure, reduce the sensitivity of people and systems, and strengthen the community's adaptive capacity. It is also useful to go into the disaster-risk-reduction terminology to note that a hazard is (UN ISDR, 2009):

> *…a potentially damaging physical event, phenomenon or human activity that MAY cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.* (emphasis added)

Conditions of vulnerability are determined by physical, social, economic, and environmental factors or processes that increase the susceptibility of a community to the impact of hazards. Disasters result when there is the intersection of a hazard and vulnerability. For our discussion, the hazards are those generated by a changing climate and, hence, avoiding disasters necessitates actions to reduce vulnerability.

Climate-Adaptation Policy

Impacts are largely determined by a community's vulnerability, which is a function of its exposure to climate hazards, its sensitivity to the stresses they impose, and its capacity to adapt to these stresses (Henstra and McBean, 2009). That vulnerability can be reduced through actions to:

- minimize exposure;
- reduce the sensitivity of people and systems; and
- strengthen the community's adaptive capacity.

Four factors contribute to achieving adaptive capacity:

- access to information;
- expertise with information, analyses and translation of information into policy;
- fiscal capacity; and
- political will to act.

Designing adaptation policy for climate change requires, *inter alia*:

- assessments of the effectiveness, costs and feasibility of measures to reduce vulnerability;
- stakeholder analyses to identify targets and beneficiaries of adaptation interventions; and
- analyses of the consequences of inaction.

Research and development are underway to address these issues of design. However, there are clear difficulties with regard to fiscal capacity as at least some level of public expenditure will be needed and that will be limited by competing demands on scarce economic resources. In the end, a critical issue will be generation of the political will to act, which will most likely come with more general recognition that adaptation is necessary and possible, and that it is desirable to adapt.

As noted earlier, the international policy regime of the Climate Convention and its Kyoto Protocol include statements on needs for adaptation. The Bali Action Plan of 2007 moved climate-change adaptation more to the forefront. One section is on the need for "(c) Enhanced action on adaptation." The Bali Action Plan calls for:

- international cooperation to support urgent implementation of adaptation actions;
- risk-management and risk-reduction strategies, including risk sharing and transfer mechanisms such as insurance;

- disaster-reduction strategies and means to address loss and damage associated with climate-change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change;
- economic diversification to build resilience; and
- ways to strengthen the catalytic role of the Convention in encouraging multilateral bodies, the public and private sectors and civil society, building on synergies among activities and processes, as a means to support adaptation in a coherent and integrated manner.

Concluding Remarks

What issues might an adaptation-policy regime consider? As the climate changes, there will be stresses on agricultural production in some regions and opportunities in others. Will there be financial and regulatory support for diversification into other crops and for possibly relocating agriculture production to other areas? If so, in the latter case, will there be investments in public infrastructure, such as transportation and water supply, to support the new region? In the case of water supply, some regions of Canada will become very water stressed and there will be conflicting demands for whatever water is available. Will regulatory regimes favor or be a disincentive to agricultural production?

Canadian adaptation policies are in development at least in some provinces (*e.g.* Ontario), but they are clearly not at the forefront of major political thinking on climate change, which continues to be focussed on emission reductions. It is important to recognize that choices made now will have continuing economic and social impacts for a long time. Choices on emission-reduction strategies will have impact on the global climate of 2030 and beyond. However choices for cap and trade, offsets and the rest of the various instruments for reducing emissions will have impacts as soon as they are implemented. Based on recent announcements, it seems likely that emission-reduction policies will be in place by, or possibly before, 2012. Adaptation strategies are needed in all sectors to adjust to these policies and to take advantage of favorable rules and regulations. With the continuing uncertainty as to what those policies will be, the agricultural community needs to be flexible and resilient.

Choices on adaptation strategies for the impacts of climate change are needed now as changing climate is already having impacts. The chosen strategies will have impacts on local economic and social activities within Canada as soon as they are effectively in place. In this case, there is uncertainty of the details of the changing climate, *e.g.* how much change and frequency of occurrence of extreme events. Implementation of adaptation strategies will require some investments—fiscal capacity—and the political will to act.

It is essential that climate change be recognized as the long-term issue it is, and that it cannot and should not be put aside whenever another seemingly more important and immediate issue appears on the scene. It is an issue of intergenerational and international equity that must be given appropriate attention. Remember (Sauchyn and Kulshreshtha, 2008):

> *We have options, but the past is not one of them.*

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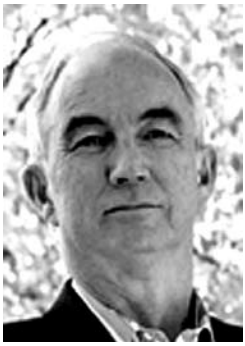

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