INTERNATIONAL INITIATIVE ON AGRI-ENVIRONMENTAL ISSUES

AAFC07-08, M1J16

3-2: REVIEW OF INTERNATIONAL ASSESSMENTS

FINAL

Authors:

Jane Barr
Brady Deaton
Jenny Gleeson
Alfons Weersink

For IISD

April 2008

TABLE OF CONTENTS

KEY

AKST	Agricultural knowledge, science and technology
GEO-4	Global Environment Outlook-4, numbers refer to chapters
IAASTD	International Assessment of Agriculture, Science and Technology for Development
IAASTD G	Global chapters of IAASTD, numbers refer to chapters
IAASTD G SDM	Global IAASTD Summary for Decision Makers
IAASTD SYR	IAASTD Synthesis Report
IAASTD NAE	North America/Europe sub-global chapters of IAASTD, numbers refer to chapters
IAASTD NAE SDM	IAASTD NAE Summary for Decision Makers
IPPC	Intergovernmental Panel on Climate Change
IPCC AR4	IPCC Fourth Assessment Report, *Climate Change 2007*
IPCC SYR	IPCC Synthesis Report
IPCC WGI	IPCC Working Group I, numbers refer to chapters
IPCC WGII	IPCC Working Group II, numbers refer to chapters
IPCC WGIII	IPCC Working Group III, numbers refer to chapters
NAE	North America/Europe
SRES	Special Report on Emissions Scenarios (IPCC)

EXECUTIVE SUMMARY

AAFC Policy Goal 1: Focus on building a competitive and innovative sector.

- **The effects of climate change on the competitiveness of Canadian agriculture are expected to be moderate-to-large and generally positive**: the projected increase in average temperature and precipitation levels are expected to increase yields for most sectors of Canadian agriculture with limited warming of 1 to 3^{o}C. In addition, the likely decrease in production projected for low latitude regions increases Canada's competitive advantage. This could be enhanced if a carbon market provides further revenue opportunities.
- **Significant indirect effects from some types of more stringent environmental regulations may affect competitiveness.** For example, controls on the livestock sector could significantly affect the competitive position of production in certain livestock-intensive regions of the country. Similarly, the possibility of limits on fertilizer levels could impose higher costs on Canadian farmers relative to farmers in other regions.
- **Opportunities continue to open for niche markets responding to consumer demands for higher-value, differentiated foods.** The effect on competitiveness depends on the size and projected growth of this emerging food sector as well as on domestic and international standards governing the production and labeling of alternative foods.
- **The competitive advantage of Canadian farmers using GMO groups has increased** relative to farmers in EU countries and Australia where their use is banned. The future advantage is unclear, however. An outright ban on GMOs, or regulations requiring labeling of BMOs may lead to a price discount to GMO crops. On the other hand, a premium may be created for non-GMO crops if labelling allows products to be designated as GMO-free in a scenario in which GMO crops become the standard.
- **Rising energy production could increase output prices and enhance the competitive position of Canadian agriculture**. Given its large land base, there is the potential for Canada to be a major supplier of feedstock to the biofuel sector.

AAFC Policy Goal 2: Ensure the sector contributes to society's priorities.

- **Climate change remains a public policy concern and spurs a call to action**. Despite the generally positive impacts for Canadian agriculture, many Canadians demand more stringent responses to the negative impacts of climate change, including the disproportionate effect on agriculture in developing regions and their lack of adaptive capacity.
- **There is a small but growing demand for agricultural goods that can be differentiated from conventional agricultural goods by production and delivery systems that incorporate social concerns**, such as: healthy food (fresh produce, and organic, for example); food safety (e.g., hormones and antibiotics in meat); perceptions of risk (e.g., GMOs); environmental impacts of food production (land degradation, air and water pollution); concerns about animal welfare (industrial livestock); concerns about the transportation and greenhouse gas costs of food (food miles); and equity concerns (fair trade). Increased wealth and consumer awareness, and an aging population will continue to stimulate a demand for product differentiation.
- **Urban sprawl is likely to remain an important social issue in Canada**. Urban and suburban residents may value the landscape amenities of agricultural land on urban fringes, as well as controls on urban growth. Others are concerned about conserving agricultural land near cities to reduce food miles.
- **Water quality is an important environmental concern in Canada.** In many cases, such as the Walkerton crisis or fish kills in PEI, the problem can be associated to some degree with agricultural production systems.

- **There is an emerging concern that energy crops will compete for land for food production, with impacts on food prices.** Social concern in Canada may extend to the potential effect on developing countries where a larger portion of people's income is spent on food and for whom the farm value represents a greater percentage of the food dollar. The long-term viability of small farmers in developing regions under free trade conditions and subsidies enjoyed by North American farmers is of concern to some Canadians.

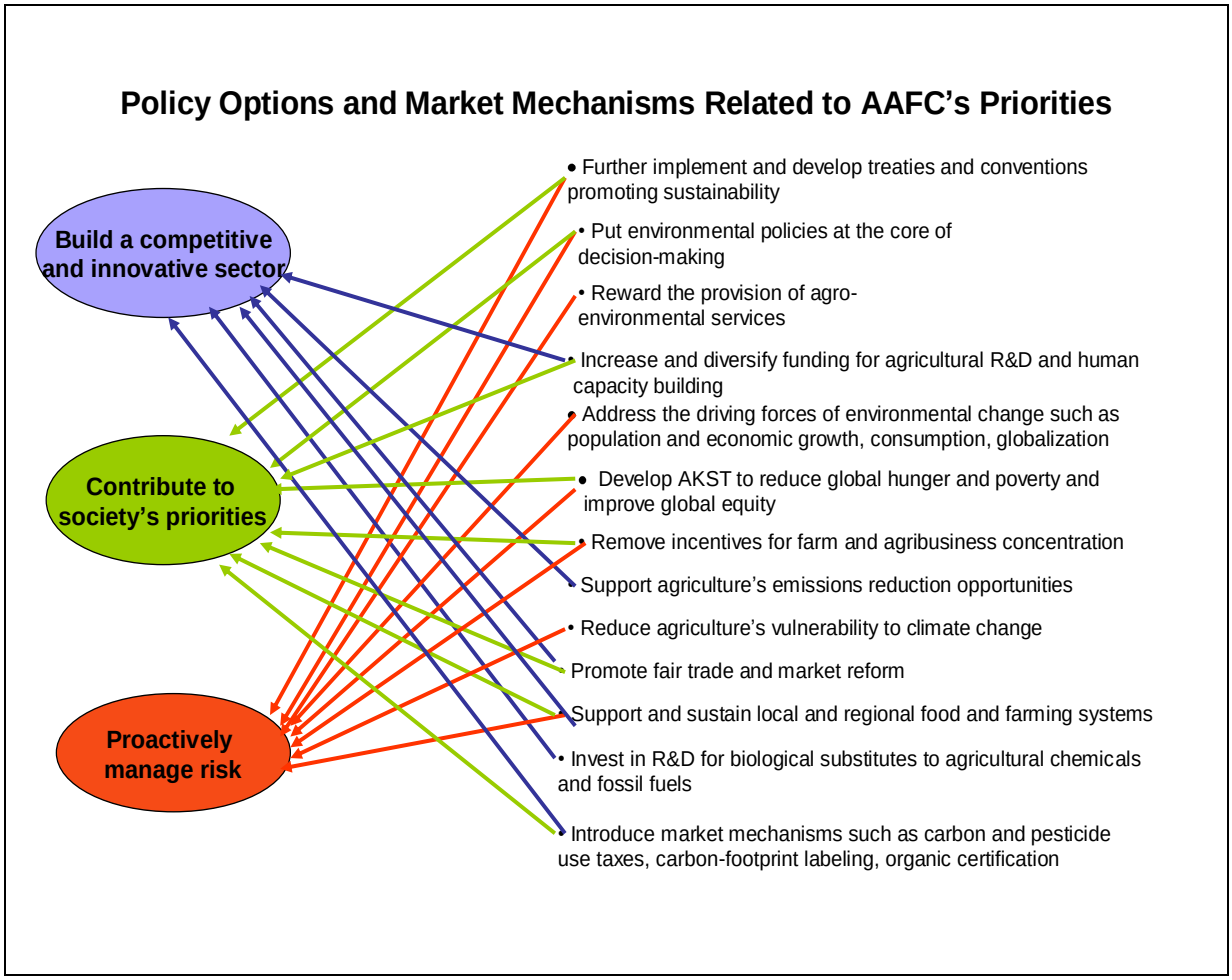
AAFC Policy goal 3: Be proactive in managing risks.

- **Climate change has increased the vulnerability of Canada's agricultural sector and the need to manage risks.** Extended drought and rainfall variability, at the same time as population growth and economic development, have led to competition among agricultural, municipal and industrial users for scarcer water resources. Severe weather events, potential new pests and disease, out-migration from rural areas and economic stresses further increase the sector's vulnerability.
- **Urban sprawl may pose risks to agricultural producers** due to increased interaction (potential conflict) between farmers and new, non-farming residents and risks from policy responses to sprawl that may affect land values (e.g., zoning).
- **Changes in market niches are likely to increase risks** related to prices and markets, and contractual risks as farmers and retailers negotiate to deliver food products with desired health attributes. They may lack information about the standards and processes governing such foods and they may face conflicts with conventional agricultural producers related to the presence of externalities: e.g., contamination of organic crops from synthetic pesticides or GMO's.
- **Producers need to emphasize price risk management** in the current situation of increased price variability and volatility for commodities, due in part to energy policies and biofuels.

In sum, Canada's agriculture and agrifood sectors are likely to enjoy some competitive advantages due to the warming trends of climate change, given its favourable geographic position, and because of increased demand and support for biofuel production and its use of GMOs. Will these advantages be offset by the negative impacts of climate change, however, given its increased vulnerability to extended drought, extreme weather events, and pests and disease? Canada will likely find ways to address public concern about equity issues with regard to climate change and consumer demand for healthy, safe, local and humanely produced food, in ways that do not negatively affect its competitiveness and that may even provide it with opportunities for gain. AAFC's greatest challenge may lie in taking decisions to protect and enhance ecosystem services provided by agricultural ecosystems and of those that agricultural activity affects, even if such actions are not immediately rewarding. The risks of not doing so are sure to threaten the future productive capacity of agricultural ecosystems, the livelihoods of future Canadian farmers, and perhaps the food security and health of future generations at both local and global levels.

The reports analyzed here point to a number of policy options to address the climate, environmental, and agricultural issues they assess. The following flow graphic (Figure 1) illustrates how these suggested options relate to AAFC's three policy goals.

Figure 1: Policy options suggested in the literature



INTRODUCTION

Given its export orientation and sensitivity to global forces of socio-economic and environmental change, the sustainability and competitiveness of Canadian agriculture requires keeping external conditions constantly under review. This is particularly important in the environmental domain where the interactive forces of global change, including new trade patterns, climatic conditions, and international regulations, are bound to affect entire agricultural supply chains that often stretch across countries and continents. Understanding emerging risk factors and the way they may affect Canada's agriculture sector and society's needs and expectations is in the interest of not only producers and the wider industry but also federal agencies who fundamentally affect the success of the sector through anticipatory policy regimes.

Last year (2007) was a unique year for international assessments given that several multi-year science assessments released their reports, including the Global Environment Outlook (GEO); and the fourth report of the International Panel on Climate Change (IPCC). The International Assessment of Agricultural Science and Technology for Development (IAASTD) released drafts that are currently under review.

Structure of this Report

This IISD report is an interpretive analysis of the findings of the three aforementioned assessments. It summarizes the results of each assessment (in the Annex to this document) using agriculture as its reviewing lens and identifies and analyzes the main implications of these findings for Canadian agriculture in light of AAFC's policy goals (in this main document).

Thus, this report consists of two documents: the main report and an Annex. The goal of this main report is to present the analysis. It first outlines the methodology by which the analysis was undertaken. Then, it provides context by briefly introducing the three scientific assessments and describing the overarching drivers of change they identify and presenting the key policy options they advocate. All three assessments present the findings of scenario exercises based on various assumptions and choices about the future. This report also briefly describes these scenarios since they are referred to in the summaries in the Annex and influence some of the interpretive analysis and conclusions. Finally, the report concludes by looking at the usefulness of the three assessments for AAFC's purposes and proposing a number of questions that may stimulate further reflection on the future of agriculture in Canada.

METHODOLOGY

Structural Framework to Summarize the Assessments

The three assessments were scrutinized with a view to extracting the findings of most relevance to Canadian agriculture. To avoid repetition and redundancy, rather than summarize each assessment separately, the material drawn from them was organized under 11 topic headings: climate change; land degradation; urban sprawl; biodiversity; water quality; water supply; biotechnology; energy production and use; consumer demand; human health; and trade and markets. These 11 themes were selected by synthesizing the subjects covered by the three assessments and focusing on those of most pertinence to agriculture in Canada. Identification of these themes was also guided by AAFC's three policy priorities that provided a focus for the analysis, as described below. The summaries focus on current and emerging drivers and trends in the agricultural sector and their potential impacts on AAFC policies. These summaries inform the analysis, but given the length of the text, they have been assembled in the Annex to this document.

Conceptual Framework for the Interpretive Analysis

Analysis of the findings is based on AAFC's common vision and associated set of priorities outlined in *Growing Forward: Toward a New Agricultural Policy Framework,* which provides the basis for governments to work towards a new Agricultural Policy Framework (APF). The three priority areas are as follows:

- Focusing on building a competitive and innovative sector;
- Ensuring the sector contributes to society's priorities;
- Being proactive in managing risks.

This report's interpretive analysis recognizes that AAFC aspires to broaden the competitive success of the agriculture sector by supporting innovation and competitiveness. It understands AAFC's aim to modernize regulatory systems, improve regulatory cooperation across Canada and support a market-driven approach in the agri-food and agri-product sector as means to improve competitively. In its analysis, IISD also accounts for AAFC's concern to respond to Canadian society's priorities, as citizens become increasingly health-conscious and environmentally aware and demand more information, choice, and safety in food provision. Finally, this report also considers AAFC's goal to support more flexible government programs that help the sector be proactive at managing risks that are beyond its control, such as weather, disease and fluctuations in international markets (AAFC, 2007).

Interpretation is based on the assumption that the competitiveness and risk management objectives focus on the primary agriculture sector in the short term (1-5 years) while social issues are assessed in terms of their importance for the Canadian public as a whole.

The analysis places the three desired policy outcomes (an agricultural sector that is (1) competitive and innovative, (2) contributes to society's priorities, and (3) proactively manages risk) within the discussion of each of the 11 issues or themes. It focuses on the impacts of the findings related to each issue on the three AAFC policy outcomes. It also provides some thoughts about the implications of the analysis on potential future scenario planning.

The meta-critique evaluation uses a subjective weighting scheme, employing the terms "small," "moderate," "large" and "unclear" to help AAFC assess the extent and degree to which the status and trends in each issue as identified in the assessments are likely to affect AAFC's three policy goals. It is important to note that these terms are not used in a consistent, scientific manner. Rather, they reflect a general perception of the issue as presented in the documents and interpreted through the authors' subjective judgments; they are not magnitudes derived from an objective and scientific research of the issue.

Symbols are used to indicate the direction of perceived impact: positive, negative or unclear. In many cases, there are tradeoffs that temper negative or positive outcomes, as when perceived large negative impacts are offset by different factors that have positive impacts or opportunities, for example. The discussion highlights where there are such tradeoffs between outcomes within a given issue or among issues for a given policy outcome.

THE THREE MULTI-YEAR SCIENTIFIC ASSESSMENTS

The Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) was awarded the Nobel Peace Prize in 2007 for its efforts to disseminate knowledge about climate change through its comprehensive review of climate change research in the Fourth Assessment Report, *Climate Change 2007,* (referred to hereafter as AR4).

The IPCC was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme. It provides assessment reports about the state of scientific, technical and socio-economic information and knowledge on climate change and produces special reports at the request of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). Four assessment reports have been completed to date: in 1990, 1995, 2001 and 2007.

The most recent assessment—the AR4, released in 2007 and the assessment summarized in this report—represents six years of work and input from more than 450 lead authors and more than 800 contributing authors. Some 2,500 experts reviewed the draft documents. AR4 is structured in three volumes, one for each Working Group, and a synthesis report of key findings. Working Group I (WGI) addresses the scientific aspects of the climate system and climate change; Working Group II (WGII) looks at the vulnerability of socioeconomic and natural systems to climate change, the negative and positive consequences of climate change, and adaptation options; and Working Group III (WGIII) proposes options for limiting greenhouse gas emissions and otherwise mitigating climate change.

The IPCC has a well-established role assessing peer-reviewed research in a multi-state review process to reflect global scientific consensus in an apolitical manner. IPCC reports are frequently used as the basis for decisions made under the UNFCCC Convention. The first assessment report of 1990 was submitted to the UN General Assembly, which responded by formally recognizing that climate change required global action and launching negotiations that led to the adoption of the UNFCCC. Subsequent assessment reports played a major role in the negotiations leading to the Kyoto Protocol and the recent Bali Roadmap. At COP 13 in December 2007 in Bali, Parties to the Convention welcomed the AR4, recognizing the report as the most comprehensive and authoritative assessment of climate change to date, and urged Parties to make use of the information for negotiations on future action on climate change and in the development of national policies on climate change.

International Assessment of Agricultural Science and Technology for Development (IAASTD)

The International Assessment of Agricultural Science and Technology for Development (IAASTD) is a three-year collaborative effort (2005 - 2007) that assesses agricultural knowledge, science and technology (AKST) in terms of how they meet the development and sustainability goals of reducing hunger and poverty; improving nutrition, health and rural livelihoods; and facilitating social and environmental sustainability. The IAASTD was launched as an intergovernmental process, with a multi-stakeholder Bureau, under the co-sponsorship of the FAO, GEF, UNDP, UNEP, UNESCO, the World Bank and WHO. The project is a major global initiative, developed out of a consultative process, involving 900 participants and 110 countries from all regions of the world.

The IAASTD products are composed of one eight-chapter Global Assessment and five multi-chapter Sub-global Assessments, all of which use the same basic framework related to the overall purpose. Different teams prepared the Sub-global assessments simultaneously with the Global Assessment. A separate Synthesis Report combines the major points of all of the reports and highlights findings from crosscutting thematic issues. In its synthesis report, the IAASTD organized its findings of the global and sub-global assessments into the following eight topics: bioenergy; biotechnology; climate change; human health; natural resource management; trade and markets; traditional and local knowledge; community-based innovation; and women in agriculture. Canada is part of the North America and Europe (NAE) Sub-global assessment.

The Global and Sub-global assessments have been peer-reviewed by governments and experts, and approved by the Panel of participating governments. They form the basis for discussion planned for an Intergovernmental Plenary to have taken place on 14-19 January 2008 in Nairobi, Kenya. Due to the unrest and conflict in Kenya after the January elections, this Plenary was postponed and re-located. It will take place from 6-12 April 2008 in Johannesburg, South Africa.

It is important to note that the IAASTD documents referred to in this IISD report are still in draft form and are not to be cited. *Also, new drafts were posted on the IAASTD web site (http://www.agassessment.org/index.cfm?Page=Plenary&ItemID=2713) in March, after this report had been completed. The chapters referred to in this IISD report are dated November 2007.*

The IAASTD's conceptual framework is based on the recognition of the role of local and traditional knowledge in addition to science and technology, and in its adoption of the concept of multifunctionality. The latter term characterizes agriculture as having multiple functions in terms of sustaining economic, environmental, social and cultural goals, and producing multiple outputs, including ecosystem services, landscape amenities and cultural heritage, in addition to the traditional commodities of food, fodder, fibres and biofuels (IAASTD SYR: (IAASTD, 2007c).

GEO-4

The Global Environment Outlook (GEO) project is the implementation of the United Nations Environment Programme's (UNEP) mandate to keep the global environment under review. Initiated at the request of the UNEP Governing Council in 1995, GEO is both a process and a series of reports, analyzing environmental change, causes, impacts, and policy responses. It provides information for decision-making, supports early warning and builds capacity at the global and sub-global levels. GEO is also a communication process that aims to raise awareness about environmental issues and provide options for action. GEO-4 was prepared through a consultative process that included about 390 experts and more than 1,000 reviewers across the world.

GEO-4 uses the DPSIR framework for its analysis (Driving Forces, Pressures, State, Impact, Response), describes the changes since 1987 when the Word Commission on Environment and Development released *Our Common Future* (the Brundtland report), and focuses on *Environment for Development* as its underlying theme. The report places sustainable development at the core of the assessment, particularly on issues dealing with intra- and intergenerational equity. It pays special attention to the role and impact of the environment on human well-being and vulnerability.

GEO-4 is an overall global assessment of the state of the environment, with examples and case studies drawn from all parts of the world. GEO-4 structures its assessment under the following headings: atmosphere; land; water; biodiversity; regional perspectives; vulnerability of people and the environment; interlinkages; the outlook towards 2015 and beyond; and options for action. Chapter 6 looks in more depth at each of the seven world regions focusing on a selected set of priority issues that differ for each region. The North American section, which comprises Canada and the United States, addresses energy use and climate change, urban sprawl, and freshwater stresses.

OUTLOOKS IN THE THREE ASSESSMENTS

All three assessments make use of scenarios to aid decision makers visualize the future, depending on different choices and assumptions. These assumptions and the main conclusions of the scenario exercises are summarized below. Details about the potential futures for each of the 11 issues analyzed in this report are provided in the Annex.

IPCC Scenarios

Scenarios used in the IPCC reports provide projections that are widely used in assessments of future climate change. The scenarios use model simulations that cover a range of possible futures including idealized emission and concentrations assumptions. In comparison to the earlier Third Assessment Report, the AR4 report relies on a larger number of climate models of increasing complexity.

Box 1: IPCC's four scenario families

The A1 storyline assumes a world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1FI), non-fossil energy resources (A1T), and a balance across all sources (A1B).

B1 describes a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy.

B2 describes a world with intermediate population and economic growth, emphasizing local solutions to economic, social, and environmental sustainability.

A2 describes a very heterogeneous world with high population growth, slow economic development and slow technological change (IPCC WG1, 2007, 18).

The SRES scenarios refer to the scenarios described in the IPCC Special Report on Emission Scenarios (2000), and are grouped into four scenario families (A1, A2, B1, and B2) that explore alternative development pathways, covering a wide range of demographic, economic, and technological driving forces and resulting GHG emissions (Box 1).

Table 1: Estimates of global average surface air warming under IPCC scenarios

	Temperature change (°C at 2090-2099 relative to 1980-1999) [a, d]		Sea level rise (m at 2090-2099 relative to 1980-1999)
Case	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant year 2000 concentrations [b]	0.6	0.3 – 0.9	Not available
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Notes:

a) *These estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth Models of Intermediate Complexity, and a large number of Atmosphere-Ocean General Circulation Models (AOGCMs) as well as observational constraints.*

b) *Year 2000 constant composition is derived from AOGCMs only.*

c) *All scenarios above are six SRES marker scenarios. Approximate CO_2-eq concentrations corresponding to the computed radiative forcing due to anthropogenic GHGs and aerosols in 2100 (see p. 823 of the WGI TAR) for the SRES B1, AIT, B2, A1B, A2 and A1FI illustrative marker scenarios are about 600, 700, 800, 850, 1250 and 1550 ppm, respectively.*

d) *Temperature changes are expressed as the difference from the period 1980-1999. To express the change relative to the period 1850-1899 add 0.5 °C.*

Source: IPCC WG1, 2007,13

Table 1 shows best estimates and likely ranges for global average surface air warming for the six SRES emissions marker scenarios (including climate-carbon cycle feedbacks).

IAASTD Scenarios

IAASTD NAE reviews the key global scenario exercises undertaken by various institutions and organizations that have relevance to the future of AKSTD. At the global level, quantitative projections indicate that demand and supply factors, including population and economic growth and rapid increase in demand for meat and dairy products, will lead to tightened world food markets, increased resource scarcity and rising food prices. Bioenergy is expected to compete with land and water resources. “Higher prices can benefit surplus agricultural producers, but can also reduce access to food for a larger number of poor consumers, including farmers who do not produce net surplus for the market. As a result, progress in reducing malnutrition is projected to be slow” (IAASTD NAE 5: (de Lattre-Gasquet, 2007), p. 12).

Scenarios suggest that the NAE region will continue to produce for and export to other world regions to help satisfy demand and that land and water are the most limiting resources to the

production of food and other goods provided by agroecosystems (IAASTD NAE 5: (de Lattre-Gasquet, 2007). Chapter 5 NAE summarizes the risks for the future of AKSTD in North America: "NAE agrifood systems will continue to face long-standing problems to increase the output level of agricultural products and services without jeopardizing … the natural resource base … . The conclusion of a number of recent global and regional foresight exercises on agriculture, rural development and environment is that business as usual will not be good enough. Consumers, producers and information providers will have to rapidly recognize and respect the physical limits of the planet and the biological equilibriums needed to ensure long-term survival. New responses must be found" (IAASTD NAE 5: (de Lattre-Gasquet, 2007), p. 2).

Box 2: IAASTD's four normative scenarios of agricultural innovation systems

- In a *Market-led AKST* future, multinational corporations and other private sector actors play a major role and public policies and consumer protection are reactive. Policies focus on trade liberalization and ensuring free competition. Such a future could decrease hunger and poverty and improve nutrition and human health, but would likely contribute little to equity and sustainable economic development.
- In an *Ecosystem-oriented AKST* future, increased government intervention and strong input from the public sector leads to regulations, taxation, subsidies and international standards to internalize environmental externalities. Precision farming and GMOs are widely implemented. This scenario has potential to increase equity, but it lacks emphasis on societal needs.
- In the *Local food-supply led AKST* scenario, research tends to ignore growing problems such as water scarcity, soil depletion and socioeconomic viability of agricultural systems, especially if efforts are not coordinated and if budget cuts are instituted. Such as future would not contribute to development and sustainability goals.
- The *Local-learning AKST* scenario is characterized by cross-sectoral public-private governance emphasizing regional and local decision making informed by subsidiary and bottom-up approaches. Subsidies help to internalize positive ecological, socio-cultural and economic externalities. This scenario could enhance equity and environmental sustainability, especially within the regions (IAASTD NAE 5: (de Lattre-Gasquet, 2007), p. 6-7, 95-100).

Chapter 5 also highlights four normative agricultural innovation systems (Box 2). These are referred to in several of the issues summarized in the Annex.

GEO-4 Scenarios

Box 3: GEO-4's Four Scenarios

- *Markets First:* the private sector, with active government support, pursues maximum economic growth as the best path to improve the environment and human well-being;
- *Policy First:* government, with active private and civil sector support, initiates and implements strong policies to improve the environment and human well-being, while still emphasizing economic development;
- *Security First:* government and private sector compete for control in efforts to improve, or at least maintain, human well-being for mainly the rich and powerful in society;
- *Sustainability First:* government, civil society and the private sector work collaboratively to improve the environment and human well-being, with a strong emphasis on equity.

(GEO-4 9: (Rothman et al., 2007).

Box 3 describes the main assumptions of the four scenarios developed in the GEO-4 report. In all scenarios, the use of land for traditional agricultural purposes – food crops and pasture and fodder – increases more in regions where arable land is still available, notably Africa, and Latin America and the Caribbean. There are differences among scenarios regarding reliance on land expansion versus aggressive improvements in agricultural yields. In *Security First*, agricultural land expansion is the smallest, since low economic growth limits land acquisition. In *Markets First,* increased demand for land is partially compensated for by technological developments, whereas in *Sustainability First*, such improvements are counterbalanced by greater concern for food availability. In *Policy First* and *Sustainability First*, which include strong targets to mitigate GHGs, demand is greater for land to produce of biofuel crops. The impacts of these scenarios on agriculture and food are explored in more detail in some of the issues summarized in the Annex.

DRIVERS

The three assessments point to a number of overarching drivers that steer the course and depth of the changes to the issues summarized in the Annex.

IPCC outlines human and natural direct drivers of climate change, focusing on changes in the atmospheric concentration of greenhouse gases and aerosols, in solar radiation and in land surface properties. Advances since earlier IPCC reports suggest that most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations (IPCC WG1 2007, 10). Human activities affecting increased concentrations in carbon dioxide, for example, result directly from increasing fossil fuel use and land-use change. Increased methane is attributed to anthropogenic activities, predominantly in agriculture and fossil fuel use (IPCC WG1 2007, 2-3)

According to IAASTD's framework, direct drivers of change include food demand and consumption patterns, land use change, the availability and management of natural resources, climate and climate change, energy and labour, as well as the development and use of agricultural knowledge, science and technology (AKST). Indirect drivers are demographic, economic, and sociopolitical factors (IAASTD G 1: (Hurni and Osman-Elasha, 2007).

GEO-4 distinguishes between drivers and pressures: drivers are fundamental processes in society that drive activities with a direct impact on the environment, including demographics; consumption and production patterns; scientific and technological innovation; economic demand, markets and trade; distribution patterns; institutional and social-political frameworks; and value systems. Pressures, on the other hand, have direct impacts on environmental resources and services and include the emission of pollutants and waste, external inputs such as fertilizers, chemicals and irrigation; land use; resource extraction; and the modification and movement of organisms (GEO-4: (UNEP, 2007).

Trends in the following overarching driving forces have most significance for the agriculture and food sectors and the issues summarized in the Annex. In addition, the following issues in the Annex are key drivers or direct pressures themselves: climate change, consumer demand, biotechnology, urban sprawl, energy use and production, and markets and trade.

Population and Economic Growth, and Food Demand

The global population has continued to rise over the past 20 years, increasing from 5 billion in 1987 to 6.7 billion in 2007, with an average annual growth rate of 1.4 per cent (GEO-4 1: (Martino and Zommers, 2007). It is projected that the world's population will rise to over 9 billion by 2050 (GEO-4 3: (Dent, 2007). While Europe and North America's populations will remain essentially the same, between 2007 and 2050, the population of less developed regions is projected to grow from 5.4 to 7.9 billion. About 67 percent of the global population will live in less-developed regions, 19 percent in least-developed nations and 14 percent in the world's more developed regions (IAASTD NAE 5: (de Lattre-Gasquet, 2007).

Rural migration and natural growth are fueling increased urbanization, particularly in developing countries. By the end of 2007, for the first time in history, more people lived in cities than in rural areas. These changing demographic patterns alter land use and the demand for ecosystem services (GEO-4 1: (Martino and Zommers, 2007).

As the human population rises, so does the demand for food. Food consumption has increased in all regions of the world over the past 20 years, and economic and population growth, as well as urbanization will drive continued increases (GEO-4 1: (Martino and Zommers, 2007). Rising

incomes in some developing regions will continue to stimulate the ongoing shift from cereal to meat consumption. Along with over-consumption and waste of food, it will lead to a 2.5 to 3.5 increase in food demand (GEO-4 3: (Dent, 2007). “Between 1962 and 2003 *per capita* meat consumption grew by a factor of 2.9, and milk by 1.7 in developing countries” (IAASTD G 3: (Leakey and Kranjac-Berisavljevic, 2007).

Table 2: Global land use – areas unchanged (thousands km2) and conversions 1987–2006 (thousands km2/yr)

From \ To	Forest	Woodland/ Grassland	Farmland	Urban areas	Losses	Gains	Net change
Forest	39 699	30	98	2	–130	57	–73
Woodland/Grassland	14	34 355	10	2	–26	50	24
Farmland	43	20	15 138	16	–79	108	29
Urban areas	n.s.	n.s.	n.s.	380	0	20	20
Total					–235	235	

n.s. = not significant; farmland includes cropland and intensive pasture

Source: GEO-4 3: (Dent, 2007) p. 86

To meet the Millennium Development Goal to halve the number of hungry people by 2015, a doubling of global food production will be required (GEO-4 3: (Dent, 2007). In the short-to-medium term, production is expected to meet demand, but since 11 percent of the world’s land is already under agricultural production and water is scarce in many regions, there is little room for expansion and land will need to be used more intensely (GEO-4 1: (Martino and Zommers, 2007). Table 2 shows that farmland occupies 15,138,000 km^2 of global land area and that there was a net gain of 29,000 km^2 each year between 1987 and 2006 at the expense of forests, woodlands and grasslands.

Production per hectare increased dramatically over the past few decades; cereal yields increased by 17 per cent in North America, 25 per cent in Asia, 37 per cent in West Asia, and 40 per cent in Latin America and the Caribbean, but remained the same or declined in Africa (Dent, 2007). Despite the increase in average cereal yields, production per person peaked in the 1980s and declined slowly since. Some of the reasons include land degradation and loss, agricultural policies in regions of surplus, limitations to current technology, increased urbanization, and market competition from other land uses (GEO-4 3: (Dent, 2007).

The intensification of land already in use will compromise the productive capacity of many agroecosystems that will increasingly be stressed by water scarcity and soil degradation (IAASTD G 1: (Hurni and Osman-Elasha, 2007).

Developing countries experiencing population growth rates, economic growth, rising income levels, concerns about food safety and burgeoning urbanization, will shape the global pattern of food demand for cereals, sugar and oil crops, produce, livestock and fish (IAASTD G 1: (Hurni and Osman-Elasha, 2007). The rise in these demands outside the North American region will influence the availability of natural resources and the approach to land management within the region; questions remain about how North America will respond to these demands (IAASTD NAE 5: (de Lattre-Gasquet, 2007).

“In the future, the NAE region will be concerned with food demand from its own population and the needs of the rest of the world, especially the less developed countries. How will NAE respond to the need to feed the growing populations of Africa and Asia and the need to ensure environmental sustainability in these regions?” (IAASTD NAE 5: (de Lattre-Gasquet, 2007).

Within North America, affluent consumers are less concerned about food supply than food safety and nutrition. They are also more informed about environmental issues and are likely to be willing to pay for environmental services associated with agricultural production (IAASTD NAE 5: (de

Lattre-Gasquet, 2007). One result is that the demand for organic produce in North America has increased significantly. North American producers are unable to match supply with demand and much organic food is imported (IAASTD NAE 2: (Hendrickson and Miele, 2007). “The higher labor requirements of organic farming provides a comparative advantage to developing countries with relatively low labor costs” (IAASTD G 3: (Leakey and Kranjac-Berisavljevic, 2007).

Globalization and Trade

Globalization, characterized by the integration of the global economy through flows in trade, finance, knowledge, technology and culture, has and continues to have implications for the environment and land use as well as the agriculture sector. The environment and globalization are intrinsically linked as they create opportunities and challenges for each other. As an example, agricultural profits increase when international grain prices rise, which can result in the expansion of farming into forested areas. Another example is that international trade can exacerbate environmental problems when production subsidies promote over-production (GEO-4 1: (Martino and Zommers, 2007).

Both IAASTD and GEO-4 recognize that globalization is an indirect economic driver with enormous impacts on agricultural trade and markets. This is especially the case since its increase over the past 30 years due to lower transportation and communication costs. For many countries, globalized trade has led to the availability of seasonal agricultural products all year round. It has also increased competition such that nations attempt to institute policies to favour their own farmers, such as providing subsidies. Trade liberalization and multilateral trade agreements, such as the North American Free Trade Agreement, are also important indirect drivers of change in the agricultural sector. “Agricultural trade policies and subsidies in NAE tend to undermine the achievement of development goals in other parts of the world. There is uncertainty about whether the World Trade Organization will be effective in harmonizing approaches to internal subsidies, and about whom is likely to benefit, how much and for how long if NAE subsidies are removed” (IAASTD NAE 5: (de Lattre-Gasquet, 2007) p. 3, 49-50; GEO-4 1: (Martino and Zommers, 2007) p. 25-26).

Energy Demand

Global energy demand continues to grow at an average rate of 1.4 percent per year (between 1990 and 2004) (IPCC WGIII, 2007, 43). The projected rapid population growth in developing countries and need for increased food production will require a further increase in fossil energy consumption for agricultural production. Simultaneous structural changes in the economy and decreased labour supply in the agriculture sector will lead to further intensification and result in a significant increase in energy consumption for food processing. It is expected that these developments could increase the demand for energy in the agriculture sector, albeit at a lower rate than overall energy consumption growth (IAASTD G4: (van Vuuren et al., 2007).

The growing global demand for energy and the threat of inadequate, insecure and expensive energy supplies has led to the growth in alternative energy sources, including biofuels. There has been an increase in the share of the US maize crop to produce bioethanol, for example, fueling concerns about threats to food production (IAASTD NAE 3:(Lutman and Marsh, 2007). The growth in biofuels has been aided by subsidies for bioethanol and biodiesel from maize and oilseed rape (IAASTD NAE 2: (Hendrickson and Miele, 2007). It is predicted that the North American agriculture sector will become a major source of energy, especially with growing energy needs in China and India, which will increase the competition between the production of food and fuel, and potentially make it difficult to meet greater demands for meat (IAASTD NAE 5: (de Lattre-Gasquet, 2007). Pressures to grow biofuels could mean crops will be grown on marginal lands, with threats to highly erodible soils as well as to wetlands, protected areas and forests and the environmental services these lands provide (IAASTD NAE 3: (Lutman and Marsh, 2007; IAASTD NAE 2: Hendrickson and Miele, 2007; IAASTD G 6: Gurib-Fakim and Smith, 2007).

Science, Technology and Information Development

"Large multinational companies are increasingly influencing priorities and investments in agricultural science and technology and are highly involved in agricultural extension. Some consider this trend as positive, others as negative". There is insufficient public funding in science and technology to address agricultural problems, including responding to consumer demands and supporting sustainability. Research on issues such as food security and safety, sustainability, and climate change is restricted, with negative impacts on partnerships with other world regions. Although the number of students in "sustainability programs" in NAE is increasing, few have agricultural backgrounds. Larger R&D budgets and better R&D results in Asia are changing the relationship of NAE research with that of the rest of the world. This could lead to more networking and increased competition among agriculture, industry and services" (IAASTD NAE 5: (de Lattre-Gasquet, 2007), p. 5-6).

POLICY OPTIONS

The three assessments refrain from advocating specific policies; by offering options for action, they are "policy relevant, but not policy prescriptive". This section briefly summarizes the overarching policy approaches suggested by the literature. Policy options more specifically oriented to each of the 11 issues are summarized in the Annex.

GEO-4 notes that North America has had particular success in addressing conventional environmental problems but that there are emerging and persistent issues that still need policy action (GEO-4 6: (Barr and Mafuta, 2007). IAASTD notes that despite the region's efforts to reduce environmental degradation, policies and new technologies have been inadequate to reverse unsustainable trends (IAASTD NAE 5: (de Lattre-Gasquet, 2007). It reports that the large and growing ecological footprint of industrial agriculture requires the institution of policies that promote the more rapid uptake of proven AKST-based mitigation and adaptation solutions to curb or reverse this trend while maintaining adequate food production (IAASTD SYR (IAASTD, 2007c).

"Public policy, regulatory frameworks and international agreements are critical to implementing more sustainable agricultural practices. These policies need to be informed by broad-based evidence from natural and social sciences with multistakeholder participation" (IAASTD G SDM: (IAASTD, 2007a).

Box 4: IAASTD's concept of multifunctionality

"The concept of multifunctionality recognizes agriculture as a multi-output activity producing not only commodities (food, fodder, fibers and biofuels), but also non-commodity outputs such as ecosystem services, landscape amenities and cultural heritages" (IAASTD, 2007a). "Activities and services such as mitigating climate change, regulating water, controlling erosion; and support services such as soil formation, providing habitats for wildlife, as well as cultural activities such as use and preservation of landscapes and spiritual sites are also involved" (IAASTD G 1: (Hurni and Osman-Elasha, 2007). It focuses on the tradeoffs inherent in choices about resource use, and emphasizes the importance of adapting to local environmental and social contexts" (IAASTD G SDM: (IAASTD, 2007b).

At the broadest and highest level of understanding, the IAASTD maintains that agricultural policies should be based on the concept of multifunctionality, which acknowledges that agricultural activity is not solely concerned with the production of commodities, but also with services that sustain ecosystems and human livelihoods and culture (Box 4) (IAASTD G 6: (Gurib-Fakim and Smith, 2007).

Box 5: GEO-4's fundamental concept: the environment is the foundation for development

Development is the process of furthering people's well-being. Good development entails:

- increasing the asset base and its productivity;
- empowering poor people and marginalized communities;
- reducing and managing risks; and
- taking a long-term perspective with regard to intra- and intergenerational equity.

The environment is central to all four of these requirements. Long-term development can only be achieved through sustainable management of various assets: financial, material, human, social and natural. Natural assets, including water, soils, plants and animals, underpin the livelihoods of all people. At the national level, natural assets account for 26 per cent of the wealth of low-income countries. Sectors such as agriculture, fishery, forestry, tourism and minerals provide important economic and social benefits to people. The challenge lies in the proper management of these resources. Sustainable development provides a framework for managing human and economic development, while ensuring a proper and optimal functioning over time of the natural environment" (GEO-4 1: (Martino and Zommers, 2007).

GEO-4 stresses that future policies and action to address environmental change need to focus on the fact that the environment, including productive land and soil resources, is the basis of economic and social security. GEO-4's theme is "environment for development" (Box 5). It cites one of the main findings of the Millennium Ecosystem Assessement: services provided by ecosystems (such as healthy soils) mediate the relationship between human well-being and the natural environment and changes to these services affect human security, material needs, health and social and cultural relations. The world's poor are particularly vulnerable to environmental change, especially those who derive their livelihoods from the environment (GEO-4 1: (Martino and Zommers, 2007). Thus, both IAASTD and GEO-4 adopt the Millennium Ecosystem Assessment's focus on maintaining the viability of ecosystem goods and services.

IAASDT calls for an ecological and evolutionary approach that allows for the understanding of specific ecosystems and the ecological principles by which they function for both productivity and conservation (IAASTD NAE 6: (Lefort and Wright, 2007). The global assessment states that "[a] systematic redirection of AKST towards agroecological strategies is needed to address environmental issues. Formal, traditional and community-based AKST need to respond to increasing pressures on natural resources, such as reduced availability and worsening quality of water, degraded soils and landscapes, loss of biodiversity and agroecosystem function, etc" (IAASTD SYN: (IAASTD, 2007c).

IPCC notes that climate-related policy instruments are rarely applied in complete isolation given the cross-cutting issues that the policies affect relating to forestry, agriculture, energy, transport, among others (IPCC WGIII, 2007, 748). Likewise, policy options for a global climate change regime are inherently linked to actions taken by national and sub-national governments, the private sector and other areas of civil society. The assessment stresses that an effective carbon-price signal (by way of policies including economic instruments, government funding and regulation) could realize significant mitigation potential in all sectors, including agriculture. IPCC's focus on climate change policies and measures notes that various instruments exist to directly control GHG emissions or manage activities that indirectly lead to GHG emissions (IPCC WGIII, 19).

One of the main findings reported in GEO-4 is that new policy approaches are needed to shift environmental policy making to the core of decision-making through structural changes that will mainstream environmental planning into the various governmental sectors and to introduce a more holistic approach to planning and implementation (GEO-4 10: (King et al., 2007). "[T]he usual focus on technical aspects misses the more complex, underlying political and economic issues that must also be addressed" (GEO-4 3: (Dent, 2007).

It also notes that environmental policies need to not only reduce pressures on the environment, but also address the driving forces of environmental change, such as population and economic growth, consumption, globalization and social values. It cites a number of policy options that could be applied to this goal, including the use of green taxes, creation of markets for ecosystem services and use of environmental accounting. Much experience has already been gained in implementing these approaches (GEO-4 10: (King et al., 2007).

In addition, GEO-4 notes the urgent need to monitor policy effectiveness so as to adapt management to perceived strengths and weaknesses; to use aggregate indicators to take into

account the use of natural capital; and to educate the public and involve them more in decision making (GEO-4 10: (King et al., 2007).

IAASTD stresses the need to improve the adaptive capacity of agricultural knowledge, science and technology, which will not only address the impact of global environmental change but will also benefit the sector (IAASTD NAE 5: (de Lattre-Gasquet, 2007). It notes the importance of improving the interactions between North America and other world regions especially in respect to empowering other nations and peoples. It is essential to develop AKST in the North American region to further international development and sustainability goals to reduce hunger and poverty, strengthen rural livelihoods and health and improve equity in all the world's regions. It strongly recommends that a two-way sharing point be adopted in terms of the region's international relations: "AKST institutions in NAE need to be ready to participate actively with AKST institutions in other regions in addressing the IAASTD question" (IAASTD NAE 6: (Lefort and Wright, 2007).

In short, some of the main policy options suggested in the assessments include (but are not limited to) the following:

- Implement more fully and further develop treaties and conventions that promote development and sustainability goals;
- Shift environmental policy making to the core of decision-making and introduce a more holistic approach to planning and implementation;
- Develop policy instruments to internalize current environmental and social externalities of agricultural production, and reward the provision of agroenvironmental services;
- Establish a more multifunctional approach to AKST that entails new, increased and more diverse funding and delivery mechanisms for agricultural R&D and human capacity building;
- Systematically redirect formal, traditional and community-based AKST towards agroecological strategies to address environmental issues;
- Direct environmental policies to address the driving forces of environmental change, such as population and economic growth, consumption, globalization and social values;
- Monitor policy effectiveness so as to adapt management to perceived strengths and weaknesses;
- Develop AKST in the North American region to further international development and sustainability goals to reduce hunger and poverty, strengthen rural livelihoods and health and improve equity in all the world's regions;
- Develop policy instruments to remove incentives for farm concentration and agribusiness concentration;
- Develop strategies to counteract detrimental effects of the agrifood system on climate change, and reduce its vulnerability to such change;
- Understand the processes and consequences of international trade and market liberalization, and identify actions to promote fair trade and market reform;
- Improve the sustainability of local and regional food and farming systems.

(IAASTD NAE SDM (IAASTD, 2007b); GEO-4 10: (King et al., 2007).

Market mechanisms and investment

This section outlines some of the market approaches and investment opportunities that the literature suggests policy options could support.

Market mechanisms, including "payment/reward for environmental services" (PES), help internalize agricultural production's environmental externalities and reward the protection of agroenvironmental services. Such mechanisms effectively stimulate the adoption of sustainable agricultural practices, improve natural resources management, and benefit small-scale farmers and local communities. Sustainable agricultural practices include low-input/low-emission production, conservation tillage, watershed management, agroforestry practices and carbon sequestration. Market approaches include carbon and pesticide use taxes that provide incentives

to attain international or national reduction targets, carbon-footprint labeling of food and the certification of sustainable and organic agriculture. Market incentives can also promote IPM and environmentally resilient germplasm management, alternative markets such as green products, and local markets (IAASTD SYN: (IAASTD, 2007c). Investments that support research into these types of payment and incentive schemes could be encouraged (IAASTD G 8: (Beintema and Koc, 2007).

Chapter 10 of GEO-4, which looks at potential policies to address the threats to sustainability outlined in the report, notes that many large economic sectors, including agriculture, depend heavily on natural resources and ecosystem services and suggests that tangible economic returns can be had through investing in the protection of environmental assets. It cites a 2005 study by Pearce, who reviewed 400 efforts to quantify such returns. Using conservative assumptions, the benefit-cost ratio of conserving soils was 1.5:1 – 3.3:1 (GEO-4 10: (King et al., 2007).

Methods to evaluate ecosystem services are improving and soon site-specific valuation will be possible. Expertise on multicriteria analysis and participatory approaches will be required to apply tradeoff analysis to help design multifunctional rural landscapes (IAASTD G 6: (Gurib-Fakim and Smith, 2007).

PES and other price signals such as user fees, taxes, subsidies and grants by IFIs, donor organizations and NGOs that internalize environmental externalities will help to address the impacts of intensive export-oriented agriculture, such as the export of soil nutrients and unsustainable soil and water management. An example is the US Conservation Reserves Program, which funds farmers to remove sensitive lands from production so as to prevent land degradation and preserve biodiversity (IAASTD G 7: (Izac et al., 2007). It is estimated that the United States government spends over US$1.7 billion a year to persuade farmers to protect land. GEO-4 notes the trade distorting nature of such subsidies should be considered, in addition to the conservation value (GEO-4 10: (King et al., 2007).

Policies that promote sustainable agricultural practices through market mechanisms and other types of incentives stimulate technological innovation. New investment policies for innovative and better-targeted AKST are needed to help alleviate growing pressures on natural resources (IAASTD SYN: (IAASTD, 2007c). Investment is needed to research AKST methods to understand and quantify their impacts, both environmental and economic, and to discover which impacts best respond to investments in AKST. IAASTD points to three types of research investments: those oriented to management approaches that reduce agriculture's ecological footprint, a second type that help develop biological substitutes for industrial chemicals or fossil fuels, and a third that support traditional knowledge of sustainable agriculture and that improve rural livelihoods (IAASTD G 8: (Beintema and Koc, 2007). Future AKST will also need to focus on increasing output per unit of land through technology and management practices that avoid the negative externalities of past investments in this area (IAASTD G 8: (Beintema and Koc, 2007).

IMPLICATIONS OF THE ASSESSMENTS' FINDINGS FOR THE AAFC POLICY FRAMEWORK

As explained in the Methodology section above, analysis of the findings reported in the three assessments is based on AAFC's common vision and associated set of priorities. The matrix (Table 3) subjectively weighs the impacts of the 11 selected issues (Column 1) according to AAFC's three main policy goals (Row 1). The subjective weighting scheme employs the terms "small," "moderate," "large" and "unclear" to help AAFC assess the extent and degree to which the status and trends in each issue as identified in the assessments are likely to affect AAFC's three policy goals. Symbols are used to indicate the direction of perceived impact: positive, negative or unclear. Direction signs are not included in the "Risk" column, since none of the issues in the first column actually reduce risk. The analysis following Table 3 explains the interpretation.

Key to Table 3
Subjective weighting of impacts: Large, Moderate, Small
Direction of impacts: + (positive); - (negative); +/- (unclear – positive and negative may offset each other)

Table 3: Extent and Direction of Impacts on Three Policy Goals

Issue	Competitiveness	Social Issues	Risk
Climate Change	Moderate-Large +	Large -	Large
Land Degradation	Unclear +/-	Moderate -	Moderate
Urban Sprawl	Small -	Moderate/High -	Small
Water Supply	Small +	Moderate -	Small
Water Quality	Small -	Large -	Small
Biodiversity	Moderate -	Small -	Small
Human Health	Small -/+	Large +	Moderate
Changing Consumer Demand	Moderate -	Moderate -	Moderate
Biotechnology	Small-Moderate +	Small-Moderate +	Small
Energy Production and Use	Small +/-	Moderate +/-	Small-Moderate
Trade and Markets	Large +/-	Large /-	Large

Interpretive Analysis

Climate Change

Competitiveness

The effects of climate change on the competitiveness of Canadian agriculture are expected to be moderate-to-large and generally positive. The projected increase in average temperature and precipitation levels in the mid to high latitude regions of the world are expected to increase yields for most sectors of Canadian agriculture. This potential increase in production potential for farm goods in Canada and the subsequent increase in competitiveness is accentuated by the likely decrease in production projected for low latitude regions. Australia and Brazil are examples of two major agricultural exporting regions that could be adversely affected by warmer temperatures and lower rainfall. The severe drought experienced by much of Australia last growing season is projected to be a more common event. The net effect of higher production levels in Canada and lower levels in other major exporting regions is an improvement in the competitiveness of Canadian agriculture.

Climate change may not only increase the relative yields for Canadian producers but may also impact positively on prices. The potential increase in the volume of agricultural exports from Canada due to the spatial differences in the effects of climate change may be associated with a higher price if there are fewer substitutes (or exporting options). Even without the higher exports that could increase the price received by Canadian farmers, the tighter world supply of commodities caused by climate change would boost average prices for all farmers globally. Previous supply shocks have been often mitigated in the last few decades by large carryover stocks. However, the ability of the system to absorb such shocks has been reduced by the significant increase in demand for agricultural commodities spurred by biofuel policy and income growth in developing countries, particularly China and India. The resulting record low stock carryover combined with the greater likelihood of weather-induced supply cuts should mean a continuation of higher prices for Canadian crop farmers. Greater market returns suggests less reliance on government aid to maintain farm incomes.

General sector policies to deal with climate change include carbon taxes and a cap-and-trade emission market. Both could have potential effects on the competitiveness of the sector. The former would likely increase fuel, fertilizer and drying expenses and thus make Canadian farm products more costly as compared to its competitors. However, a carbon market would force GHG emissions from large industrial emitters and would not likely extend to smaller emitters, such as farmers, due to the transactions costs of monitoring. Agriculture could still become part of such a market by offering offsets for sale to the large emitters. The offsets include carbon sinks through the reduction of summer fallow or increase in conservation tillage and are generally considered to be lower cost forms of mitigation than available to most industrial emitters. Thus, a carbon market implemented in response to climate change concerns could provide further revenue opportunities for Canadian farmers and thus enhance its relative competitive position.

Social Issues

The societal priorities of reducing GHG emissions and climate change effects are also large. Broader domestic effects and international impacts suggest climate change will remain a public policy concern and spur a call to action despite the generally positive impacts for Canadian agriculture stemming from climate change. Domestic effects highlighted above include ecological ones ranging from changing biodiversity (particularly in the Artic) to higher risks of forest fires and diseases. In addition to the impacts of climate change on the local environment, the Canadian public is also concerned about its effect on the world ecosystem and the effect on those in developing countries. The largest negative effects on agricultural production from higher temperatures and changing weather patterns are the developing countries in low latitude regions. The adaptive capacity of farmers in developing countries is much less than in the industrialized countries implying that droughts are more likely to have severe consequences on their livelihoods. In addition, higher commodity prices stemming from tighter stock levels will negatively affect the urban poor in developing countries as demonstrated by the recent food riots in places such as Mexico and Pakistan. The net result of domestic and international concerns by the Canadian public about the effects of climate change is the likelihood for the implementation of policies to mitigate greenhouse gases. The implication for Canadian agrifood policy is to assess which policies are under consideration and which of these will enhance the competitiveness and risk-management ability of the sector.

Risk

Although average increases in both temperature and precipitation are projected to have generally positive impacts on production levels in Canadian agriculture, the vulnerability of the sector is expected to increase significantly with the projected increases in severe weather events such as droughts or heat waves. In addition, new pests and diseases are likely to enter into the sector requiring new control methods and imposing greater stresses on the system. Thus, the effects of climate change on the need to manage risk by producers will be large.

Production risk can be mitigated through various policy options. Crop insurance is one method currently available to producers but the greater likelihood of extreme events may increase the likelihood of payouts and the financial pressures faced by the insurance providers, which are often arms-length government institutions. Policies to encourage the development of crop varieties with greater stress tolerance will also allow producers to adapt to climate change. For example, the small reduction in the 2007 Ontario corn yield despite the very dry conditions throughout most of the province was attributed to enhanced drought tolerance attributes in the common corn varieties. Informing producers of new pest species and the options for control is another mean of enabling producers to adapt to climate change.

In addition to production risk, producers are also likely to face greater price risk. Prices in the recent past were low but could not go much lower. In contrast, the current high prices could jump further with supply shocks or fall with supply increases combined with demand reductions. A policy implication associated with the greater variability in prices stemming partially from climate change is to inform producers about the higher volatility associated with the higher prices and the options for managing this price risk, such as forward contracting and hedging.

Implications for scenario planning

The appropriate mitigation and/or adaptation policies to respond to climate change depend on projections of the impacts of climate change on agriculture both domestically and globally. The scenarios examined with climate change models should focus on the increasing likelihood of extreme weather events rather than small changes in averages over a long period of time.

Land Degradation

Competitiveness

IAASTD reports that fertility loss is much greater in tropical areas than in temperate areas. In the North American region, the primary drivers of erosion are wind and rain. The effects of soil erosion will vary by crop and area.

Social Issues

Land degradation has the potential to become a component of a broad set of environmental concerns shared by many Canadians. This concern may be heightened if soil degradation increases from the use of marginal land; a scenario that may result from increased demand for crops due to the energy demand – i.e., demand for biofuels. Legislation is currently addressing this issue in Canada. For example, in the PEI, crop rotation legislation bans row crop production on farmland with slope above 9%, while requiring 30% surface residue when seeding potatoes and a winter cover crop on all conventionally-tilled land seeded to potatoes in the previous year.

Risk

The risks to farmers will depend on a number of factors including: (1) expected variation in wind and rain, (2) the area of land (particularly marginal land) in crop production (which may depend on energy policy in Canada and the U.S.), and (3) the policy response. For these reasons, particularly reason two, the risk is characterized as moderate.

Implications for scenario planning

Scenario planning should account for the changes in commodity prices that could bring into production significant amounts of marginal land. These lands are more susceptible to erosion and degradation than higher quality land that is continually in production. Thus, the extent of degradation could be directly related to crop prices and policy makers should consider the price responsiveness of crop area.

Urban Sprawl

Competitiveness

The conversion of farmland to urban development is most intense in urbanizing areas where the majority of people live. However, in Canada, total farmland area and cropland has remained fairly stable over the last twenty years. Hence, while the effect of sprawl is significant to specific areas—such as crucial high-quality fruit-growing areas like Niagara—the effect is small relative to total farmland area. For this reason, we indicate that urban sprawl is likely to have a small effect on the relative competitiveness of the Canadian Agricultural Sector.

Social Issues

Urban sprawl is likely to remain an important social issue in Canada because the majority of people live in urban areas and they are likely to be very concerned about changes in the landscape that directly affect their well being. Canada has 3 of the world's 10 most sprawling urban areas (Calgary, Vancouver, and Toronto). Urban residents may value farmland as a means of controlling urban growth and providing valued landscape amenities; on the other hand, some may find farm dirt and smells distasteful. Hence, Sprawl is likely to remain an issue that effects nearby farming. As shown in the *Consumer Demand* issue (further on), there is increasing demand from a sector of Canadian society for locally-grown foods, which may stimulate regulatory incentives for local farmers and zoning to protect agricultural land on the fringes of urban areas.

Risk

The risks to the agricultural sector will be concentrated in farming areas near the urban fringe and, while significant to some, may not be significant for the agricultural sector in general. Two risks to consider for farmers in nearby urban areas include: (1) risks to agricultural producers that emerge because sprawl leads to an increasing level of interaction (potential conflict) between farmers and new, non-farming residents and (2) risks from policy responses to sprawl which may affect land values (e.g., zoning).

Implications for scenario planning

Policy makers may want to assess the character and extent of farming in close proximity to rapidly urbanizing areas of Canada. This information will allow policy makers to better assess the extent to which sprawl is likely to affect the competitiveness of the Canadian agricultural sector. Given that sprawl is likely to remain a social concern, policy makers may want to review a variety of policies (transportation planning, zoning) that influence sprawl and determine the effect of those policies on Canadian agriculture.

Water supply

Competitiveness

The agricultural sector is responsible for 70% of all water withdrawn from freshwater sources in the NAE region (IASSTD). However, this appears to be in great contrast with Canada where agriculture consumes about 11.7% of total water (GEO-4). Data on the state of groundwater in Canada is limited, but studies suggest that most aquifers are not yet threatened by overdrafting (GE0-4). If water supply is less of a constraint in Canada than in other countries, in the short run it may provide a slight comparative advantage. On the other hand, the IPCC reports decreased precipitation in the west and the Prairies and vulnerability to extended drought as water demand from other uses increases, which puts the agricultural sector in competition with them for potentially ever-scarcer water resources.

Social Issues

Increasing demand for agricultural products that rely on irrigation will increase water withdrawals and, in some cases, may have implications for current alternative uses of water (e.g., drinking

water) and future uses. Much will depend on the rate of withdrawal, competing uses, and the specific characteristics of the water supply.

Risk

Assuming the GEO-4 assessment of Canadian water supply is correct (aquifers are not threatened by over drafting) the risk to farmers may be minimal. Risk from the impacts of climate change on water supplies are greater, however. Assessing the extent of risk will require more detailed information (See below)

Implications for scenario planning

Policy makers may want to review, regionally, water sources most affected by agricultural production. First, it will be useful to distinguish between surface water (e.g., rivers) and ground water (aquifers). Variation in the supply of surface water is likely to be greater than aquifers. In some cases, ground water may be best characterized as a depletable (rather than a renewable resource). Second, one can identify the specific areas where the character of the water source and/or the demands on the water source, imply that agricultural withdrawals may significantly affect competing uses. Given this information policy makers might review a portfolio of options identified by GEO-4 and IAASTD which include: pricing, improved irrigation techniques, artificial groundwater recharge, conservation tillage, water-saving biotechnologies, soil management, etc.

Water Quality

Competitiveness

Water quality is unlikely to have a major direct impact on the competitiveness of Canadian farmers. While agriculture has an effect on the quality of water as noted in the summary of this issue in the Annex, the reverse is not true. High levels of nitrates in groundwater or excessive nutrient levels and sediment in surface water do not affect the cost structure of Canadian farmers. The limited regions in the country relying on irrigation for their crop are more concerned about the quantity of water rather than the quality with the possible exception of salinity consequences in southern Alberta. Similarly, livestock producers have not had to adjust their practices to deal with deteriorating water quality.

While the direct impacts of declining water quality are minimal, there are possible significant indirect effects resulting from more stringent environmental regulations imposed on the agricultural sector. Municipal, and in some cases provincial, legislation are requiring farmers to complete a nutrient management plan that calculates crop nutrient needs, the required application rate, and storage/application methods to ensure excessive amounts are not used. Such plans do not impose a significant financial cost on producers and may actually reduce costs. However, tighter regulations such as stocking density restrictions or even building moratoriums, could significantly affect the competitive position of livestock production in certain livestock-intensive regions of the country. Similarly, the possibility of limits on fertilizer levels could impose higher costs on Canadian farmers relative to farmers in other regions.

Social Issues

The quality of water is arguably one of the more tangible, environmental concerns in Canada. In many cases, such as the Walkerton crisis or fish kills in PEI, the water quality problem can be associated to some degree with agricultural production systems. Thus, it is likely that one of the means to address this social issue will be to correct the problem at the source. Such legislation will not arise from the federal level although federal directives on water quality measures provide guidelines to other levels of government. Provinces have the mandate to deal with water quality and municipal governments generally dictate land use decisions, which may need to be altered to improve water quality.

Risk

The risk management consequences stemming from water quality changes are similar to that for the competitiveness of Canadian agriculture; the direct effects are minimal but the policy responses to water quality concerns could have significant risk management effects for certain sectors in livestock-intensive regions. These risks will likely be concentrated in such regions. Farmers have attempted to manage the risks of environmental policy changes by voluntarily adopting a number of stewardship measures. For example, the adoption rate of environmental farm plans is higher in more urbanized regions as farmers seek to mitigate the potential for individual liability suits regarding their practices and to reduce the potential of direct government regulations.

Implications for scenario planning

Policy makers should account for the cause-and-effect of actions, including agricultural practices, on water quality. The water quality concern and the reasons for deteriorating water quality tend to vary spatially and understanding these relationships is fundamental to designing effective policies for dealing with the problem.

Biodiversity

Competitiveness

Reductions in biodiversity from farming activities are unlikely to have any significant impact on the competitive position of Canadian agriculture in the short term. The movement toward specialization, and the resulting loss of mixed operations and subsequently biodiversity, stem from technological advancements and relative prices. The reductions in native species that can occur with specialization do not affect the competitive position of the farm sector, and arguably serve to increase it in the short run. In moderate and longer terms, however, biodiversity is fundamental to continued productivity enhancement. A diverse genetic pool is required for successful breeding programs in the crop and livestock sectors. In addition, microbial activity is a key indicator of soil quality. To maintain its competitiveness, Canada will need to maintain biodiversity to create new crop varieties and improve livestock, and to take advantage of the agroecosystem services of microbes. In fact, agro-biodiversity is required to help face all the other challenges noted in this report.

Social Issues

The loss in biodiversity associated with agriculture is not a major social issue in Canada due partially to the amount of non-agricultural land in the country. In urbanized regions, there are concerns about the maintenance of green space, which is often provided by farmland. Society's perceived amenity value of preserving land as either farmland or forest in these areas is primarily for the open, green space with less focus on the preservation of native species. Thus, relative to other social issues that impinge on agriculture (or vice versa), biodiversity ranks low.

Risk

The potential risk to Canadian agriculture from a loss in biodiversity is largely a long term one associated with the reduction in genetic stock for future plant breeding options. This risk has to be dealt with by the public and is not a risk management issue for individual producers. Conventions on Biological Diversity and the International Treaty on Plant Genetics are examples of public sector involvement to protect biodiversity and reduce risks to agriculture.

Implications for scenario planning

The critical step in scenario planning for biodiversity requires determining how the goal is to be measured. There are many attributes that could be included in a biodiversity target and little consensus on which should be included. Scenario planning to examine how to enhance

biodiversity cannot be effective without a well-defined measure and the practices that influence its level.

Human Health

Competitiveness

Human health concerns have a limited potential to have a net positive impact on the competitive position of Canadian agriculture. Negative effects could result from higher cost structures stemming from regulations to reduce the likelihood of food safety issues. An example might be the prohibition of certain antibiotics in livestock production in an effort to reduce the increase in antibiotic resistance in humans. Another cost impact may arise from greater surveillance and monitoring of animal health in order to prevent any disease spread to humans. These risks are perceived to be low as noted in the matrix in the main report, and the effect of regulations to reduce the risks on the competitive position of Canadian farmers depends on the relative stringency of the regulations as compared to other countries.

There could also be positive impacts for Canadian agriculture stemming from human health concerns that may be sufficient to offset the small, negative effects mentioned above. Food is increasingly viewed as a means to reduce the likelihood of diseases such as cancer and diabetes. Functional foods are increasingly being developed with attributes that reduce those risks and/or enhance the positive health goals, such as stronger bone density. The use of food to enhance human health is an example of a market niche that is transforming the agricultural sector from one growing commodities to one producing food products. These niches present opportunities for price premiums associated with foods having the desired health attributes.

Social Issues

The importance of health to an individual increases with age so the aging Canadian population suggests that concerns over human health and the costs of treating the increasing number of older people will continue to grow. One means to reduce these costs and enhance health quality is through prevention, which involves either exercise or diet. Thus, agriculture may increasingly become a potential solution to this pressing social issue. Note that the use of food to address human health concerns relates to its ability to lower the risk of diseases and not to the quantity of food. While food insecurity is a major issue in many regions of the world and in certain parts of Canada, the primary focus of food in terms of human health is with the treatment and prevention of diseases aside from hunger.

Risk

The risks to Canadian farmers stemming from human health are primarily related to the risks of livestock disease being transmitted to humans or the risks of bacterial contamination of primary food commodities. Production systems are increasingly designed to minimize the risks of either occurrence and are often considered part of normal farming practices. The other risk that is likely to increase is the risk of changing market niches. The risk associated with producing commodities is primarily related to price but the risks change to market and contractual risk as farmers move to negotiation coordination to deliver food products with desired health attributes.

Implications for scenario planning

The implications for scenario planning with regard to human health issues are very similar to the discussion on consumer demand below. Since food will increasingly be used to deal with obesity and disease prevention, it is necessary to understand how consumers will respond to information surrounding labels on the nutritional attributes of food and relative prices of food options.

Consumer Demand

Competitiveness

There is a small but growing demand for agricultural goods that can be differentiated from conventional agricultural products by production and delivery systems that incorporate social concerns regarding: (1) food safety, (2) perceptions of risk (e.g., European response to GMO's); (3) environmental concerns (e.g., Organic); (4) concerns about animal welfare; and (5) equity concerns (e.g., fair trade). The effect on the competitive position of Canadian agricultural ultimately depends on the size of the consumer sector concerned with the above issues. The effect on competitiveness depends on the current size and project growth of this emerging food sector. In addition, however, it is important to note that the competitive effect will depend on a number of variables including both the size of the changing consumer sector and the standards (both domestically and internationally) which govern the production and labeling of alternative foods.

Social Issues

The response of European consumers to GMO's and the emerging market for organic foods, etc., suggest that consumers and producers will, respectively, continue to demand and supply agricultural products with process attributes that reflect consumer concerns. In this way, changing consumer demand is increasingly likely to reflect social issues. In some cases, changing consumer demand may precipitate the need for new standards. For example, increasing demand for organic has led to the development of federal standards to guide organic food production in Canada. The creation of standards and the harmonization of standards (to ensure access to export markets) may themselves become social issues.

Risk

A lack of information about the standards and processes that govern the production of alternative foods will pose risks to agricultural producers and retailers seeking to produce for this market. In addition, in the presence of externalities: e.g., contamination of organic crops from synthetic pesticides or GMO's, conventional and alternative/new forms of agricultural production may conflict. Reducing this risk depends, in part, on the dynamic character of the Canadian institutions (public and private) which develop and certify standards for governing and labeling agricultural production practices.

Implications for scenario planning

Policy makers may want to identify and empirically assess the extent of new consumer markets that are emerging as a result of changes in consumer demand (e.g., health issues, environment, equity, etc.). In assessing these issues and anticipating future markets it will be important to evaluate information taking into consideration a broad set of stakeholders in the food chain (including consumers). Given this information, one can evaluate the need and the readiness by which transparent, traceable, systems of standards (public and private) emerge to enable Canadian agricultural producers to grow, certify, label and sell these new, alternative, agricultural products domestically and abroad. In addition, where relevant, policy makers may want to evaluate the extent to which different agricultural production systems may conflict: e.g., pesticide drift on crops being grown for organic.

Biotechnology

Competitiveness

The adoption of GMOs has varied across countries due to regulatory regimes and prices. The first-generation of GMO crops allowed farmers to lower average cost either by increasing yield or by reducing pesticide expenditure. These insect resistant or herbicide tolerant varieties have had positive financial impacts on those planting the GMO varieties; otherwise the adoption would not have occurred or would have been reversed. Although there are examples of lost markets, the

competitive advantage of Canadian farmers using GMO groups and bioprocesses has increased relative to farmers in EU countries and Australia where their use is banned.

The banning of GMO crops, particularly in Europe, has segmented the market and created the potential for two different types of commodities. There may be a price discount to GMO crops if there is an outright ban. A discount may also result if BMOs are allowed but labelling requires consumers to be aware that the product may contain a GMO. In contrast, a premium may be created for non-GMO crops with GMO crops becoming the standard if labelling allows products to be designated at GMO-free.

Social Issues

There has been a continental divide regarding the opposition to GMOs with strong, general resistance in Europe and limited concern in North America. The backlash to biotechnology was understandable given that the benefits of the first generation GMOs were the users and providers of the technology. Consumers concerned over the potential environmental and ecological risks would dismiss the limited advantage of lower food prices when making their purchase decisions.

The resistance to biotechnology associated with GMO crops appears to be waning for several reasons (See Economist Feb 23, 2008). Years of use in North America have not produced the serious ecological consequences predicted by some although there have been incidents of unintentional spread. While the ecological risks remain, the perceived danger has been reduced. Second, the rapid increase in commodity prices and low stock levels, all in a time of abundance rather than supply reductions, has generated concerns about food security. Higher yields offered through GMO crops may help address the potential shortages. Finally, and most importantly, the second generation of GMO crops offer tangible benefits to consumers that could overcome the perceived negatives. Examples include nutrient reinforced rice, which will reduce blindness in developing countries, and high-oleic soybeans, which will result in healthier cooking oil. Thus, the relative importance to Canadian society of biotechnology for crop production appears to be declining.

Biotechnology issues related to livestock production, such as cloning are more contentious, although the commercial use is not immediate.

Risk

The creation of market segments by biotechnology present opportunities but also risks to producers. These market niches can change rapidly depending on consumer attitudes. Consequently, farmers need to be aware biotechnology-process standards that define whether a market will evolve over time and even disappear so over-reliance on such a niche should be avoided.

The other risk for producers stemming from GMO crops is the possibility of herbicide resistance, particularly for glyphosate (or Roundup). This burndown herbicide is an extremely cost-effective means of weed control. The reliance on Roundup associated with products such as Roundup-Ready soybeans increases the likelihood of weed escapes and thus the opportunity for resistance. Given the high cost of alternative herbicides and the greater environmental toxicity of those alternatives, farmers should consider strategies for minimizing the risk of resistance.

Implications for scenario planning

Planning for alternative biotechnology scenarios largely involves assessing labeling options (GMO-free versus non-GMO) and consumer responses to these options and GMO products in general. As noted above, consumer resistance to biotechnology appears to be waning and scenario planning should account for the factors influencing the change.

Energy Production and Use

Competitiveness

The impact of energy use on the competitiveness of the Canadian agricultural sector depends on the relative changes in energy prices compared to other regions and the relative differences in the energy-intensity of the farming systems across these same regions. The reports suggest that global energy prices will rise with increasing demand and growing uncertainties about supply. All farms will have to bear higher fuel and fertilizer prices. While the projected change in the difference in relative energy prices across countries is likely to be small, the impact of the competitive position of Canadian farmers depends on the sector. The crop sector, particularly in the Prairies, is an extensive-based system compared to many other countries so the amount of energy used per acre is significantly less. In contrast, our livestock systems are energy-intensive due to the greater investments required in housing to deal with temperature extremes. Since hogs are the only intensive livestock sector that exports, it may face greater competition but the effect from this factor will be small.

While rising energy prices will have ambiguous effects on the agricultural sector depending on the relative energy intensity of the farming systems employed, energy production could increase output prices and enhance the competitive position of Canadian agriculture. Given the large land base in the country, there is the potential to be a major supplier of feedstock to the biofuel sector. It is projected that one-third of Canadian and American oilseed and cereal crops are needed to meet growing biofuel standards. The relative price effect will be largest for those crop sectors and regions that switch from being an exporter to an importer. The local price will change from the price at delivery less transportation cost to one where the transportation costs of bringing it into the region are added to the price at an export point. While the effect will be positive for local crop farmers from such a change, it could hurt livestock producers depending on the extent to which the biofuel waste (i.e. distiller's grain) can be substituted into the ration. This could be offset again if the incentives for biogas production from livestock production continue to grow.

Relative output prices for crop commodities may also be affected by concerns over energy use and production through the local food movement. The desire by some consumers to reduce their ecological footprint and reduce food miles could result in greater market opportunities for those farmers located close to urban centres.

Social Issues

The level of energy use and production and the implications on its availability for future generations is a direct concern for the general public. However, the issue appears to be largely couched in terms of the environmental consequences associated with the amount and type of energy used/produced. For example, it is climate change concerns that are partially responsible for policies with regard to renewable fuels and energy conservation incentives. The form of these policies has changed as concerns have risen about the negative environmental impacts associated with the first generation biofuels using crops such as corn, soybeans, and palms. For example, the incentives for the construction of corn ethanol plants in Quebec have been removed and a sustainability criterion has been set for biofuels to be able to be part of the renewable fuel requirement in some EU countries. In addition, the passage of a federal bill to set 5% ethanol and 2% biodiesel limits by 2010 has been returned to the Commons agriculture committee. This concern will likely fall with the movement toward cellulosic biofuels, or second generation sources, with more carbon dioxide reductions and less land use per energy unit.

The other social concern attributable partially to the emphasis on renewable energy is the impact on food prices. This effect will be felt largely by developing countries whose consumers spend a larger portion of their income on food and for which the farm value represents a greater percentage of the food dollar. Such countries that import large amounts of food and have large, poor urban populations are likely to be hardest hit and this may generate social concern within Canada.

Risk

The risk management strategies for farmers are unlikely to be affected by changes in energy use and production. However, the greater demand for commodities spurred by biofuel policies has led to greater volatility in commodity markets. The limits for price changes for crop contracts on the Chicago Board of Trade have been raised to reflect the increasing price variability for commodities. Energy policy and biofuels are only one part of the reason for the increase in both the average price and its variance but the consequence of the higher price volatility is the need for producers to place more emphasis on price risk management.

Implications for scenario planning

The significant effect of biofuels on commodity prices implies that planning for a number of the previous issues hinges on domestic and global energy scenarios. Continuation of biofuel standards will continue the upward pressure on crop prices and have implications on the competitiveness of alternative farm sectors and perhaps on land and water resources. However, growing concerns about environmental quality and the effects of rising food prices on the urban poor in developing countries has tarnished the halo around biofuels. Farm prices could also be altered with the development of celluosic technology that can use the whole plant and a wider variety of feedstocks thereby lowering crop prices. The net result is significant uncertainty in the future scenarios surrounding energy, which must be accounted for in policy planning.

Trade and Markets

Competitiveness

IASSTD notes that developments in the following agricultural policy agreements will be crucial in determining international competitiveness: (1) reform of the EU Common Agricultural Policy, NAFTA, CAFTA, negations with WTO, the conventions on Biological Diversity, International Treaty on Plant Genetic Resources.

Social Issues

Trade policy will continue to be an important social issue. In general, all trade issues become part of an ongoing social concern regarding globalization. In addition, the economic effect of trade often affects some groups more than others. These groups will have incentives to organize and raise the level of public awareness regarding trade.

Risk

In some situations changes, uncertainty in the future direction of international trade agreements may present considerable risks. As a hypothetical example, farmers would face considerable risks if new trade agreements required the removal of quotas.

Implications for scenario planning

IAASTD suggests the need for increased use of strategic impact assessments (IAASTD, 2007b), p. 108). Policy makers will want to simulate the effects of potential trade agreements on the agricultural sector. Given the magnitude of these effects, policy makers may want to develop the portfolio of policy options that would assist farmers as they adjust to new market conditions.

USEFULLNESS OF ASSESSMENTS FOR AAFC

Given that the three assessments summarized and analyzed in this report reflect findings at global and regional levels, they do not contain status and trends data specific to Canada, nor to any other nation. The IPCC reports contain sub-global chapters that examine climate change impacts and adaptation issues, including an assessment for North America, as well as North America-specific assessments of mitigation in agriculture. The reports provide examples based on peer-reviewed literature that range from local site-specific assessments to broader North American studies. That said, a large majority of the information related to agriculture in North

America focuses on information from the United States. The IAASTD's NAE sub-global assessment covers three regions and about 46 countries[1], so there is little specific mention of any one nation. The IAASTD's reports are still in draft form, however, and at the time of writing do not include graphs and tables, which no doubt include illustrative data on the issues examined in this report. The North American region in GEO-4 is comprised of only Canada and the United States, but a discussion of this region is the focus of only one of seven sections in one of 10 chapters (Chapter 6). Furthermore, at the regional level, the assessments of conditions in North America are generally biased towards the United States, or, in the case of the IAASTD, towards Europe, due to the relative size of their economies and therefore of their impacts on regional trends in matters related to agriculture and food. Since the North American perspective in GEO-4 focuses on only three issues—energy and climate change, sprawl, and stresses on freshwater—there is little analysis of the state, trends and outlooks related to the agriculture sector. Thus, the IAASTD and GEO-4 assessments should not be regarded as sources of Canadian data and indicators. Canada's own statistics on the state of its environment, agricultural resources, and the agriculture and food sectors are the best source of these data.

The global assessments also treat the themes that are the subject of each chapter at a scale that is generally too broad to deliver significant messages to the Canadian agriculture sector. Many of the issues of greatest severity in terms of the condition of land and water resources and the threats of climate change to the future viability of agriculture occur in developing regions or in the tropics. This situation, however, is of significance to Canada given its position as the supplier of food to these regions; it will thus be affected by the trends described in the assessments.

The assessments did not look specifically at competitiveness, social issues, and risk, although they do address consumer demands and uncertainty. The significance of these reports for AAFC may lie outside questions of immediate competitiveness and risk: rather, it may be in their messages that warn of the need to protect the multifunctional nature of agricultural ecosystems so they continue to support productive capacity for the equitable development of global human well being.

The three assessments provided a catalyst to study AAFC's policy goals in light of the changing state of global agricultural systems. Analysis of each of the 11 issues carried out above, as well as the questions posed in the following section, were enabled by close examination of the assessments' findings and speculation about the implications for Canadian agriculture as perceived by the authors. The resulting analysis may not have been possible without the stimulus provided by the assessments' conclusions.

The value of extracting information from these assessments lies not in the provision of data, but in synthesizing the report's findings about the significance of human impacts on agricultural ecosystems, teasing out the implications of both global and regional trends on future prospects for Canadian agriculture, and extrapolating from the assessments suggestions to address the threats to the ability of Canada's agricultural sector to realize AAFC's goals.

SUMMARY AND CONCLUSIONS

In analyzing the implications of the findings in the literature on AAFC's main policy goals, the authors drew on their own perceptions of the state of Canadian agriculture and food sectors, knowledge of national, regional and global economic and social factors that affect them, and understanding of AAFC's policies. The analyses of the 11 issues are careful not to speculate on the future of Canadian agriculture without supporting information from the three assessments. The conclusions are also focused on AAFC's three policy goals as they pertain to Canada, to the

[1] It consists of three sub-regions. North America comprises the US and Canada; western Europe comprises the 27 countries of the European Union1 with Iceland, Norway, San Marino and Switzerland; while Eastern Europe is the remaining countries in the Balkans2, Russia, and its neighboring states Belarus, Georgia, Kazakhstan, Moldova, Uzbekistan and Ukraine. Israel is also included in the region.

exclusion of other policy considerations, such as the impacts of agricultural practices on water, air and land resources. A number of questions remain about such issues, and about how Canada might respond to changing conditions in other parts of the world that have the potential to affect the future of agriculture and the provision of food both in this country and at the global level.

Speculation Stimulated by the Three Assessments

Questions related to building a competitive and innovative sector:

- How will Canada take advantage of opportunities presented by an emerging carbon market in Canada and the positive effects on agricultural competitiveness as a result of climate change?
- How will Canada contribute to broadening agriculture's role in a post-Kyoto international climate regime to ensure that a future agreement captures the significant mitigation potential of agriculture, particularly of soil sequestration?
- If more stringent climate change regulations are agreed upon, how might they affect agricultural production and production orientation in Canada?
- With growing energy needs throughout the world, how can Canada's agriculture sector produce biofuels and bioenergy, following sustainable production pathways and without infringing on lands for food production or conservation, or land susceptible to degradation?

Questions related to ensuring the sector contributes to society's priorities:

- How will Canada respond to the increased global demand for food, as populations, incomes and urban areas grow in developing countries?
- How will Canada respond to changes in meat and cereal consumption that will take place in the other regions of the world?
- How might Canada respond to increased demand for labour-intensive organic produce in light of lower labour costs in developing countries?
- Will Canada engage more intensely in the coordination and harmonization of international food standards? How strict will it be in protecting consumers and human health?
- What will be the implications for natural resource use, land use practices and environmental quality if the trend towards public concern for environment and health, food safety (labeling and traceability), organic products, less meat and more convenient foods continues?

Questions related to being proactive in managing risks:

- How will the impacts of climate change in other world regions affect changes in Canada's policies and trade?
- How can the agriculture sector in Canada help in a situation in which climate change has disproportionate impacts on developing regions and where farmers lack adaptive capacity?
- What could be the implications of increased land degradation and associated productivity losses in developing countries on demands for Canadian crops and livestock?
- How will a WTO extension of the scope for the exchange of goods, services, labour and capital among countries affect agricultural systems in Canada? How will Canada prepare for or react to possible harmonization of internal subsidies by the World Trade Organization? What will happen if almost all trade barriers for agricultural products and subventions are eliminated?
- If there is further liberalization of agriculture, how can the effects of subsidies in Canada be offset for the small producers in the rest of the world?
- How will Canada support multifunctional agriculture and seek ways to maintain the viability of ecosystem goods and services in agricultural areas?
- What gains in efficiency and increases in water, land, energy and labour for agriculture would be needed to avoid jeopardizing future environmental sustainability? What gains could

be achieved by new, improved production technologies and better water resources management? Will policy interventions be sufficient to overcome expected shortages?

(Many of these questions were adapted from those posed in IAASTD NAE 5).

Scenario Planning for the Canadian Agriculture and Agri-food sectors

Many aspects of the future scenarios presented in the IAASTD and GEO-4 reports are similar: both propose one outlook based on reliance on market forces and another that presumes strong policies, for example. The IAASTD's scan of the scenario exercises conducted by numerous organizations also found that many scenarios display some similarities. AAFC's policy agenda may be informed by the outcomes of these scenarios, but it would also be in its interest to conduct its own outlook process that would enrich these global scenarios by reflecting descriptors, drivers and impacts related specifically to its goals. The implications for future scenario planning suggested in the issue analyses could be valuable to inform such an exercise. In planning the models for scenario development, IAASTD suggests that to better understand the potential future of agricultural systems, models will need to simulate ecosystem services (IAASTD NAE 5: (de Lattre-Gasquet, 2007), p. 20).

Summary

In summing up, suffice it to say that Canada's agriculture and agrifood sectors are likely to enjoy some competitive advantages due to the warming trends of climate change, given its favourable geographic position, and because of increased demand and support for biofuel production and its use of GMOs. Will these advantages be offset by the negative impacts of climate change, however, given its increased vulnerability to extended drought, extreme weather events, and pests and disease? Canada will likely find ways to address public concern about equity issues with regard to climate change and consumer demand for healthy, safe, local and humanely produced food in ways that do not negatively affect its competitiveness and that may even provide it with opportunities for gain. AAFC's greatest challenge may lie in taking decisions to protect and enhance the ecosystem services provided by agricultural ecosystems and those that agricultural activity affects, even if such actions are not immediately rewarding. The risks of not doing so are sure to threaten the future productive capacity of agricultural ecosystems, the livelihoods of future Canadian farmers, and perhaps the food security and health of future generations at both local and global levels.

REFERENCES

AAFC (2007). *Growing Forward: Toward a New Agricultural Policy Framework.* Agriculture and Agri-Food Canada, http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1200427834045&lang=e [Accessed 18 November 2007]

Barr, J. & Mafuta, C. (2007). Chapter 6: Sustaining a Common Future. *Global Environment Outlook 4: Environment for Development.* United Nations Environment Programme, Nairobi, Kenya, http://www.unep.org/geo/geo4/media/ [Accessed 5 December 2007]

Beintema, N. & Koc, A. (2007). IAASTD Global Report Chapter 8: Agricultural Knowledge, Science and Technology: Investment and Economic Returns. *International Assessment of Agricultural Science and Technology for Development.* http://www.agassessment.org/index.cfm?Page=Plenary&ItemID=2713 [Accessed 7 January 2008]

de Lattre-Gasquet, M. (2007). IAASTD North America/Europe Chapter 5: Looking into the Future for KST (Knowledge, Science and Technology) Agriculture and AKST (Agricultural Knowledge, Science and Technology). *International Assessment of Agricultural Science and Technology for Development.* http://www.agassessment.org/index [Accessed 7 January 2008]

Dent, D. (2007). Chapter 3: Land. *Global Environment Outlook 4: Environment for Development.* United Nations Environment Programme, Nairobi, Kenya, http://www.unep.org/geo/geo4/media/ [Accessed 31 October 2007]

Gurib-Fakim, A. & Smith, L. (2007). *IAASTD Global Report Chapter 6: Options to Enhance the Impact of AKST on Development and Sustainability Goals (DRAFT 16 November 2007 - not for citation).* http://www.agassessment.org/index.cfm?Page=Plenary&ItemID=2713 [Accessed 8 January 2008]

Hendrickson, M. & Miele, M. (2007). Chapter 2: Changes in Agriculture and Food Production in NAE Since 1945. *International Assessment of Agricultural Science and Technology for Development, North America/Europe.* http://www.agassessment.org/index.cfm?Page=Plenary&ItemID=2713 [Accessed 11 December 2007]

Hurni, H. & Osman-Elasha, B. (2007). *IAASTD Global Report Chapter 1: Context, Conceptual Framework and Sustainability Indicators (DRAFT 20 November 2007 - not for citation).* http://www.agassessment.org/index.cfm?Page=Plenary&ItemID=2713 [Accessed 8 January 2008]

IAASTD (2007a). *IAASTD Global Summary for Decision Makers (DRAFT 23 November 2007 - not for citation).* http://www.agassessment.org/docs/Global_SDM_251107.pdf [Accessed 7 January 2008]

IAASTD (2007b). *IAASTD NAE Report: Summary for Decision Makers.* http://www.agassessment.org/ [Accessed 20 October 2007]

IAASTD (2007c). *Synthesis Report of the International Assessment of Agricultural Science and Technology for Development (IAASTD) (DRAFT 25 November 2007 - not for citation).* http://www.agassessment.org/ [Accessed 4 February 2008]

[IPCC] Intergovernmental Panel on Climate Change. (2007). *Climate Change 2007: The Physical Science Basis.* Working Group I Contribution to the Fourth Assessment Report of the IPCC. Cambridge University Press.

[IPCC] Intergovernmental Panel on Climate Change. (2007). *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability*. Working Group II Contribution to the Fourth Assessment Report of the IPCC. Cambridge University Press.

[IPCC] Intergovernmental Panel on Climate Change. (2007). *Climate Change 2007: Mitigation of Climate Change*. Working Group III Contribution to the Fourth Assessment Report of the IPCC. Cambridge University Press.

Izac, A.-M., Egelyng, H. & Ferreira, G. (2007). *IAASTD Global Report Chapter 7: Options for Enabling Policies and Regulatory Environments (DRAFT 14 November 2007 - not for*

citation). http://www.agassessment.org/index.cfm?Page=Plenary&ItemID=2713 [Accessed 8 January 2008]

King, P. N., Levy, M. A. & Varughese, G. C. (2007). Chapter 10: From the Periphery to the Core of Decision-Making - Options for Action. *Global Environment Outlook 4: Environment for Development.* United Nations Environment Programme, Nairobi, Kenya, http://www.unep.org/geo/geo4/media/ [Accessed 5 December 2007]

Leakey, R. & Kranjac-Berisavljevic, G. (2007). IAASTD Global Report Chapter 3: Impacts of AKST on Development and Sustainability Goals. *International Assessment of Agricultural Science and Technology for Development.* http://www.agassessment.org/docs/Global_C3_141107_text.pdf [Accessed 7 January 2008]

Lefort, M. & Wright, A. (2007). IAASTD North America/EuropeChapter 6: Options for action. *International Assessment of Agricultural Science and Technology for Development, North America/Europe.* http://www.agassessment.org/index.cfm?Page=Plenary&ItemID=2713 [Accessed 6 December 2007]

Lutman, P. & Marsh, J. (2007). IAASTD North America/EuropeChapter 3: Environmental, Economic and Social Impacts of NAE Agriculture and AKST. *International Assessment of Agricultural Science and Technology for Development, North America/Europe.* http://www.agassessment.org/index.cfm?Page=Plenary&ItemID=2713 [Accessed 6 December 2007]

Martino, D. & Zommers, Z. (2007). Chapter 1: Environment for Development. *Global Environment Outlook 4: Environment for Development.* United Nations Environment Programme, Nairobi, Kenya, http://www.unep.org/geo/geo4/media/ [Accessed 5 December 2007]

Rothman, D. S., Agard, J. & Alcamo, J. (2007). Chapter 9: The Future Today. *Global Environment Outlook 4: Environment for Development.* United Nations Environment Programme, Nairobi, Kenya, http://www.unep.org/geo/geo4/media/ [Accessed 5 December 2007]

UNEP (2007). *Global Environment Outlook 4: Environment for Development.* United Nations Environment Programme, Nairobi, Kenya http://www.unep.org/geo/geo4/media/ [Accessed 31 October 2007]

van Vuuren, D., Ochola, W. O. & Riha, S. (2007). IAASTD Global Report Chapter 4: Outlook on Agricultural Change and its Drivers. *International Assessment of Agricultural Science and Technology for Development.* http://www.agassessment.org/docs/Global_C4_211107_text.pdf [Accessed 7 January 2008]