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Analysis of EG&S Policy Options Fostering Adaptation of Canadian Farmers to Climate Change and Development of a Decision-making Tool

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About this Publication

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Executive Summary

Synopsis

Policy-makers are increasingly confronted with the difficult public policy challenge of fostering climate change adaptation in the agricultural sector. The first challenge is to identify economically viable Beneficial (or Best) Management Practices (BMPs) that provide Ecological Goods and Services (EG&S) that foster adaptation to climate change. The second challenge is to determine optimal financing arrangements for the implementation of these BMPs (i.e., "who pays, how much, to whom, and for what?").

Developing clarity for policy-makers on "who should pay, how much, to whom and for what" is essential for EG&S produced through agricultural BMPs programming to:

- Ensure agriculture adapts successfully to a changing climate; and therefore;
- Ensure long-term food sustainability;
- Meet society's environmental objectives; and
- Position Canadian producers for impending North American and global greenhouse gas (GHG) reduction policies.

Addressing these inter-connected policy objectives, this report delivers the following key messages:

1. **Versatile BMPs are needed to achieve multiple societal objectives:** To adapt to a changing climate, to meet environmental requirements and to maintain agricultural production; there is a need to identify the most robust BMPs.
2. **EG&S bridges agricultural and environmental opportunities:** Such BMPs can advance objectives in both agriculture and the environment domains.
3. **Clear process is needed to decide on "who should pay":** A new tool, *a decision framework*, facilitates the decision on "who should pay" for EG&S. It is based on several steps. This framework enhances the transparency and clarity of the decision process for government, society and producers.
4. **Balancing societal and producer interests:** The decision framework clarifies the circumstances under which society should support producers and their capacity to adapt to a changing climate. It recognizes that society should not impose an unfair burden on producers that would compromise their capacity to produce food but also recognizes that producers have to do their fair share in meeting environmental obligations. The framework outlines a process to help determine the balance point between these interests.
5. **Decisions are region/geography dependent:** Decision-making depends on local or regional considerations since climatic, environmental and agricultural factors vary geographically. The decision framework can be applied to any region in the country.
6. **Selection of appropriate policy instruments:** Once it is determined who should bear the cost of BMP implementation, the most cost-effective policy options should be considered following "Smart Regulation Principles": 1) Flexibility, 2) Ease of Implementation, 3) Transparency, 4) Equity, 5) Coherence with other Objectives and Policies, and 6) Efficiency. Selection of appropriate policy instrument types will differ depending on whether it is society or producers who should be responsible for the costs of BMP implementation, and also on other factors.

7. **Case studies confirm the approach:** The research tested this decision framework for two case studies, one in Manitoba and one in Quebec:
    a. "Riparian buffer strips" were identified as one of the key best management practice to achieve multiple objectives;
    b. In both Manitoba and Quebec the choice of the reference level has an impact on who should pay and the amount that should be paid; and the same reference level does not have the same implications in the two provinces in terms of who should pay and how much should be paid.

Climate Change and Agriculture

Agriculture is an economic sector dependant on natural resources and favourable climate conditions, and thus a sector highly vulnerable to the negative impacts of climate change, such as increased frequency and severity of droughts and excessive moisture events. Food security and human well-being are fundamentally dependant on a healthy agricultural sector, thus the issue of climatic risk reduction in agriculture is a central public policy issue. Generally, climatic models predict increasing climatic variability and increased seasonal aridity on the central prairies of North America, a major global grain growing region. Similarly, increases in climatic variability and extremes, i.e. floods and droughts, are also key climate impact concerns for Central Canada, though the likelihood of severe aridity is less of a concern than for the Prairies.

Society has two basic response options to climate change; mitigation and/or adaptation. Climate change mitigation is the practice of reducing GHG emissions, mainly by reducing fossil fuel combustion or through sequestration of atmospheric carbon dioxide. However, it is very unlikely that climate change mitigation will completely halt climate change and as such, the agriculture sector will need to adapt to a changing and potentially less benign climate.

Climate change impacts will vary greatly over time and space; near-term impacts are expected to be less severe than several decades hence, and some key agricultural regions of Canada – notably the Prairies - are believed to be more vulnerable than others, but there is much uncertainty. Without perfect knowledge of exactly how climate change impacts will manifest, the major challenge for policy-makers is to protect and enhance food security, producer competitiveness, agricultural livelihoods, and rural communities in the face of growing climatic uncertainty. An adaptation approach that includes a multitude of potential co-benefits is available in the form of EG&S programming.

Ecological goods and services are the positive benefits derived from healthy ecosystems, including clean air, water and enhanced biodiversity. The EG&S concept includes market goods produced by ecosystems such as food, fibre and fuel as well as ecosystem process benefits such as nutrient cycling, water purification, and pollination, and non-material benefits such as aesthetic values and recreation. Agriculture is both a beneficiary and provider of ecosystem services. EG&S programming in agriculture policy is common in the U.S., Europe, and Australia where programs are motivated primarily by biodiversity and regional water quality issues. EG&S programming is still embryonic in Canada, as only a few short-term regional pilot programs have been implemented. EG&S programming can be directed towards climate change adaptation if the focus is strengthening the components of agro-ecosystems most vulnerable to climate impacts.

BMP Selection

In this study, the criteria for selecting EG&S relevant to adaptation priorities in two key agricultural regions of Canada (Prairies and Central Canada) were that they have a perceptible EG&S benefit and be amenable to quantifiable biophysical measurement related to climate change impacts. The EG&S thus selected were:

- Conservation/restoration of physical water quality;
- Conservation/restoration of biochemical water quality;
- Conservation/restoration of moisture balance;
- Reducing odours and dust;
- Greenhouse gas (GHG) reduction;
- Carbon storage;
- Conservation/restoration of biodiversity in wetlands and aquatic environments;
- Control of diseases and invasions by exotic species;
- Habitat creation;
- Landscape protection.

Many EG&S that foster adaptation have a direct or indirect benefit for climate change mitigation, specifically those that increase biologically sequestered carbon in soils and biomass, such as wetland restoration and habitat creation.

We identified specific BMPs that provide key EG&S relevant to climate adaptation, examined BMPs relevant to climate mitigation policy (i.e., developing carbon markets) in North America, and then developed a list of BMPs that produce synergies between climate change adaptation and mitigation. The broad BMP categories that have a synergistic adaptation/mitigation benefit include livestock management, and various land management BMPs such as:

- Rangeland management;
- Riparian management;
- Conservation tillage;
- Establishing permanent grass and shelterbelts; and
- Nutrient management.

In principle, wetlands management can also produce a mitigation/adaptation synergy; however we found no currently accepted wetlands mitigation protocols[1] in our survey of North American carbon markets. A further important caution to policy-makers is also critical. The voluntary carbon markets now functioning in North America are still embryonic and not focussed on delivering adaptation co-benefits, while compliance-based markets have also not yet fully developed across the region. Although carbon markets may eventually provide a significant source of revenue for adaptation BMPs, some degree of proactive policy-led adaptation will also be essential. The main adaptation policy challenge is to define which BMPs should be applied to address problems at specific locations, and who should pay for their implementation. Regional adaptation priorities will define appropriate BMPs; the extent to which uptake of any specific BMP can be expected of producers or should be incentivized is a function of societal norms, expectations and economics.

[1] As of November 2010, Alberta Environment was reviewing a Quantification Protocol for Wetlands Restoration Projects for possible inclusion in the Alberta Carbon Offsets System (http://carbonoffsetsolutions.climatechangecentral.com/).

In some cases BMP implementation is clearly in the interest of producers, and monetary compensation to sustain uptake will not be necessary (though technology transfer and extension support may be necessary). Conservation tillage is a good example of a BMP where the private benefit of reduced labour and fuel costs tend to outweigh the private adaptation costs. In other cases, farm-level BMP implementation to the adaptation and EG&S level desired by society will impose a significant private cost burden on producers. Assessing the costs and benefits for both the producer and society is crucial for determining who should pay for the implementation of farm-level BMPs.

The Reference Level Concept

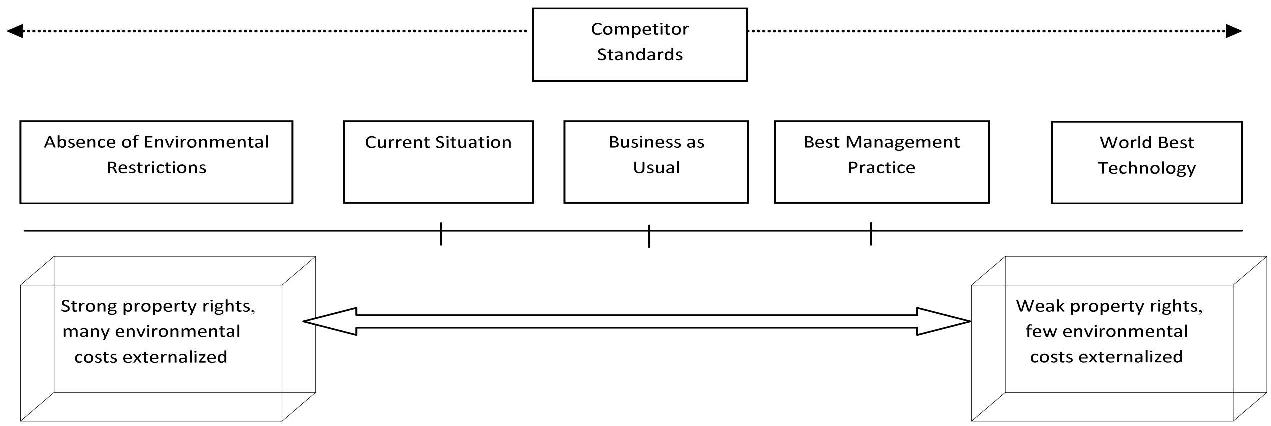
We present a logic framework for establishing the conditions under which society should (or should not) be expected to compensate producers for BMP implementation. The logic framework hinges on the "reference level" concept, which can be interpreted as the base level of benefit or protection society can reasonably expect from the agriculture sector. The reference level can be stipulated as a regulatory standard, performance standard or as an EG&S program objective and will generally emerge from a negotiation process with stakeholders. Defining the reference level for a particular BMP with respect to prevailing practice, the theoretical optimum, and the level of EG&S benefit necessary for adaptation establishes whether or not society should compensate producers for the social benefit.

Concretely speaking, when public managers are selecting an appropriate reference level for agri-environmental issues, they must consider various societal context elements. These elements include property rights, the time-dependent nature of reference levels, the level of scientific knowledge and economic considerations. Another element is the influence of the food supply chain, with each actor having unique interests, which takes into account the demands of distributors and processors.

In theory, different categories of reference levels can be used (Figure A). The following possibilities have been catalogued as reference levels: "absence of environmental standards"; "current situation" (*status quo*); "business as usual" (evolving *status quo*); "best management practice" (economically viable); "world best technology" (not necessarily economically viable); and, "representative competitor standards". The figure shows that different definitions of reference level will have different implications in terms of the recognition of the property rights of the producers.

It is worth noting that the reference level called "competitor standards", which refers to the reference levels of competing jurisdictions, is found on all levels of the scale.

FIGURE A: SUMMARY AND CLASSIFICATION OF THE REFERENCE LEVELS STUDIED



Logic Framework

Although the reference level concept is useful to establish the basis for decision-making, other concerns have to be factored into the process. A "logic framework" has been proposed that facilitates the decision-making process to help guide the discussion on who should pay for the production of EG&S. This framework is composed of eight decision steps which represent the choices that must be made within the process. Each decision level requires local involvement to adapt policy choices to the existing context.

These eight "decision gates" must be passed to answer to the final question: "who should pay for the production of EG&S through agricultural BMPs?" A key output of this research project is this process. It recognizes that this complex issue can be segmented into distinct decision steps. It should enable greater transparency for governments, the farm sector, and others when assessing and defining EG&S options and decisions. It allows for flexibility in that while each situation is different, the fundamental decision points remain intact. This decision process allows for an adaptive approach while adhering to a structured process. This process may also facilitate decisions by helping diverse interests come to an agreement on certain points more quickly and reveal where more effort is required in cases of disagreement.

These decision levels are, as follows:

- Level 1: Determining the main goals of the policy (e.g., environmental objectives, climate change adaptation, food sustainability, etc.).
- Level 2: Selecting the main EG&S associated with the policy goals.
- Level 3: Identifying the BMPs which produce the EG&S selected at step 2.
- Level 4: Determining the reference level and the degree of environmental protection required (the EG&S production level objective).

a. When the EG&S production level objective is higher than the reference level, there is a benefit for society which may also represent a net cost or benefit for the farmer.
b. When the initial EG&S production level is lower than the reference level, the actions undertaken essentially bring the practice up to a standard. In other words, this action may be perceived as repayment of a debt to society. In this situation, producers should have to pay for implementation of the BMP.

- Level 5: Considering producers' costs and benefits before deciding who should pay:
- Level 5a: Cost-benefit analysis for situations where EG&S production level is lower than the reference level. There are two possible outcomes:

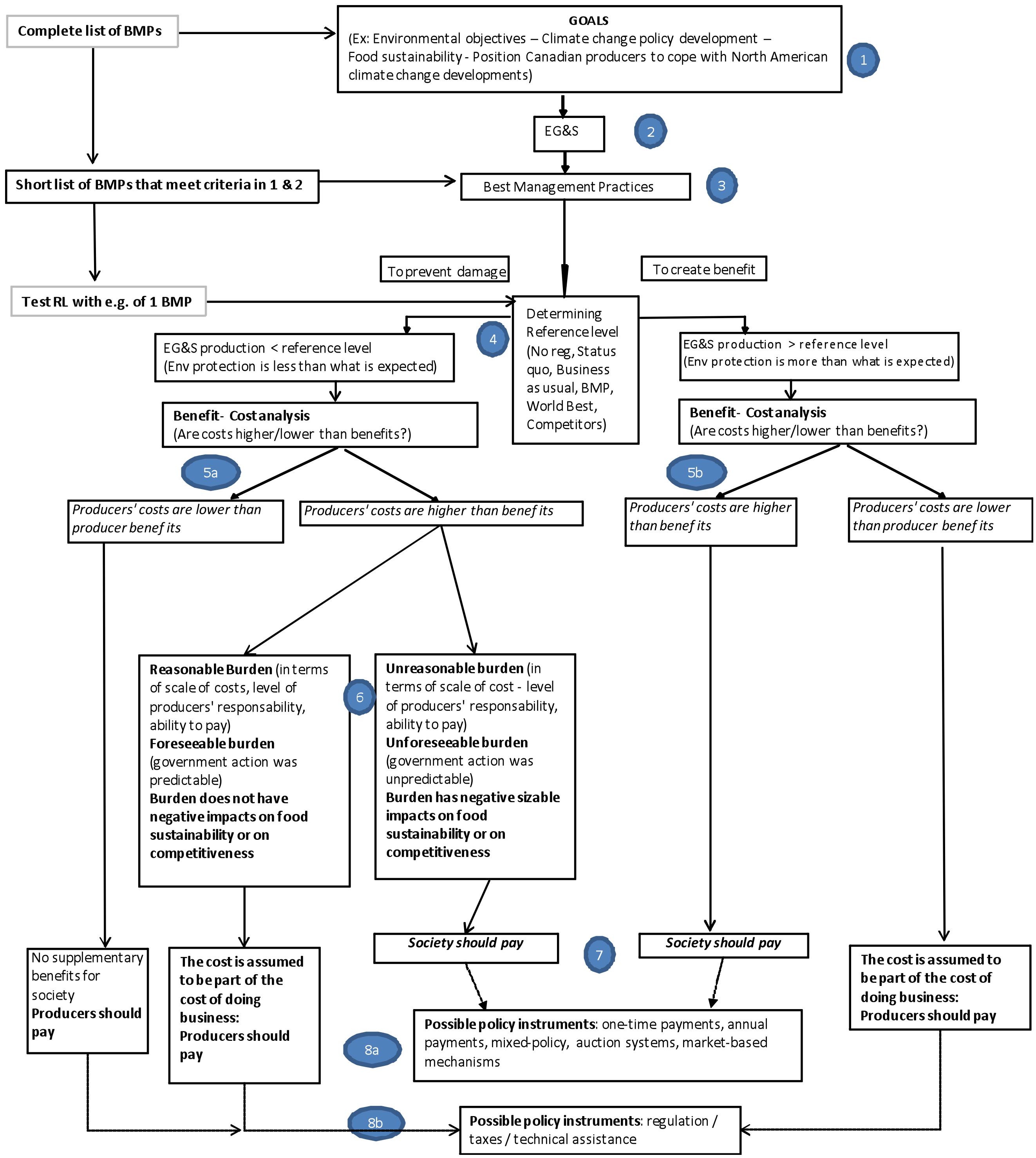
a. Producers' benefits are greater than or equal to producers' costs. This action can be associated with good agriculture practice and thus, the farmer should pay.
b. Producers' benefits are lower than producers' costs. The farmer may or may not be required to pay (See Level 6).

- Level 5b: Cost-benefit analysis for situations where EG&S production level is greater than the reference level. There are two potential outcomes:

a. Producers' benefits are greater than or equal to producers' costs. This action can be associated with good agriculture practice and thus, the farmer should pay.
b. Producers' benefits are lower than producers' costs, thus society should pay to compensate for these additional costs.

- Level 6: Assessing burden. In a situation where the farmer is not providing an environmental benefit to society but simply avoiding environmental damage, the producer should normally be required to pay. However, considering aspects other than EG&S production level, we may consider that producers deserve some help on a transitory basis: Is the burden reasonable? Is it foreseeable (was government action predictable)? Could this burden have negative impacts on food sustainability or competitiveness? The farmer should not bear an unforeseen and unreasonable burden and/or one which may have negative impacts on the viability of the Canadian agricultural sector or its competitiveness. In those situations it is suggested that society should pay.
- Level 7: Determining who should pay. Given the above logic, a decision has to be taken on "who should be responsible to pay?"
- Level 8: Choosing policy options. Policy instruments differ whether the financial burden of implementing BMP falls to farmers or to society.
- Level 8a: Taxes, regulations and technical assistance are useful instruments when it is deemed that producers should bear the implementation costs.
- Level 8b: Incentive-based instruments, such as one-time or annual payments, are more relevant when it is deemed that society should pay for BMP implementation.

FIGURE B: LOGIC DECISION FRAMEWORK



Once it is determined who should bear the cost of BMP implementation, the most cost-effective policy options should be considered following "Smart Regulation Principles": 1) Flexibility, 2) Ease of Implementation, 3) Transparency, 4) Equity, 5) Coherence with other Objectives and Policies, and 6) Efficiency. Selection of appropriate policy instrument types will differ depending on whether it is society or producers who should be responsible for the costs of BMP implementation, and also on other factors. Furthermore, the choice of policy instrument depends on:

- The main issue targeted;
- The territory targeted;
- Other environmental issues and characteristics;
- Available information on producers, their practices, the efficiency of their practices, their costs and revenues, etc.;
- The organisational and legislative context;
- The state of readiness of the producers to act.

A further fundamental consideration is that the "reference level" may change temporally or spatially. The policy-making challenge in the context of climate change adaptation is to define an appropriate reference level in the near-term and use the appropriate instruments, be they extension, regulation or compensation, to implement the necessary level of BMP adoption. As climate change is manifested through weather extremes, adaptation requirements will also shift and policy-makers should recognize that the reference level for BMP implementation may also need to be revised. Similarly, the reference level will vary regionally depending on the required level of EG&S as determined by the public and local conditions.

Riparian buffer strip implementation is a BMP providing adaptation capacity in all regions of Canada. We have chosen to apply the logic framework to riparian buffer strips in Québec and Manitoba to explore the decision steps for BMP implementation in two different contexts. In both regions, we used three different reference level scenarios. Similar reference level scenarios were used in both provinces for comparison. It was found that 1) the choice of the reference level has an impact on who should pay and the amount that should be paid; 2) the same reference level does not have the same implications in the two provinces in terms of who should pay and how much.

Over the course of this research project, two key research gaps emerged; the first operational, and the second concerning EG&S policy development. Firstly, although the impacts of climate change vary geographically, no consolidated "Atlas of Climate Impacts on Canadian Agriculture" exists to guide regional adaptation, nor does there exist a comprehensive catalogue of BMPs appropriate for regional adaptation.

Secondly, although we have demonstrated that in some circumstances society should compensate producers for agricultural adaptation, we have not investigated "how society should pay". Furthermore, we observe that very little peer-reviewed Canadian research exists on this topic.

We therefore recommend a research agenda that is essentially three-fold and comprised of:

- A geographic analysis of climate adaptation priorities in the various agricultural regions of Canada, with associated analyses of priority BMPs by region.
- Scientific research focused on factors and parameters to better determine reference levels for different BMPs across diverse contexts.

- Policy research on the cost-efficiency of alternative EG&S instruments with a focus on those of greatest importance to adaptation, including:
    1. Analyses of the fiscal capacity and budgetary implications, and revenue generation options within the agri-food sector.
    2. Implications for federal EG&S policy development in Canada given shared jurisdiction with the provinces.
    3. Analysis of the available policy options to take into account the need not to establish negative perverse incentives with early adopters of BMPs.

This report marks the beginning of a challenging and critical dialogue on agricultural adaptation in Canada that is necessary to ensure long-term food sustainability, address society's environmental objectives, and to position Canadian producers successfully within the context of emerging North American climate policy.

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1. Introduction

Canadian agriculture is impacted by various economic, environmental and social issues, including:

- Farm income crisis, provoked by increase of input prices, changes in consumer demand, foreign competition and increasing severity of food-safety standards, despite supportive agricultural policies and governmental funding transfers;
- Cohabitation problems and conflicts due to the negative externalities (noise, odour, dust, etc.) of certain agricultural practices;
- Search for innovative solutions to reduce the impacts of modern agriculture on the environment and on rural landscapes.

Environmental and socio-economic problems may also be exacerbated by climate change impacts in some regions. With the objective of assuring the sustainability of the agrifood industry in Canada, the current concern is how the agricultural sector will adapt to long-term climate change. The need for adaptation to climate variability has already been part of the reality of agriculture producers, but will play an increasingly important role in the future. The agricultural and food-processing systems will have to adapt to the variations of climate not only through the choice of crops and livestock, but also by adopting new cropping techniques, different management tools, adapting new infrastructure, searching for new forms of organization, developing research programs as well as conceiving new policies.

Moreover, Canadian farmers are now being pressured to change their practices to reduce the environmental impacts caused by agricultural activity and implement best management practices (BMPs) that promote ecological goods and services (EG&S). The recognition, protection and/or enhancement of EG&S, will also help reduce vulnerability to climate change impacts. However, even though producers may benefit from these adjustments in the long-term, such changes may entail significant short-term costs.

Thus, the improvement of environmental quality and associated legislative obligations for the agriculture sector are of increasing concern. These concerns directly affect the competitiveness of Canadian agricultural products in the extremely competitive North American markets and, increasingly, in international markets.

Due to concerns related to competitiveness, Canadian farmers are increasingly demanding compensation for the additional costs associated with meeting new environmental standards. Many producers claim that they should be compensated for the implementation of new standards and the benefits that those new standards provide to society. On the other hand, public authorities are confronted with limited financial resources that must be allocated amongst all socio-economic sectors.

In order to attain objectives such as food sustainability, adaptation to climate change and environmental improvements, governments are introducing programs or policies to convince producers to adopt new practices and BMPs that will induce the provision of EG&S.

Therefore, this project takes place in a context where Canadian governments are interested in identifying the most efficient policy options inducing the adoption of the BMPs that produce EG&S that meet the objectives of food sustainability, adaptation to climate change and environmental improvement.

The objectives of this study are two-fold: 1) to identify viable BMPs that provide EG&S that foster adaptation to climate change and other environmental goals; and 2) to develop decision-making capacity for the implementation of these BMPs (i.e., "who pays, how much, to whom, and for what?"). In this sense, the objective of this project is to build a decision making framework based on the "reference level" concept in order to determine who should pay for the adoption of BMPs producing EG&S that respond to the goals of 1) food sustainability, 2) adaptation to climate change, 3) making environmental improvements and 4) positioning Canadian producers to cope with and benefit from emerging North-American climate change policies. This research focuses on agriculture in the Canadian prairies and in Central Canada (Quebec and Ontario).

Accordingly the project will:

- Identify key environmental concerns for agricultural areas within a climate change context in the Prairies and Central Canada;
- Select BMPs that produce one or several of the required EG&S and foster adaptation to climate change. BMPs fostered by developing North America climate change policy will also be identified;
- Introduce the "reference level" concept to help determine who should pay for the production of EG&S through agricultural BMPs, as costs for implementing BMPs are unavoidable;
- Develop a "decision tree" that provides a policy development framework to help guide discussion on who should pay for the production of EG&S through agricultural BMPs (the reference level concept is useful to establish the basis of the debate, but other concerns have to be factored into the decision making process);
- Finally, "test" the proposed framework with the implementation of riparian buffer zones, a BMP that produces the targeted EG&S, confers adaptation, and is fostered by future North America climate change policy. The implementation of riparian buffer zones will be "tested" in both the Prairies and Central Canada.

2. Determine key environmental concerns in Prairie and Central Canada agricultural areas

PRAIRIES

The Canadian Prairies have a long history of agri-environmental concerns and policy responses for addressing them. Adapting to climatic and environmental realities has long been a challenge for prairie farmers. Canada's history of agri-environmental programming goes back to Western Canada in the 1930s, where soils were heavily degraded and the Prairie landscape was threatened with desertification. The response of the Canadian government was to form the Prairie Farm Rehabilitation Administration (PFRA) in 1935. Through a combination of research and outreach, PFRA was able to help restore productivity throughout the Prairies. After 74 years, PFRA ceased to exist in 2009, and its remaining elements were incorporated into Agriculture and Agri-Food Canada's (AAFC's) Agri-Environment Services Branch (AESB).

Since the 1930s, the main prairie-wide issues of concern have been soil and water conservation. These continue to be the main environmental concerns for farmers across the prairies. Table 1 lists environmental issues of concern from a survey of landowners from the three Prairie Provinces.

TABLE 1: ISSUES OF CONCERN TO PRAIRIE LANDOWNERS.

Concern	*Manitoba*	*Saskatchewan*	*Alberta*
Enhancing soil productivity	80	82	83
Improving water quality	73	78	82
Rural values and way of life	67	81	81
Reducing greenhouse gas emissions	58	70	61
Plant and animal diversity	59	67	64
Wildlife habitat	62	66	63

Source: Environics Research 2006 p35

While many issues of concern are common across the Prairies, others are more specific to certain provinces.

Alberta

Alberta, on average, receives the least precipitation of any Canadian province. As a result, water quantity and drought are perpetual concerns with water conservation being a priority. Alberta presently has several policies in place to improve water security, protect water resources, and improve irrigation efficiency. These include:

- The Alberta Riparian Habitat Management Agency (Cows and Fish) – runs programs related to protecting riparian habitat.
- Alberta Irrigation Efficiency Program – intended to foster water conservation through improved irrigation efficiency.
- Water Management Program – program supporting farmers undertaking water efficiency improvements on their farms.

- Water Pumping Program – program to assist farmers installing pumping equipment for domestic or livestock use.

(Alberta Agriculture and Rural Development 2010)

Saskatchewan

Saskatchewan's primary concerns regarding agriculture and the environment relate to soil and water conservation, as well as more specific concerns such as:

- Residue burning;
- Management of salt-affected land;
- Agrochemical management (spray drift).

(Saskatchewan Agriculture 2010)

Manitoba

There are two main objectives driving agri-environmental policy in Manitoba at present: climate change mitigation and water quality. Another key associated issue is related to biodiversity and wildlife habitat on farmlands; for example, Manitoba's Protected Areas Initiative is dedicated to building a network of protected areas that contains the biological diversity found in Manitoba's varied landscapes (Manitoba Conservation, 2010). Manitoba's Beyond Kyoto plan suggested that the province's agricultural sector could reduce greenhouse gas emissions by up to 250,000 tonnes per year by 2012 (Science Technology Energy and Mines, 2008). These reductions could be largely achieved with implementation of best management practices. BMPs are also cited as options for reducing agricultural nutrient loading to Lake Winnipeg (Lake Winnipeg Stewardship Board, 2006). By coordinating BMP implementation to address biodiversity loss, greenhouse gas emissions and nutrient loading, maximum public benefits can be delivered.

CENTRAL CANADA

Quebec

In 2006, the Quebec government formed the *Commission sur l'avenir de l'agriculture et de l'agroalimentaire québécois* (Pronovost Commission) tasked to report on the challenges and issues faced by Quebec's agriculture and agrifood sector. The commission held public hearings and tabled its report in 2008. The report contained specific recommendations on environmental issues in reinforcing water policy and reiterated the recommendations of a previous commission report on sustainable hog production. More precisely, the report highlights the need for agricultural measures and practices that eliminate environmental damage.

Moreover, the major environmental concerns that face Quebec agriculture were outlined:

1. Water contamination from agricultural sources: The intensity of agricultural activity overwhelms watershed support capacity. A research report from the Québec Ministry of the Environment established the link between the proportion of cultivated areas on a territory and the existing eutrophication problems within a watershed. In this study 83% of the watersheds where agricultural land represents more than 20% of the territory have phosphorus concentrations in water exceeding 0.03 TP mg/L (eutrophication criteria / support capacity criteria). The concentration of nitrates in groundwater is also increasing in areas with intensive agriculture on permeable soils (CAAAQ,

2008). Eutrophication problems are significant and may have major impacts on the local environment. However, impacts on drinking water quality are the main concern in Quebec, as "surface water networks serve more than 5.3 million people, that is, more than 70% of Quebecers." MDDEP (2002).

2. Soil degradation problems are primarily observed on lands dedicated to single-crop farming. Key concerns are: 1) deterioration of soil structure; 2) fertilizer load exceeding crop needs and soil support capacity in some regions; 3) decreasing content of soil organic matter; 4) soil acidification and 5) soil compaction.
3. Air quality degradation due to greenhouse gas emissions (nitrous oxide, from crop production and fertilizer use, and methane emissions from livestock operations) along with ammonia emissions.
4. Biodiversity loss: loss of wooded areas and wetlands from converting these areas to farmlands, and decrease of aquatic organism diversity due to water quality degradation.

Ontario

The concentration of livestock industry and the intensification of crop production result in growing pressures on the natural environment in Ontario. Soil and water quality are the most important environmental issues associated with farm activities. Air quality and wildlife compatibility with agriculture are also key environmental concerns. These issues were the focus of the Green Plan which aimed at achieving environmental sustainability in Ontario during the last decade (Bowman *et al*., n.d.).

Water quality

Ontario has more than 250 000 inland lakes. Therefore, water related issues are a major environmental concern in Ontario. Water contamination from non-point source pollution is a significant threat in agricultural areas. The application of pesticides and fertilizers, and the bacteria which are a component of manure are examples of pollution sources. Agriculture is an important source of nitrogen and phosphorus in the environment. In Ontario, a survey of 1,300 farm wells in the main agricultural regions of the province found that 37% contained bacteria or nitrate levels exceeding the Ontario Drinking Water Objectives (Goss and Fleming, 1993 in (Agriculture and Agrifood Canada, 1997).

Soil quality

Soil organic matter and erosion are two important aspects of soil quality. Soil erosion is still an important issue in Ontario. Under 2001 management practices, about 13% of cultivated lands in Ontario were at high or very high risk of water erosion, compared to 4% in Canada. Between 1981 and 2001, Ontario also had one of the highest levels of tillage erosion of the country. In Canada soil organic matter, a key element of soil quality is measured by the Soil Organic Carbon Change indicator which estimates the rate of change of organic carbon in the soil. In 58% of cropland of Ontario, the reduction of soil organic carbon content was more than 10 kg/ha/year between 1981 and 2001 (Agriculture and Agrifood Canada, 2005).

Air quality

Ontario faces air pollution problems due to the release of greenhouse gases in the atmosphere. Air pollution contributes to acidification of rainwater and may have harmful effects on health and on the environment. According to the 2007 report on air quality published by the Ministry of the Environment of Ontario (Ministry of the Environment Ontario, 2008), ozone (O3) and fine particulate matter, both major components of smog, exceed the ambient air quality criteria and Canada-wide Standards and thus, remain the air pollutants of most concern.

Wildlife compatibility with agriculture / biodiversity threat

Critical losses of fish and wildlife habitats have occurred due to agricultural practices. Water, air and soil pollution has an impact on species populations and habitats. In Ontario, the conversion of native ecosystems to farmlands is considered to have been the main cause of biodiversity decline (OECD, 2008). Moreover, the habitat capacity of farmland decreased between 1981 and 2001 (Agriculture and Agrifood Canada 2005).

SUMMARY OF KEY ENVIRONMENTAL CONCERNS FOR PRAIRIE AND CENTRAL CANADA AGRICULTURE

From the discussion above, the key agri-environmental issues for the Prairies and Central Canada can be summarized as:

- Water quality and quantity
- Soil degradation and quality
- Air quality degradation, including GHG
- Biodiversity/wildlife
- Rural values and way of life/social

3. Identify main potential EG&S

The definition of EG&S for federal/provincial (F/P) policymakers is the following:

“Ecological Goods and Services (EG&S) are the positive environmental benefits that Canadians derive from healthy ecosystems, including clean water and air, and enhanced biodiversity. The EG&S concept includes market goods produced from ecosystems (e.g. food, fibre, fuel, fresh water, genetic resources, biochemicals, etc.), the benefits from ecosystem processes (e.g. nutrient cycling, climate regulation, water purification, waste treatment, pollination, etc.) and non-material benefits (e.g. aesthetic values, recreation, etc.) Agriculture is both a beneficiary and a provider of EG&S. For example, farming's viability depends on ecosystem processes like soil renewal, climate regulation, and precipitation. At the same time, well-managed agricultural lands can provide benefits to broader society like fish and wildlife habitat, scenic views, and purification of air and water through natural processes” (Agriculture and Agrifood Canada, 2007).

Table 2 is a table created by Swinton and Zhang (2005) and presents an extensive list of EG&S cited in the literature by various authors. This list includes 28 EG&S categorized by the ecosystem functions they support. Some EG&S, including crop pollination and climate control, are unanimously recognized in the literature, while others, like ecosystem resistance to invasive species, are only cited by one or two authors.

TABLE 2: ECOLOGICAL GOODS AND SERVICES RECOGNIZED IN THE LITERATURE (SWINTON AND ZHANG, 2005, P.21)

Ecological Goods and Services		Daily (1997)	Constanza et al. (1997)	ESA*	ESP**	EcoValue Project	De Groot et al. (2002)	Firth (2004)	MEA*** (2006)	IISD (2008)
Regulation functions	Purification of air	X		X			X	X	X	
	Climate regulation	X	X	X	X	X	X	X	X	X
	Regulation of atmospheric chemistry		X			X	X	X		X
	Protection from harmful solar radiation	X		X			X	X		
	Regulation of river flows and groundwater levels	X	X	X	X	X	X	X	X	X
	Water supply		X			X	X		X	X
	Purification of water	X		X	X			X		
	Regulation of oceanic chemistry							X		
	Soil formation	X	X	X		X	X	X		X
	Renewal of soil fertility	X		X	X		X	X		
	Erosion control		X	X	X	X	X	X	X	X
	Nutrient regulation and storage	X	X	X		X	X	X		X
	Dispersal of seeds	X		X						
	Waste absorption and breakdown	X	X	X	X	X	X	X		X
	Disease control (Regulate disease carrying organisms)			X			X	X	X	
	Pollination	X	X	X	X	X	X	X	X	X
	Ecosystem resistance to invasive species							X		
	Biological control of pest and pathogens	X	X	X	X		X	X	X	X

		Daily (1997)	Constanza et al. (1997)	ESA*	ESP**	EcoValue Project	De Groot et al. (2002)	Firth (2004)	MEA***(2006)	IISD (2008)
Habitat functions	Provision of shade and shelter				X					
	Provision of habitat for various organisms		X		X	X	X			X
Production functions	Production of food, fibre, turf and fuel		X				X	X	X	X
	Maintenance of biodiversity and genetic resources	X	X	X	X		X	X	X	X
	Medicinal resources							X	X	
	Ornamental resources							X		
Social well-being	Aesthetic and spiritual amenities	X		X	X	X	X		X	
	Recreation		X		X	X			X	X
	Disturbance prevention								X	X
	Support of diverse human cultures	X	X		X		X		X	X

(*) Ecological Society of America

(**) Ecosystem Services Project

(***) Millennium Ecosystem Assessment

Source: Swinton and Zhang (2005, p. 21)

3.1 Selection of EG&S

Within the wide range of identified EG&S categories it was necessary to identify those most relevant to the key environmental concerns in Prairie and Central Canada agricultural areas, as they are priorities in meeting the objectives of this study.

Based on Table 2, we were able to identify the EG&S related to the main environmental concerns in the Prairies and Central Canada most likely to be influenced by agri-environmental measures. These EG&S are listed in Table 3 for different components of the natural and social environment. As BMPs directly or indirectly generate a substantial number of EG&S, it was necessary to identify the priority EG&S necessary to achieve the objectives of this study.

TABLE 3: EG&S RELEVANT TO THE MAIN ENVIRONMENTAL CONCERNS IN THE PRAIRIES AND CENTRAL CANADA AND LIKELY TO BE GENERATED BY VARIOUS BMPS

Environmental Concern	EG&S
Water quality and quantity	• Conservation/restoration of water physical quality • Conservation/restoration of water biochemical quality • Conservation/restoration of moisture balance • Conservation/restoration of biodiversity in wetlands and aquatic environments • Control of household and industrial wastes • Water supply (filtering, retention and storage of freshwater)
Soil degradation and quality	• Conservation/restoration of soil physical structure • Conservation/restoration of soil biochemical composition • Conservation/restoration of soil biodiversity
Air quality degradation	• Conservation/restoration of air quality • Reducing odour and dust • Controlling the chemical properties of air • Climate control • Greenhouse gas (GHG) reduction • Carbon storage • Creation of favourable microclimates
Wildlife compatibility with agriculture / biodiversity threat	• Habitat creation • Control of diseases and invasions by exotic species • Improved pollination of crops and natural vegetation • Conservation/restoration of vulnerable and threatened species and populations
Rural values and way of life / Social	• Conservation/restoration of recreational environment • Landscape protection • Respect for and conservation of cultural specificities

Sources: adapted from Binning *et al.* (2001), De Groot *et al*. (2002), Anielski and Wilson (2005), Wilson (2008), Voora and Venema (2008), Olewiler (2004), Anielski and Wilson (2009a and 2009b).

Selection criteria were defined to identify EG&S for analysis. The EG&S listed in Table 3 were subjected to further selection using the following criteria:

1. **Quantifiable biophysical change:**
   EG&S with hard to quantify biophysical changes were eliminated.
2. **Non-marginal biophysical change:**
   EG&S whose biophysical changes generated by BMPs were deemed insignificant were eliminated.
3. **Perceptible public impact:**
   EG&S that are difficult for the public to perceive (such as conserving soil biochemical structure) were eliminated. This criterion will facilitate the allocation of monetary values to each EG&S.

The selection process was based on available information. Without downplaying the importance of the rejected EG&S, it seems that a number of EG&S in Table 3 represent substantial challenges in terms of measurement and quantification, i.e., evaluating the impact of BMPs on target EG&S levels.

The elimination process of EG&S based on each of these criteria is outlined below. It is followed by a description of the indicators used to analyze the impact of BMPs on prioritized EG&S.

3.1.1 Quantifiable Biophysical Change

Those EG&S for which no evaluation process exists and/or for which the information needed to measure change is unavailable or insufficient were eliminated. A number of EG&S listed in Table 3 are hard to quantify. Though technically feasible, the quantification of factors associated with other EG&S is unlikely to be completed for analysis within a reasonable time. Some of these data are quantifiable but not compiled and thus unavailable at the watershed level. We therefore rejected the following EG&S from our analysis.

- Conservation/restoration of soil biodiversity;
- Improved pollination of crops and natural vegetation;
- Conservation/restoration of vulnerable and threatened species and populations;
- Controlling the chemical properties of air;
- Conservation/restoration of air quality;
- Climate control;
- Creation of favourable microclimates.

3.1.2 Non-Marginal Biophysical Change

EG&S are marginal when the biophysical change caused by a BMP is insignificant. This second selection criterion eliminates marginal EG&S. We thus removed the following EG&S from further analysis.

- Control of household and industrial wastes: This EG&S refers mainly to waste treatment techniques using plant materials. Several Canadian jurisdictions heavily regulate the reclamation of household and industrial wastes anywhere near food intended for human or animal consumption. In our view, the implementation of waste treatment techniques goes far beyond the scope of this study.
- Respect for and conservation of cultural specificities and conservation/restoration of recreational environments: The protection of historic sites and recreational areas is not the purview of BMPs. Other measures are more effective for this purpose.

3.1.3 Perceptible Public Impact

This selection criterion introduces the public perception of goods and services. For example, the "conservation/restoration of soil biochemical structure", which refers to the maintenance or the improvement of the fertility of soils while maintaining the quality of water, air and soil, generally escapes public notice, though it is noticed by farm producers who must apply organic and mineral fertilizers to maintain fertility. On the other hand, the "conservation/restoration of biochemical water quality" EG&S is more noticeable to the public through private wells, boil-water warnings, odour, taste, etc. This third criterion eliminates the following EG&S identified as imperceptible by society:

- Conservation/restoration of soil physical structure;
- Conservation/restoration of soil biochemical structure.

3.1.4 Analytical Results and Parameters

The elimination of the EG&S identified as non-priority by using the three selection criteria described above maintains the following EG&S, which are the focus of our analysis.

- Water supply (filtering, retention and storage of freshwater);
- Conservation/restoration of physical water quality;
- Conservation/restoration of biochemical water quality;
- Conservation/restoration of moisture balance;
- Reducing odours and dust;
- GHG reduction;
- Carbon storage;
- Conservation/restoration of biodiversity in wetlands and aquatic environments;
- Control of diseases and invasions by exotic species;
- Habitat creation;
- Landscape protection.

Clearly, the EG&S listed above are of socio-economic importance to a number of sectors. Since they are readily quantifiable, significantly influenced by the introduction of BMPs and perceptible by the public, these EG&S have been selected as priorities for further analysis.

Table 4 below shows a summary of the EG&S selection process:

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TABLE 4: SELECTION PROCESS OF THE MOST RELEVANT EG&S

Relevant EG&S in the context of key environmental concerns in selected Provinces	Quantifiable bio physical changes	Non marginal biophysical changes	Perceptible public impact	Final selection
Conservation/restoration of soil physical structure	X	X	0	
Conservation/restoration of soil biochemical composition	X	X	0	
Conservation/restoration of soil biodiversity	0			
Water supply	X	X	X	X
Conservation/restoration of water physical quality	X	X	X	X
Conservation/restoration of water biochemical quality	X	X	X	X
Conservation/restoration of moisture balance	X	X	X	X
Conservation/restoration of biodiversity in wetlands and aquatic environments	X	X	X	X
Control of household and industrial wastes	X	0		
Conservation/restoration of air quality	0			
Reducing odour and dust	X	X	X	X
Controlling the chemical properties of air	0			
Climate control	0			
GHG reduction	X	X	X	X
Carbon storage	X	X	X	X
Creation of favourable microclimates	0			
Habitat creation	X	X	X	X
Control of diseases and invasions by exotic species	X	X	X	X
Improved pollination of harvests and natural vegetation	0			
Conservation/restoration of vulnerable and threatened species and populations	0			
Conservation/restoration of recreational environments	X	X	0	
Landscape protection	X	X	X	X
Respect for and conservation of cultural specificities	X	0		

X: the EG&S meet the criteria
0: the EG&S do not meet the criteria

4. Identify BMPs producing the selected EG&S

Table 5 shows the Environmental Goods and Services identified in Step 2 (Chapter 3) and a list of BMPs aimed at producing each of the EG&S.

TABLE 5: AGRICULTURAL BMPS FOR THE PRODUCTION OF SELECTED EG&S

EG&S	Beneficial Management Practices
Water supply	Irrigation Water Management Irrigation equipment modification/improvement to increase water efficiency: - Sprinkler - Drop irrigation systems - Rewiring Drainage systems modifications to allow controlled drainage (flow control) Cultivation of crops requiring less water
Purification of water (Conservation/restoration of physical and biochemical water quality)	Improved manure storage and handling Riparian buffer zones (wooded and grassy) Including more forages in rotation Winter cover crops Conservation tillage (no-till) Crop residue on the soil surface Conservation of grasslands Windbreaks
Conservation/restoration of moisture balance	Including more forages in rotation Grassed zones to improve water retention by soils Conservation tillage (no-till)
Reducing odours and dust	Windbreaks Improved manure storage and handling Conservation tillage (no-till) Other BMPs that reduce soil wind erosion
GHG reduction Carbon storage	Livestock management: - Improving animal performance (reduction of methane emissions from enteric fermentation) - Improving feeding practices (reduction of the nitrogen content of animal excreta and reduction of methane emissions from enteric fermentation through altered nutrition, increased livestock nutrient use efficiency, grain supplementation, improvement in forage quality, mineral and/or salt supplements, use of feed additives, or use of ionophores as a methanogenic inhibitor) Manure Management: - Biogas capture and combustion or use as an energy source - Removing manure from buildings daily and moving to storage - Composting, co-composting, and aerobic waste treatment - Optimizing soil application of animal manures - Using advanced fertilizer and manure technologies

EG&S	Beneficial Management Practices
	Cropland management: - Nutrient management: Improving N use efficiency (adjusting application rates based on precise estimation of crop needs; using slow- or controlled-release fertilizer forms or nitrification inhibitors; applying N when least susceptible to loss; placing the N more precisely into the soil to make it more accessible to crop roots) - Tillage/residue management: allowing crops to grow with minimal or reduced tillage or without any tillage at all (no-till) - Agroforestry - Riparian management - Establishing permanent grass and shelterbelts - Improved grazing practices - Including more forages in rotation - Eliminating summer fallow
Habitat	Removing lands prone to flooding from production Restoring wetlands and conservation of existing wetlands in agricultural zones Integrated Pest Management Grassed strips (grainlands)
Conservation/restoration of biodiversity in wetlands and aquatic environments	Native vegetation enhancement (wild habitat enhancement) Erosion control (bank stabilisation, sediment control) Irrigation management (prevention of backflow of altered irrigation water into water sources) Riparian area habitat management (buffer zones, fencing to limit grazing area, habitat restoration or establishment) Relocation of livestock confinement and horticultural facilities from riparian areas Improved manure storage and handling Farmyard and horticultural facilities runoff control Preventing wildlife damage (buffer strips around wetlands) Biodiversity enhancement planning Riparian health assessment
Landscape protection	Reforestation and revegetation (shelterbelt, windbreaks) Conservation of natural ponds Ponds for agricultural water supply management
Control of diseases and invasions by exotic species	Integrated Pest Management Multiple cropping amid intercropping Crop rotation

Sources: adapted from Binning *et al.* (2001), De Groot *et al.* (2002), Anielski and Wilson (2005), IPCC (2007), OSCIA (2009), UNFCCC (2008), Wilson (2008), Voora and Venema (2008), Olewiler (2004), Anielski and Wilson (2009a and 2009b).

It is important to highlight that some BMPs such as riparian buffer zones, crop rotation, winter cover crops or conservation tillage – no-tillage practices can contribute to multiple EG&S categories. Other practices may contribute to a lower diversity of EG&S types, such as, removing lands prone to flooding from production, converting marginal farmland to wetlands or conservation of existing wetlands on agricultural lands, which address habitat production and conservation, but could still provide important levels of EG&S. It is worth noting that some BMPs may also result in positive consequences for some EG&S, and negative effects on others.

5. BMPs fostering adaptation

Sectors that are dependent upon natural resources, such as agriculture, are among the most vulnerable to the negative impacts of climate change (IPCC, 2007). However, climate change could have both positive and negative impacts on agriculture in the Prairies and Central Canada. As an example of positive impacts, warmer temperatures would increase the length of growing seasons and this may allow the expansion of some crops such as corn, soybeans, forages and horticultural crops into new areas. On the other hand, soil type and lack of reliable soil moisture in the growing season could hinder that expansion. Warmer temperatures could also result in crop damage due to increases in pest problems, heat, and moisture stresses.

Moreover, agriculture may also suffer indirectly from the effects of climate change on natural resources such as water. As water supplies diminish and water quality decreases, there would be less high-quality water available for human use, simultaneously water demand for agricultural irrigation systems will increase in parts of the country that become warmer and drier. Increased frequency and intensity of extreme events (e.g., droughts, floods and storms) have also been identified as challenges that the agricultural industry would face (Government of Canada, 2004; Lemmen et al., 2008). To respond to negative impacts, farmers have already begun to adjust practices in order to adapt to climatic stresses such as drought, to reduce soil erosion, and to manage environmental water quality (Boutin, 2005; Corkal and Adkins, 2008). With new threats posed by further climate change in Central Canada and the Prairies, BMPs that foster climate change adaptation by anticipating and minimizing risks should be implemented. For each climate change impact identified by Natural Resources Canada in the agricultural sector in Central Canada and the Prairies (Lemmen *et al*., 2008) the associated BMPs that could address the impact are presented in Table 6. BMPs that are underlined are those that produce the selected EG&S identified in section 4. The BMPs listed in Table 6 are amassed from a variety of sources, so the specific BMP names may not be the same as those listed in Tables 4 and 5.

TABLE 6: BMPS FOSTERING ADAPTATION TO CLIMATE CHANGE[2]

Climate change impacts	Impacts on agriculture in Central Canada and the Prairies	Positive or negative	Beneficial Management Practices
Temperature increase	Lengthening of the growing season for some crops (ex: corn, soybeans, forages, horticultural crops, maize, sorghum).	Positive	N\A
	Northward extension of crop production.	Positive	N\A
	Threat to the winter survival of fall seeded and forage plants (due to warmer autumns and reduced snow cover).	Negative	Adaptation of cultivars and crops
	Less risk of damage to fruit trees.	Positive	N/A
	Heat stress on livestock.	Negative	• Adaptation of livestock buildings (development of new cooling systems) • Adaptation of density and feeding of livestock indoor during hot spells • Adding more shelter and drinking droughts during the summer
	Lower feed requirements, increased survival of the young and reduced energy costs during winter.	Positive	N/A
Increased temperature and humidity variability	Change in the geographical distribution and population of weeds, pest and pathogens. Increases of plant and animal diseases, of exotic diseases, disease progress rates and of the chances of pathogens survival.	Negative	• Multiple cropping and intercropping[3] • Crop Rotation • Integrated Pest Management Planning
	Lack of reliable soil moisture in the growing season.	Negative	• Adapting choice of cultivars and crops
	Increase vulnerability to severe droughts.	Negative	• Irrigation water management (increase water use efficiency and nutrient use efficiency of plants, improved infiltration, improved irrigation equipment) • Ponds for agricultural water supply management • Less water use by crops • Establishing permanent grass and shelterbelts to improve water retention by soils • Riparian management • Improved grazing practices • Tensiometric measurement

[2] Desjarlais *et al*. (2004), Bourque and Simonet (2008), Chiotti and Lavender (2008), Ontario Expert Panel on Climate Change Adaptation (2009), Gassman, *et al.* (2006), South Nation Conservation Authority (2003), Tunçsiper (2007), Vaché *et al.* (2002), Glozier *et al.* (2006), Flaten (2003), Bracmort et al. (2006) and Detenbeck *et al.* (2002).

[3] BMPs that are underlined are those that produce the selected EG&S identified in section 4

Climate change impacts	Impacts on agriculture in Central Canada and the Prairies	Positive or negative	Beneficial Management Practices
Increased precipitation	Impact on runoff and water quality.	Negative	• Reduced tillage • Water management practices • Cover crops to prevent soil erosion after harvest • Farmyard and horticultural facilities runoff control • Improved drainage system and flood control • Removing lands prone to flooding from production • Establishing permanent grass and shelterbelts • Bank stabilization • Riparian management • Improved grazing practices • Crop residue on the soil surface • Improved manure storage and handling (incl. composting) • Altering feeding practices • Improving N use efficiency
	Soil erosion.	Negative	
Increased evapo-transpiration	Increased water deficit.	Negative	• In barn improvements of livestock watering devices • Irrigation management (increase water use efficiency and nutrient use efficiency of plants, improved infiltration, improved irrigation equipment) • Improved water storage facilities • Ponds for agricultural water supply management • Cultivation of crops with less water demand • Grassy zones to improve water retention by soils
Change to the frequency or threshold of extreme events (e.g., more frequent and intense severe rainfall events)	Increased wind and water erosion.	Negative	• Reduced tillage • Use of cover crops • Windbreaks • Establishing permanent grass and shelterbelts • Improved grazing practices • Riparian management
Higher atmospheric concentration of CO_2	Stimulates plant growth and increases efficiency of water use.	Positive	N/A
	Growth of invasive weed species, pests and disease that thrive on higher levels of CO_2 in the atmosphere.	Negative	• Multiple cropping and intercropping • Crop rotation • Integrated Pest Management Planning
	Increased grassland productivity.	Positive	N/A

Based on this analysis, BMPs that foster adaptation to climate change and produce the selected EG&S include the following:

- Altering feeding practices
- Bank stabilization
- Cover crops to prevent soil erosion after harvest
- Crop residue on the soil surface
- Crop rotation
- Establishing permanent grass and shelterbelts
- Farmyard and horticultural facilities runoff control
- Grassed zones to improve water retention by soils
- Improved drainage system and flood control
- Improved grazing practices
- Improved manure storage and handling
- Improved nitrogen (N) use efficiency
- Improved water storage facilities
- Integrated Pest Management Planning
- Irrigation water management
- Multiple cropping and intercropping
- Ponds for agricultural water supply management
- Reduced tillage
- Reduced water use by crops
- Removing lands prone to flooding from production
- Riparian management
- Use of cover crops
- Water management practices
- Windbreaks

As illustrated above, several studies have examined climate change adaptation, both past and present, on the Prairies from both a climatic as well as a social point of view. Sauchyn and Kulshreshtha (2008) highlighted adaptation in the water sector as key for adapting to climate change on the prairies. Some specific highlights include:

- Changes in stream flow and timing: lower annual stream flow, higher spring and winter flow, lower summer flow;
- Water shortages in drought prone areas;
- Decreased recharge of groundwater, decline in water tables;
- Increase in water demand due to population growth and irrigation demand;
- Nutrient over-enrichment due to land use impacts of agriculture and forestry, withdrawals, runoff, dams and diversions;
- Increase in chemical and biological pathogens, acidification and salinization.

In addition, Tarnoczi and Berkes (2009) have noted the following as key water-related issues:

- Increase in droughts;
- Increase in floods.

Based on these observations, an evaluation of BMPs for their potential to assist with climate change adaptation should consider the following characteristics: water quality, water erosion, soil conservation, propensity to mitigate droughts, and propensity to mitigate floods. Prior to 2006, AAFC examined and tabulated National Farm Stewardship Program BMPs with greenhouse gas management implications. These BMPs were classified into either the "A" list – BMPs with clear GHG implications, or the "B" list – those with less clear implications (AAFC 2006b). The AAFC GHG BMP lists were evaluated, and each BMP was scored 1 if it was deemed to have a positive effect, or 0 if it was deemed to not to have a positive effect on an adaptation parameter. The total score for each BMP was summed, and is listed in Table 7. The evaluation was conducted on these lists because the relevance of these BMPs for greenhouse gas mitigation had been accepted by AAFC. BMPs with a higher adaptation score are deemed to be most important for climate change adaptation. Based on the analysis of these BMPs, *establishing permanent grass and shelterbelts* and *riparian management* had the highest scores for adaptation.

TABLE 7: GHG BMPS WITH THE CAPACITY TO ASSIST WITH ADAPTATION, LISTED FROM HIGHEST TO LOWEST ADAPTATION SCORE

BMP	Water quality - Nutrients	WQ - sediment	Soil cons	drought mitigation	flood mitigation	Adaptation score
Establishing permanent grass and shelterbelts	1	1	1	1	1	5
Riparian management	1	1	1	1	1	5
Reducing tillage	0	1	1	1	1	4
Eliminating summer fallow	1	1	1	1	0	4
Improved grazing practices	1	1	1	1	0	4
Improving soil aeration (drainage)	0	1	1	1	1	4
Composting	1	0	1	1	0	3
Manure composting	1	0	1	1	0	3
Including more forages in rotation	1	0	0	0	0	1
Reduced amounts of surplus N in soil	1	0	0	0	0	1
Synchronise timing of N applications with plant N needs	1	0	0	0	0	1
Avoiding post-harvest accumulations of N	1	0	0	0	0	1
Using advanced fertilizers and manure technologies	1	0	0	0	0	1
Use of feed additives	1	0	0	0	0	1
Altering feeding practices	1	0	0	0	0	1

6. BMPs fostered by future North America climate change policy

The agriculture sector in Canada is responsible for 8 percent of total national GHG emissions (Environment Canada, 2009). Canada's total emissions from the agriculture sector — namely enteric fermentation (methane - CH_4) and manure management (nitrous oxide - N_2O and CH_4) and N_2O from agricultural soils — were 60 Mt in 2007, an increase of 23 percent between 1990 and 2007 (Environment Canada, 2009). In 2007, the agriculture sector contributed about 26 percent and 71 percent of the total Canadian methane and nitrous oxide emissions, respectively (Environment Canada 2009). Regarding agricultural carbon cycling, agricultural soils were previously a net source of carbon, but are now a net sink due to increased uptake of carbon sequestration activities such as reduced tillage. Canada's croplands are trending towards decreasing emissions, with a removal of 3.4 Mt in 2007; and a 16.4 Mt reduction in emissions over the 1990 to 2007 period (Environment Canada, 2009). Boehm *et al*. (2004) estimated the potential for reduction of agricultural emissions in Canada at 18 Mt. The current potential is less, perhaps by as much as 10 Mt, given that the agricultural sector has experienced an increase in carbon sequestration through implementation of BMPs such as low disturbance tillage, establishment of permanent grass cover and reduction of summer fallow.

Such a great range of mitigation potential in the agricultural sector combined with the emergence of Canadian GHG emissions trading is likely to offer farmers an economic return for reducing GHG emissions. The federal government is developing an offset system designed to encourage cost-effective domestic reductions or removals in sectors not expected to be covered by proposed industrial air emissions regulations, namely agriculture, forestry and waste management. This program is being designed by Environment Canada. Some farmers in Alberta are already participating in Alberta's carbon trading market, launched in 2007.[4] Other farmers in Canada have completed transactions on the voluntary market through the Chicago Climate Exchange (CCX).[5] Additionally, the Western Climate Initiative (WCI) is developing an emissions trading systems that will include agricultural offset sales from producers in British Columbia, Manitoba, Ontario and Quebec.[6]

Some BMPs linked to GHG emission reductions or removals in the agricultural sector are currently eligible offset activities on existing carbon markets in North America. Those North American markets include both regulatory markets (e.g. the Alberta cap-and-trade scheme and the Regional Greenhouse Gas Initiative - RGGI - in the U.S.) and voluntary markets (e.g. the CCX and the Climate Action Reserve - CAR). Regulatory markets are those created by governmental entities in order to comply with a GHG emissions reduction target, whereas voluntary markets are created by private entities without any regulatory incentive. Within regulatory markets, offset programs are established so as to allow offset credits to be traded on the market and to allow regulated entities (i.e. those that are subject to an emission reduction limitation) to offset their emissions. The offset program determines which GHG emission reduction or removal activity is eligible to generate tradable offset credits and establishes quantification protocols to calculate how many credits could be claimed from the implementation of an eligible activity.

[4] See: http://carbonoffsetsolutions.climatechangecentral.com/.
[5] See: http://www.chicagoclimatex.com/.
[6] See: http://www.westernclimateinitiative.org/.

The generation of offset credits from BMPs on both voluntary and regulatory markets is an opportunity for farmers to gain revenues from the sale of the credits. Quantification protocols established by the offset programs provide guidance to determine the quantity of reduced or sequestrated emissions that will generate offset credits. Although quantification protocols are specific to an offset program and to a market, they share several similarities when addressing a same eligible practice. It is then usual that a newly established offset program use and adapt existing quantification protocols according to its requirements. For example, in Canada, the federal offset program that is being designed by Environment Canada has selected several existing quantification protocols (i.e. quantification protocols from Alberta offset program and from the Climate Action Reserve program have been selected by Environment Canada on the fast track eligibility list)[7]. Although this program is not yet in force, this helps to determine which activity is likely to be eligible within a future Canadian federal offset program. Furthermore, as Canada is willing to harmonize its future cap-and-trade system with the future American system, it is very likely that federal Canadian and American offset programs will share common similarities and have a very comparable list of eligible activities and quantification protocols.

As several climate change bills are under examination in the American Senate following the passing of the Waxman-Markey bill by the House of Representatives in June 2009[8], an offset program could eventually be established in the U.S.[9]. Both the Waxman-Markey text and the two climate change bills examined by the Senate[10] propose the creation of offset programs under which several agricultural activities would be eligible. Some of the bills provide a list of eligible activities in the agricultural sector for which quantification protocols already exist.

To identify the BMPs fostered by North American climate change policies through the establishment of offset programs, BMPs that have a positive impact on climate change and that are likely to generate offsets in both emerging Canadian and American offset programs have been selected. Table 8 identifies BMPs:

- That are eligible on existing regulatory carbon markets in North America;
- That are eligible on existing voluntary carbon markets in North America;
- That are likely to be eligible on emerging regulatory offset programs in Canada and the United States; and
- For which a quantification protocol has been approved but is not yet linked to any regulatory or voluntary offset program.

This table aims to show which BMPs are likely to be fostered by emerging North American policies either because they are already eligible activities within existing markets, or because quantification protocols have been designed, or because regulatory and legislative texts designate those BMPs as potential eligible offset activities within a future federal offset program.

[7] See: <http://www.ec.gc.ca/creditscompensatoires-offsets/default.asp?lang=En&n=7CAD67C6-1&offset=14&toc=show>.
[8] The Waxman - Markey American Clean Energy and Security Act (ACESA), H.R.2454.
[9] The Republican gains in the November 2010 mid-term elections indicate that the United States is not likely to adopt a cap and trade approach to mitigation in the near future; it is also unlikely that Canada will adopt this approach until the U.S. does.
[10] The Kerry - Boxer Clean Energy Jobs and American Power Act (CEJAPA), S. 1733. <http://www.pewclimate.org/docUploads/Pew-detailed-summary-kerry-boxer-epw-11-18-09.pdf> and The Clean Energy Partnerships Act of 2009, S. 2729. <http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:s2729is.txt.pdf>.

Thus, the BMPs with the greatest potential to be supported by carbon offset markets include the following:

- Implementing no-till and reduced till systems on agricultural lands;
- Establishing permanent grass and shelterbelts;
- Rangeland Management (including riparian management and improved grazing practices);
- Biogas capture and combustion or use as an energy source;
- Improved livestock feeding practices;
- Optimal soil application of animal manures;
- Reduction of nitrogen fertilizer use.

TABLE 8: BMPS THAT ARE FOSTERED UNDER CURRENT MARKETS OR LIKELY TO BE FOSTERED UNDER FUTURE OFFSET PROGRAMS IN CANADA AND THE U.S.

BMPs linked to potential GHG emission reductions or removals	BMPs fostered by existing regulatory markets		BMPs fostered by existing voluntary markets		BMPs fostered by Environment Canada's fast track eligibility list (future federal offset program)	BMPs fostered by the three main American climate change bills			Quantification Protocol linked to the eligible activity
	Alberta Offset Program	Regional Greenhouse Gas Initiative	Chicago Climate Exchange	Climate Action Reserve		The American Clean Energy and Security Act (ACESA), H.R.2454	The Clean Energy Jobs and American Power Act (CEJAPA), S. 1733	The Clean Energy Partnerships Act of 2009, S. 2729	
Practices that sequester carbon and enhance carbon stocks									
Implementing no-till and reduced till systems on agricultural lands	No-till and reduced-till practices on agricultural lands.	N/A	Continuous Conservation Tillage on cropland and other land where crops are planted. Practices include: no-till, strip-till, direct seed, zero till, slot till and zone till.	N/A	No-till and reduced-till practices on agricultural lands (Alberta Offset Program Quantification Protocol for Tillage System Management).	• Altered tillage, • Winter cropping, • Continuous cropping, • Other means to increase biomass returned to soil in lieu of planting.	• Altered tillage, • Winter cropping, • Continuous cropping, • Other means to increase biomass returned to soil in lieu of planting.	• Altered tillage, • Winter cropping, • Continuous cropping, • Other means to increase biomass returned to soil in lieu of planting, • Resource-conserving crop rotations of at least 3 years.	*Alberta Offset Program Quantification Protocol for Tillage System Management, Version 1.3 as of February 2009*[11]. *Chicago Climate Exchange Continuous Conservation Tillage and Conversion to Grassland: Soil Carbon Sequestration Offset Project Protocol, Updated as of September 30, 2009*[12].
Establishing permanent grass and shelterbelts	N/A	N/A	Practice that consists of converting land previously used for crop production to grassland cover.	N/A	N/A	• Agroforestry, • Planting and cultivation of permanent tree crops.	• Agroforestry, • Planting and cultivation of permanent tree crops.	• Practices that will increase the sequestration of carbon in soils on cropland, native and planted grazing land, grassland, etc.	*Chicago Climate Exchange Continuous Conservation Tillage and Conversion to Grassland: Soil Carbon Sequestration Offset Project Protocol, Updated as of September 30, 2009*[13].

[11] http://environment.gov.ab.ca/info/library/7918.pdf.
[12] http://www.chicagoclimateexchange.com/docs/offsets/CCX_Conservation_Tillage_and_Grassland_Conversion_Protocol_Final.pdf.
[13] http://www.chicagoclimateexchange.com/docs/offsets/CCX_Conservation_Tillage_and_Grassland_Conversion_Protocol_Final.pdf.

BMPs linked to potential GHG emission reductions or removals	BMPs fostered by existing regulatory markets		BMPs fostered by existing voluntary markets		BMPs fostered by Environment Canada's fast track eligibility list (future federal offset program)	BMPs fostered by the three main American climate change bills			Quantification Protocol linked to the eligible activity
	Alberta Offset Program	Regional Greenhouse Gas Initiative	Chicago Climate Exchange	Climate Action Reserve		The American Clean Energy and Security Act (ACESA), H.R.2454	The Clean Energy Jobs and American Power Act (CEJAPA), S. 1733	The Clean Energy Partnerships Act of 2009, S. 2729	
Rangeland Management (including riparian management and improved grazing practices)	N/A	N/A	Long-term, commitment to defined management practices that increase soil carbon stocks (e.g. rangeland planted in trees, improved grazing practices).	N/A	N/A	Conservation of grassland.	Conservation of grassland.	• Improved management or restoration of cropland, grassland, rangeland, and forestland.	*Chicago Climate Exchange Sustainably Managed Rangeland Soil Carbon Sequestration Offset Project Protocol, Updated as of August 20, 2009*[14].
Practices that avoid GHG emissions									
Biogas capture and combustion or use as an energy source	The practice consists of displacing fossil fuel based electricity, thermal energy or natural gas in gas transmission systems with the biogas from the anaerobic digestion of organic	The practice consists of capturing and destroying methane from animal manure and organic food waste using anaerobic digesters.	The practice consists of the installation and operation of a new agricultural methane gas collection and control system.	The practice consists of the installation of a biogas control system that captures	The practice consists of displacing fossil fuel based electricity, thermal energy or natural gas in gas transmission systems with the biogas from the anaerobic	Biogas capture and combustion.	Non-landfill methane collection, combustion and avoidance projects involving organic waste streams, including manure	Biogas capture and combustion.	*Alberta Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials, Updated as of 09/2007*[15]. *Climate Action Reserve Livestock Project Protocol – Capturing and Destroying Methane from Manure Management*

[14] http://www.chicagoclimatex.com/docs/offsets/CCX_Sustainably_Managed_Rangeland_Soil_Carbon_Sequestration_Final.pdf.
[15] http://environment.gov.ab.ca/info/library/7905.pdf.

BMPs linked to potential GHG emission reductions or removals	BMPs fostered by existing regulatory markets		BMPs fostered by existing voluntary markets		BMPs fostered by Environment Canada's fast track eligibility list (future federal offset program)	BMPs fostered by the three main American climate change bills			Quantification Protocol linked to the eligible activity
	Alberta Offset Program	Regional Greenhouse Gas Initiative	Chicago Climate Exchange	Climate Action Reserve		The American Clean Energy and Security Act (ACESA), H.R.2454	The Clean Energy Jobs and American Power Act (CEJAPA), S. 1733	The Clean Energy Partnerships Act of 2009, S. 2729	
	feedstocks from agricultural materials, such as animal manure silage, and dead animal stock.			and destroys methane gas from anaerobic manure treatment and/or storage facilities on livestock operations	digestion of organic feedstocks from agricultural materials, such as animal manure silage, and dead animal stock.		management and biogas capture and combustion.		Systems, November 3, 2009, Version 2.2[16]. RGGI Model Rule, Revised 12/31/2008[17]. Chicago Climate Exchange Agricultural Methane Collection and Combustion Offset Project Protocol, Updated as of 9/30/2009[18]. U.S. EPA Climate Leaders GHG Inventory Protocol-Offset Project Methodology for Managing Manure with Biogas Recovery Systems, Version 1.3, August 2008[19].
Optimal soil application of animal manures						Application to fields as a substitute for commercial fertilizer.	Application to fields as a substitute for commercial fertilizer.	Improved management or application to agricultural land.	There are no protocols that have been designed by the existing offset programs under examination for those practices.

[16] http://www.climateactionreserve.org/how/protocols/adopted/livestock/current-livestock-project-protocol/.
[17] http://www.rggi.org/docs/Model%20Rule%20Revised%2012.31.08.pdf
[18] http://www.chicagoclimatex.com/docs/offsets/CCX_Agricultural_Methane_Final.pdf.
[19] http://www.epa.gov/climateleaders/documents/resources/ClimateLeaders_DraftManureOffsetProtocol.pdf.

BMPs linked to potential GHG emission reductions or removals	BMPs fostered by existing regulatory markets		BMPs fostered by existing voluntary markets		BMPs fostered by Environment Canada's fast track eligibility list (future federal offset program)	BMPs fostered by the three main American climate change bills			Quantification Protocol linked to the eligible activity
	Alberta Offset Program	Regional Greenhouse Gas Initiative	Chicago Climate Exchange	Climate Action Reserve		The American Clean Energy and Security Act (ACESA), H.R.2454	The Clean Energy Jobs and American Power Act (CEJAPA), S. 1733	The Clean Energy Partnerships Act of 2009, S. 2729	
Improved livestock feeding practices	• Integration of edible oils in the range of 4% to 6% (by dry weight) in some portion of the cattle feeding regime during the finishing period. • Reducing the days on feed for cattle being finished on feed lots. • Reducing the culling age of cattle throughout the beef production supply chain. • Alternate feeding practices and manure management on	N/A	N/A	N/A	Alternate feeding practices and manure management on pig farms.	Changes in animal management practices, including dietary modifications.	Changes in animal management practices, including dietary modifications.	Changes in animal management practices, including dietary modifications.	*Quantification Protocol for Including Edible Oils in Cattle Feeding Regimes, Version 2, May 2008*[20]. *Quantification Protocol for Reducing Days on Feed of Cattle, Version 1.1, August 2008*[21]. *Quantification Protocol for Beef Lifecycle Projects, Version 1.2, July 2009*[22]. *Quantification Protocol for Innovative Feeding of Swine and Storing and Spreading of Swine Manure, Version 1, September 2007*[23].

[20] http://environment.gov.ab.ca/info/library/7970.pdf.
[21] http://carbonoffsetsolutions.climatechangecentral.com/files/microsites/OffsetProtocols/ApprovedAlbertaProtocols/Beef_Days_on_Feed_Protocol_v1_May_08%20Update%20Aug%2008.pdf.
[22] http://environment.gov.ab.ca/info/library/7916.pdf.
[23] http://environment.gov.ab.ca/info/library/7913.pdf.

BMPs linked to potential GHG emission reductions or removals	BMPs fostered by existing regulatory markets		BMPs fostered by existing voluntary markets		BMPs fostered by Environment Canada's fast track eligibility list (future federal offset program)	BMPs fostered by the three main American climate change bills			Quantification Protocol linked to the eligible activity
	Alberta Offset Program	Regional Greenhouse Gas Initiative	Chicago Climate Exchange	Climate Action Reserve		The American Clean Energy and Security Act (ACESA), H.R.2454	The Clean Energy Jobs and American Power Act (CEJAPA), S. 1733	The Clean Energy Partnerships Act of 2009, S. 2729	
	pig farms.								
Reduction of nitrogen fertilizer use	BMPs are integrated into a new technology: 4R (Right Source @ the Right Rate, the Right Time and the Right Place) Nitrogen Stewardship Plan	N/A	N/A	N/A	N/A	Reduction of nitrogen fertilizer use.	Reduction of nitrogen fertilizer use.	Use of technology to improve management of nitrogen fertilizer use.	*Quantification Protocol for Agricultural Nitrous Oxide Emmisions Reductions, Version 1.0, October 2010.*[24].
Practices that prevent the conversion of lands that increase GHG emissions									
Reduced deforestation or avoided forest conversion	N/A	N/A	N/A	N/A	N/A	Reduced deforestation or avoided forest conversion.	Reduced deforestation or avoided forest conversion.	Avoided conversion that would otherwise release carbon, Reduced deforestation.	*There are no protocols that have been designed by the existing offset programs under examination for those practices.*

[24] http://environment.gov.ab.ca/info/library/8294.pdf

Benefits caused by carbon storage and EG&S connected with GHG reduction practices in the agricultural sector have attracted society's attention through media exposure on climate change policies and voluntary measures. As an example, the Chicago Climate Exchange (CCX) has developed a methodology that allows quantification of GHG emission reductions through carbon sequestration practices (e.g. no-till) in comparison with a standardized baseline that represents the business as usual scenario (e.g. full tillage). To quantify carbon sequestration levels and to establish the baseline scenario, nationwide data collection and measurements were necessary. For each ton of GHG emission that is reduced as a result of the practice, which would not have been reduced in the business as usual scenario, a tradable carbon credit is issued. BMPs eligible for this kind of transaction include conservation tillage and grassland conversion.[25] Tillage BMPs can thus generate private benefits for farmers and public benefits for society. As those practices are also eligible for the Alberta carbon market, the data necessary to establish the baseline scenario were collected. The Alberta Tillage System Management protocol allows for the quantification of soil carbon sequestration rates resulting from agricultural projects that shift practices to reduced tillage management from a baseline condition of full tillage. Quantification methods developed by Agriculture and Agri-Food Canada (AAFC) were used in Alberta to select coefficients. Those coefficients were then used to calculate annual rates of carbon sequestration with tillage management changes (i.e. changes from full tillage to either reduced tillage or no tillage), based on measured changes in levels of soil organic carbon. Such methods could be used in the Prairies, Ontario and Quebec, to quantify soil carbon sequestration rates and then allow quantification of biophysical changes resulting from conservation practices.

[25] For further details, see http://www.chicagoclimatex.com/content.jsf?id=781

7. BMPs producing the selected EG&S, fostering adaptation and encouraged by North American climate change policies

In this section, we identify the BMPs relevant to the three issues presented above, i.e. BMPs that simultaneously:

- Produce the selected EG&S (presented in Table 5);
- Foster adaptation to climate change (presented in Table 6);
- Are encouraged by developing North American climate change policies i.e. carbon markets (presented in Table 8).

The analysis of the BMPs presented in Tables 5, 6 and 8 has resulted in the identification of broad BMP categories that were simultaneously relevant to the three issues. The broad BMP categories that meet these criteria are presented in Tables 9 and 10. They include livestock management and various land management BMPs such as:

- Rangeland management;
- Riparian management;
- Conservation tillage;
- Establishing permanent grass and shelterbelts; and
- Nutrient management.

We have not taken into account the other potential effects of BMPs, and especially how the simultaneous implementation of different BMPs may affect each other. However, it is important to keep in mind that BMP impacts may not be restricted to these three issues and may affect, sometimes in an unintended way, other elements of the farm or the environment. These effects may not be always positive. For instance, the implementation of no-till practices in the Prairies may reduce water run-off from agricultural lands, potentially leading to decreased water availability downstream. Moreover, BMPs could have a competing influence on each other. No-till practices could create an adverse impact on shelterbelt management, for example, in cases where famers may perceive that shelterbelts and no-till have overlapping roles and decide that maintaining shelterbelts is less important than the implementation of no-till practices.

The BMPs selected in this study were chosen based on current environmental concerns in the Prairies and in Central Canada. This choice is not fixed in time, and may evolve as the environmental situation changes and scientific knowledge evolves. Some practices considered as suitable BMPs today may not be seen as useful BMPs in the future. Another important point to keep in mind is that the most efficient BMPs will not always be the same across the whole geographical area of this study. A BMP may be adapted for a situation in Québec, but not in Manitoba. Therefore, the list presented hereafter is not fixed, but temporally and geographically specific.

Moreover, from a political standpoint, the implementation of BMPs is not evenly visible and recognisable by the public. For example, the conservation of wetlands is more visible to the public than preservation of soil integrity, even though the later is more valued by famers. The consequence of this visibility bias is that wetland protection is easier to justify and present to a predominantly urban public, than is soil integrity preservation.

Once choices have been made on the type and amount of EG&S required and identification of relevant BMPs, a further step is to determine who should be responsible for the costs of BMP implementation and the most appropriate policy instruments to meet these policy objectives. These decision-making processes can be facilitated by applying the “reference level” concept and by adopting a policy development framework, which will be discussed the following chapters.

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TABLE 9: SELECTION OF POTENTIAL BMPS PRODUCING THE SELECTED EG&S, FOSTERING ADAPTATION AND ENCOURAGED BY NORTH AMERICAN CLIMATE CHANGE POLICIES

Main category of BMPs	Specific BMPs	Selected EG&S	Fosters adaptation	Fostered by future North American climate change policies through offset programs
Irrigation Water Management	Irrigation equipment modification/improvement to increase water efficiency (Sprinkler or drop irrigation systems, rewiring)	Water supply	X	0
	Modifications to drainage systems to allow controlled drainage (flow control, prevention of backflow of altered irrigation water into water sources, farmyard and horticultural facilities runoff control)	Water supply Conservation/restoration of biodiversity in wetlands and aquatic environments	X	0
	Crops requiring less water	Water supply	X	0
Manure storage and handling management	Biogas capture and collection or use as an energy source	GHG reduction and carbon storage	0	X
	Improved manure storage and handling	Purification of water Reduced odour and dust Conservation/restoration of biodiversity in wetlands and aquatic environments	X	0
Livestock management	Improving animal performance and feeding practices	GHG reduction and carbon storage	X	X
Wildlife management	Biodiversity Enhancement Planning Preventing wildlife damage (buffer strips around wetlands)	Conservation/restoration of biodiversity in wetlands and aquatic environments	0	0
Pest management	Integrated Pest management	Habitat Control of diseases and invasions by exotic species	X	0

Main category of BMPs	Specific BMPs	Selected EG&S	Fosters adaptation	Fostered by future North American climate change policies through offset programs
Land management	Rangeland Management (including riparian management and improved grazing practices)	Purification of water GHG reduction and carbon storage	X	X
	Windbreaks	Purification of water Reduced odour and dust Landscape protection	X	0
	Erosion control: Bank stabilisation, sediment control	Conservation/restoration of biodiversity in wetlands and aquatic environments	X	0
	Conservation of natural ponds	Landscape protection	X	0
	Culture rotations (including more forages in rotation)	Purification of water Conservation/restoration of moisture balance Control of diseases and invasions by exotic species	X	0
	Winter cover crops and crop residue on the soil surface	Purification of water	X	0
	Conservation tillage (no-till)	Purification of water Conservation/restoration of moisture balance GHG reduction and carbon storage	X	X
	Establishing permanent grass and shelterbelts	Purification of water Conservation/restoration of moisture balance Habitat Conservation/restoration of biodiversity in wetlands and aquatic environments	X	X
	Multiple cropping and intercropping	Control of diseases and invasions by exotic species	X	0
	Nutrient management: Improving nitrogen use efficiency	GHG reduction and carbon storage	X	X
	Removing lands prone to flooding from production	Habitat	X	0

TABLE 10: LIST OF BMPS THAT PRODUCE THE SELECTED EG&S, FOSTER ADAPTATION IN BOTH THE PRAIRIES AND CENTRAL CANADA AND THAT ARE FOSTERED BY NORTH AMERICAN CLIMATE CHANGE POLICIES

Main category of BMPs	Specific BMPs	Selected EG&S produced	Adaptation fostered in	
			Prairies	Central Canada
Livestock management	Improving animal performance and feeding practices	GHG reduction and carbon storage	X	X
Land management	Rangeland Management (including riparian management and improved grazing practices)	• Purification of water • GHG reduction and carbon storage	X	X
	Conservation tillage (no-till)	• Purification of water • Conservation/restoration of moisture balance • GHG reduction and carbon storage	X	X
	Establishing permanent grass and shelterbelts	• Purification of water • Conservation/restoration of moisture balance • Habitat • Conservation/restoration of biodiversity in wetlands and aquatic environments	X	X
	Nutrient management: Improving nitrogen use efficiency	• GHG reduction and carbon storage • Purification of water	X	X

8. Policy Development Framework: who should pay?

The costs of implementing these BMPs (or other BMPs) are unavoidable. A careful and informed debate on who should pay is needed. The answer to this question depends mainly on the level of environmental stewardship that society is entitled to expect from agricultural producers, that is, the *reference level*.

8.1 The reference level: a theoretical discussion

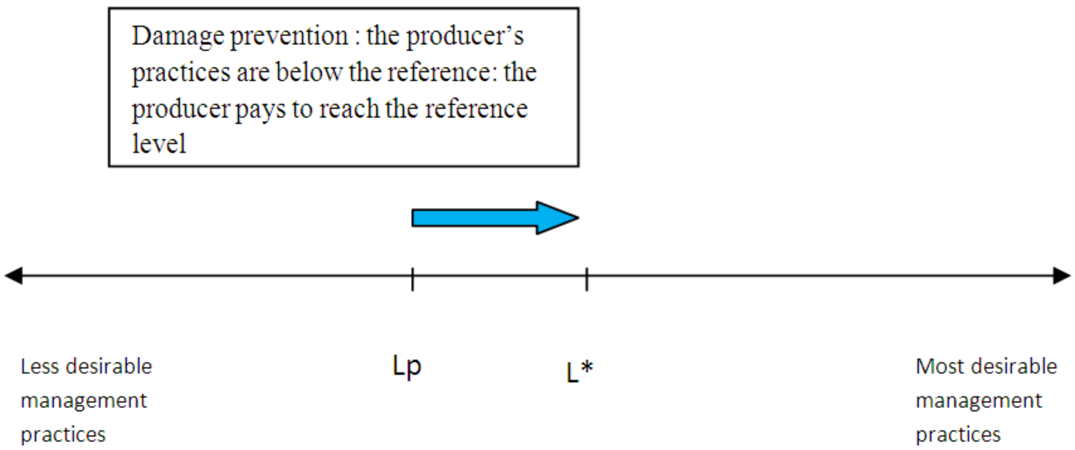
The value of the reference level concept is that by defining "what society has a right to expect from agricultural producers in terms of environmental protection", we identify the scope of producers' property rights as well as citizens' right to a clean environment. By establishing a reference level, a line is drawn between what society considers damage prevention and what it considers benefit creation. This way, a threshold is established up to which the 'polluter-pays' principle applies and beyond which the 'beneficiary-pays' principle applies. The polluter-pays principle applies to all damage prevention measures, whereas the beneficiary-pays principle applies to benefit creation measures. The underlying idea is that the society will agree to compensate economic agents who alter their practices only if this alteration gives rise to a net benefit for society.

This reference level may be defined scientifically or through exercising power relationships between the different groups within society. In any case, it is ultimately a social construct defining what society feels it has a right to expect from agricultural producers and what it feels it does not have the right to expect. In general, the adoption of a reference level will result from a negotiation process between different groups of society with different viewpoints.

Based on the above, it is possible to clarify how the costs of achieving agri-environmental performance objectives will be shared between producers and society. Thus, any action resulting in a net environmental benefit should entitle the farmer responsible for that action to a monetary compensation from society. In that situation, it is the user (beneficiary)-pays principle that applies. On the other hand, any action that prevents damage should not entitle the farmer to monetary compensation, and that farmer alone is responsible for expenses incurred. In that case, the polluter-pays principle applies.

The following figures present the possible positions of a producer regarding the reference level:

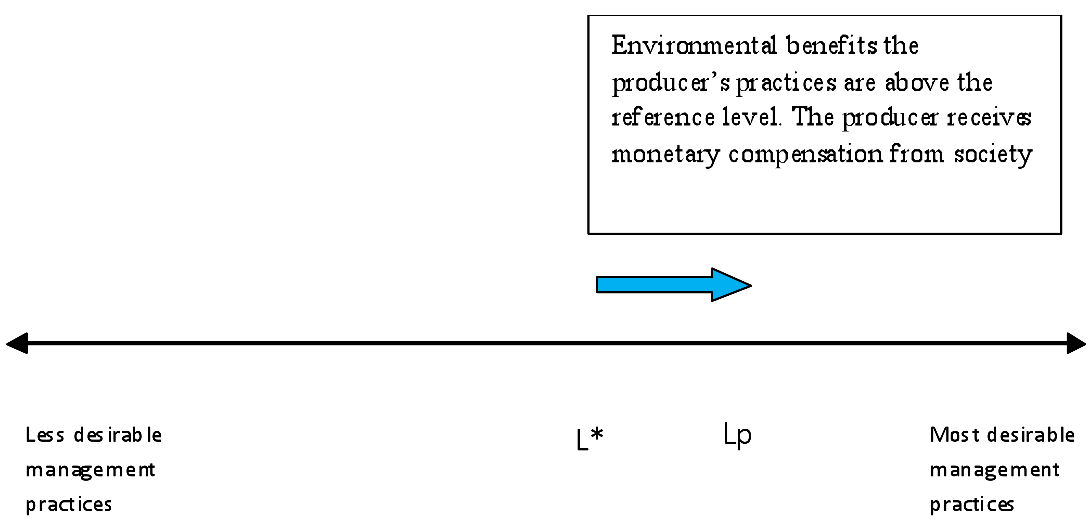
FIGURE 1: PRODUCER'S MANAGEMENT PRACTICES ARE BELOW THE REFERENCE LEVEL



Lp: Level of environmental performance attained by producers

L*: The level of reference

FIGURE 2: PRODUCER'S MANAGEMENT PRACTICES ARE ABOVE THE REFERENCE LEVEL



Lp: Level of environmental performance attained by producers

L*: The level of reference

8.1.1 Considerations for Establishing Reference Levels

Bromley (1996) maintains that the task of choosing a reference level is complicated because the notion of benefit is a societal construct. This means that different interest groups, with differing visions of the public interest, have different ideas about what a cost is and what a benefit is. Moreover, this vision changes over time, as Fletcher (1966) indicates in Nolet *et al.* (2006): "The morality of an act is a function of the state of the system at the time it is performed."

Concretely speaking, when public managers are selecting an appropriate reference level for agri-environmental issues, they must consider various societal context elements. These elements include the property rights system, the time-dependent nature of reference levels, the level of scientific knowledge and economic considerations. Another element is the influence of the food supply chain, with each actor having unique interests. The requirements of the supply-chain should also be considered in the reference level, which takes into account the demands of distributors and processors.

The property rights system influences the determination of the reference level. Absolute private property rights would entitle farmers to total compensation for any infringement of those rights. In Figure 3, this situation corresponds to using "absence of environmental restrictions" as a reference level. Conversely, the absence of property rights or very limited property rights would mean that the farmer must bear all costs associated with measures for mitigating the impact of agriculture on the environment. This situation corresponds to using "world best technology", a reference level that is likely economically unavailable to most producers.

The concept of property rights is not absolute and is not static. As environmental issues become more of a concern for society, farmers' private property rights may become increasingly limited and citizens' right to a clean environment may expand.

The reference level is also determined by taking into account the risks that could affect the environment and the public. Determining these risks requires an interdisciplinary team to set scientific standards to reduce risk at various levels and provide a range of potential reference levels. However, this may be a rather challenging task since viewpoints on a single issue may vary among scientists, impeding the attainment of consensus for prioritizing desirable practices.

8.1.2 Operationalizing the Concept of Reference Level

In theory, different categories of reference levels can be used. The following possibilities have been considered as reference levels:

- **Absence of environmental standards**;
- **Current situation (*status quo*)**: Most often, businesses targeted by an environmental requirement, whether agricultural or industrial, implicitly consider the current situation as their benchmark;
- **Business as usual**: Another way of establishing the reference level is to start not with the current situation, but with what the situation would be assuming that farmers are adopting a certain number of best environmental practices without any constraints imposed from outside. This approach assumes continuous improvement in taking environmental issues into account;

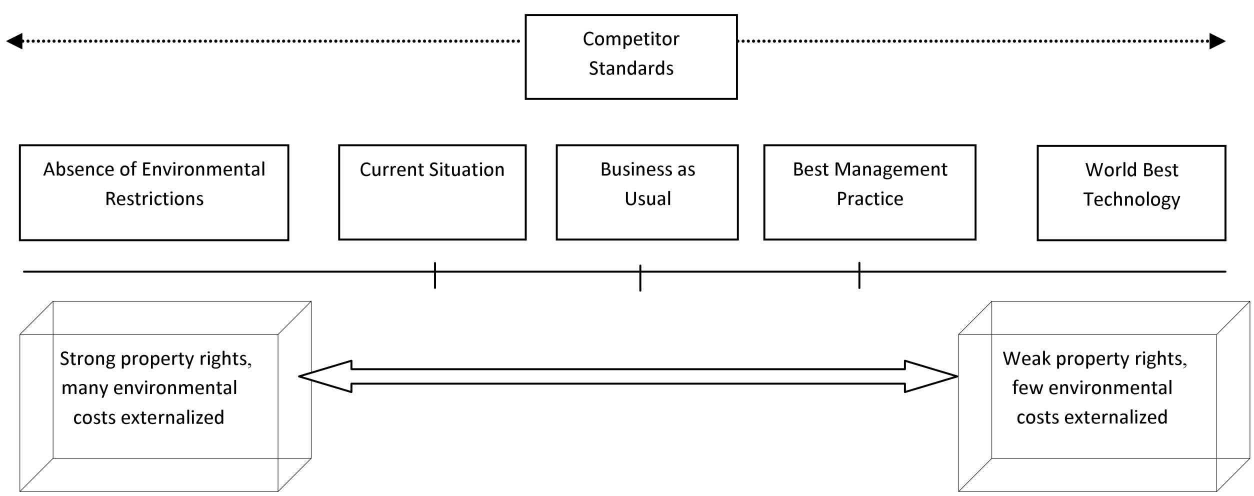
- **BMPs**: the literature on agri-environmental issues refers a great deal to BMPs. In other fields, they are usually called trade practices. These are the recognized practices in that milieu and usually incorporate an economic component in that the practices are justified from an environmental as well as economic perspective. In general, when new regulations are introduced, they are based on BMPs;
- **World best technology**: it refers to best environmental practices, but often economically unviable;
- **Representative competitor standards**: It is difficult to compare environmental standards across regions or countries because of differences in ecosystem sensitivity, the public's preferences and population density. Despite the reality of these limitations, it is still true that, with some care, comparisons can be made among regions with characteristics in common. Thus, in North America the level of wealth, although uneven, is relatively high and the public's environmental conscience is comparable within the continent. A number of environmental problems are also similar across jurisdictions. Whether we consider water quality, the odour problem or soil erosion, there is no reason to believe that certain problems and issues are dissimilar from one region to the next. Therefore, with some care, the environmental standard that a representative competitor uses could be the reference level used by a Canadian producer.

Among the benchmarks mentioned, only best management practices and world best technology involve a high degree of scientific objectivity. The other possible benchmarks are true social constructs that, depending on the case, may or may not incorporate a scientific component.

In the agriculture sector, absence of environmental standards, business as usual and world best technology are unlikely to be implemented.

The following figure shows the options presented by Doyon and Nolet (2006), in Nolet *et al*. (2006) for property rights and the internalization of environmental costs. It is worth noting that the reference level called "Competitor Standards" is found on all levels of the scale.

FIGURE 3: SUMMARY AND CLASSIFICATION OF THE REFERENCE LEVELS STUDIED



Source: Adapted from Doyon and Nolet (2006), in Nolet et al (2006)

8.2 The policy development framework

Even though the reference level concept is useful for establishing the basis of the debate, other concerns must be factored into the decision making process. A “decision tree” is proposed that provides a policy development framework to help guide the discussion on who should pay for the production of EG&S through agricultural BMPs. This framework is based on the following concepts:

- The reference level;
- The unpredictable nature of the burden;
- The reasonableness of the imposed burden.

The reference level

The reference level determines what level of EG&S production society is entitled to expect from agricultural producers. The reference level is a line drawn between what society considers damage prevention (the polluter-pays principle applies) and what it considers benefit creation (the beneficiary-pays principle applies). The theoretical discussion on which the determination of the reference level is discussed further in Section 8.1.

The unforeseeable nature of the burden

The criterion of unforeseeable burden refers to the idea that the State could agree to compensate for the costs that its intervention causes if the legislation had been developed in a context where government action was unforeseeable.[26] In such a case, the producer could not have prepared for the transition to the new regime.

Introducing the concept of unforeseeability therefore brings in the aspect of responsibility. Thus, an attempt is made to define when agricultural producers should be considered responsible, and the context within which producers should not be responsible for any losses incurred. Another aspect to be determined is the time frame within which the unforeseeability criterion applies.

The reasonableness of the imposed burden

The concept of “reasonableness” of the imposed burden refers to the extent of the cost for agricultural producers to meet the requirements of the new regulations. If a farmer or group of farmers determines that a government policy results in a disproportionate income shortfall or jeopardizes the enterprise, compensation could be considered in that case. Since the issue of “reasonableness” is subjective, other criteria need to be introduced to clarify it:

- Responsibility;
- Ability to pay;
- Need, necessity and relative state of development.

[26] Unforeseeability here means that, “at the time of the action, there was no signal from government or civil society suggesting a legislated change. Therefore, unforeseeability must not be taken in a context of uncertainty with respect to more short-term actions, as Isik (2004) discusses” (Nolet *et al.,* 2006, p.17).

Responsibility

The question to be asked here is: are agricultural producers responsible for environmental damage for which there is a cost that they must bear today?

The cost of compliance varies greatly from one operation to the next and, unlike most other production costs; the extent is often independent of farm size, efficiency or performance. Indeed, depending on their situation, some farmers face compliance costs that are much higher than others. For example, some farmers are located near a waterway, others surrounded by neighbours who may be bothered by odours, and others may be near particularly sensitive ecosystems. After all, not all producers have to install fences, respect riparian areas or adhere to separation distances. Producers facing costs such as these may be considered, in a way, victims of circumstance for which they are not always responsible.

Ability to pay

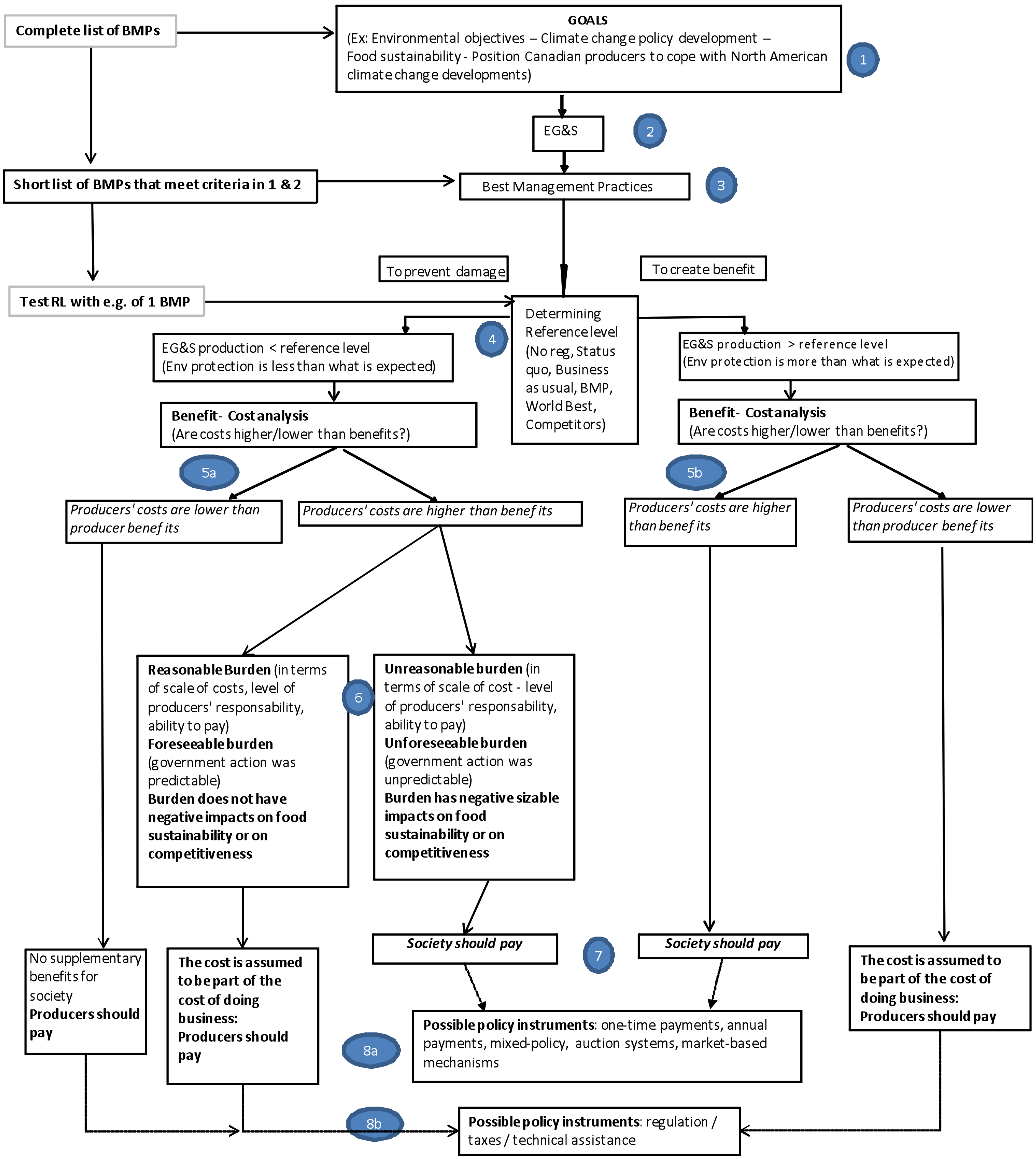
The concept of ability to pay refers directly to the relative wealth of agricultural producers. For example, even if regulations are foreseeable and a producer is responsible for the environmental damage done, the burden imposed may be unreasonable if the producer cannot cover the costs associated with the obligation. It is conceivable that, in an area where potential crop alternatives are very limited (e.g. sandy soil for potatoes), additional requirements in a difficult economic context may prove to be disastrous. In this case, compensation could be considered.

Need, Necessity and Relative State of Development

Agriculture is becoming more industrialized in North America. Without judging the value of new production models, we suggest that some types or sizes of operations have a greater need and they should be given a certain level of support to help adjust to new demands. Imposing environmental restrictions on vulnerable operations could jeopardize their economic viability. Therefore, compensation could be considered for operations that are in 'catch-up' mode (family farms) to take their need to remain competitive into account.

Based on the concepts introduced above, an innovative policy development framework has been developed (Figure 4). This policy development framework is a decision tree composed of 8 decision steps which represent the choices to be made within the decision-making process. Each decision level requires local involvement to adapt policy choices to the existing context.

Figure 4: Policy Development Framework



The decision tree is structured around eight "decision gates" which must be passed through in order to answer the question: "who should pay for the production of EG&S through the implementation of an agricultural BMP?" These decision levels are as follows:

- Level 1: Determining the main goals of the policy (e.g., environmental objectives, climate change adaptation, food sustainability, etc.);
- Level 2: Selecting the main EG&S associated with the policy goals. At this stage, the most relevant EG&S in light of those concerns are selected;
- Level 3: Identifying the BMP(s) which produce(s) one or several of the EG&S selected at step 2;
- Level 4: Determining the reference level and the degree of environmental protection (the EG&S production level) objective.

a. When the EG&S production is higher than the reference level there is a benefit for society which can also represent a cost for the farmer. In such a situation producers should normally be compensated.
b. When the EG&S production level is lower than the reference level, the actions undertaken essentially bring the practice closer or up to standard. Theoretically, this action could be considered a repayment to society of credit to which the farmer was not entitled to. In this situation, producers should normally have to pay.

- Level 5: Considers the costs and benefits accruing to the producers before deciding who should pay.

Level 5a: Cost-benefit analysis for situations where EG&S production level is lower than the reference level. This involves assessing the benefits and costs accruing to the farmer. There are two possibilities here:

a. Producer's benefits are higher than or equal to producer's costs: This action can be considered a normal good management practice. The farmer should pay.
b. Producer's benefits are lower than producer's costs: The farmer may have to pay (See Level 6).

Level 5b: Cost-benefit analysis for situations where EG&S production level is higher than the reference level. This involves assessing the benefits and costs accruing to the farmer. There are two possibilities here:

a. Producer's benefits are higher than or equal to producer's costs: This action can be considered a normal good management practice. The farmer should pay.
b. Producer's benefits are lower than producer's costs: Society should pay.

- Level 6: In a situation where the farmer is not providing a benefit to society but simply avoiding damage, the producer should normally pay. However, considering aspects other than EG&S production level, producers may be entitled to assistance on a transitional basis: Is the burden reasonable? Is it foreseeable (was the government action predictable)? Could this burden have negative impacts on food sustainability or competitiveness? The farmer should not bear an unforeseen and unreasonable burden and/or one which may have negative impacts on the viability of the Canadian agricultural sector or its competitiveness. In those situations society should pay.
- Level 7: Given the above logic, a decision can be made on "who should pay?"

- Level 8: Choosing policy options: policy instruments differ whether the financial burden of implementing BMP falls to the farmers or to society.

Level 8a: Instruments based on voluntary actions, such as one-time or annual payments and market-based instruments are more relevant when society pays for BMP implementation.

Level 8b: Instruments based on obligation such as taxes and regulations are useful when it is deemed that producers should bear implementation costs.

Once level 8 is achieved, the next step is to determine the most appropriate policy instrument(s) to implement the indentified BMPs. The next section discusses a set of guidelines and principles to help identify the most cost-efficient EG&S policy options.

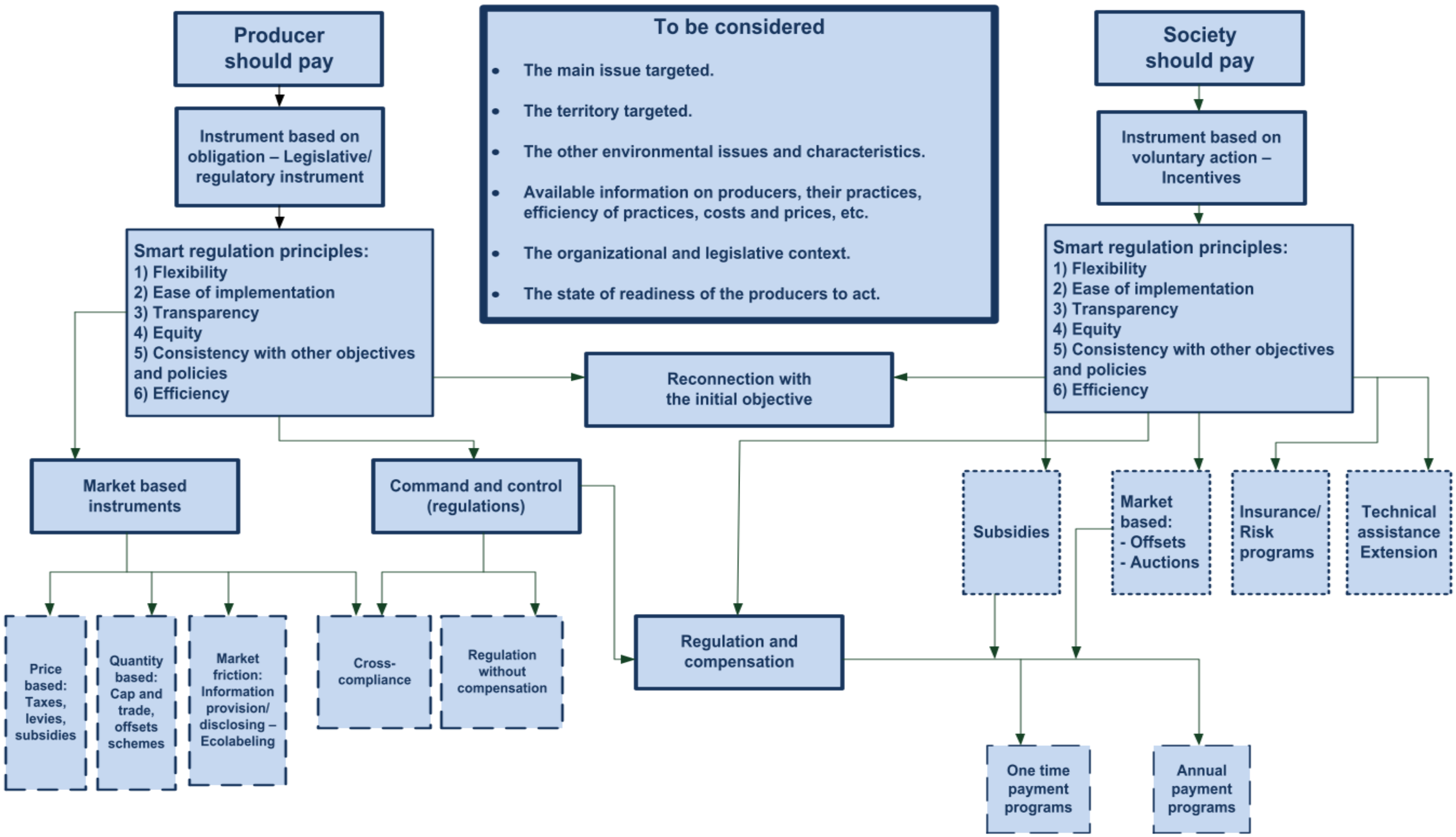
9. Identify the most cost-efficient EG&S policies

Once it has been made clear who should pay for BMP implementation, most of the policy development process has been done. However, the policy maker still faces many options as illustrated in step 8 of figure 4.

However, the formulation of a policy refers not only to the type of instrument used but also to the process that led to its selection. In this regard, the grid developed here (Figure 4) shows what elements should be considered from the outset in the decision making process regardless of the direction taken in regard to who should pay.

Figure 5 illustrates the many options available to policy makers and the elements that need to be considered before choosing appropriate policy instruments.

FIGURE 5: THE CHOICE OF POLICY OPTIONS



Thus, the choice of policy instrument depends on:

- The main issue targeted;
- The territory targeted;
- Other environmental issues and characteristics;
- Available information on producers, their practices, the efficiency of their practices, their costs and revenues, etc.;
- The organisational and legislative context;
- The state of readiness of the producers to act.

Depending on who is paying, policy makers will face different policy options. If the producer is the one who pays, the choice will normally go towards instruments based on obligations, such as command and control or market based instruments (see Table 11 for examples). Market based instruments refer to taxes, cap and trade systems and market friction instruments. Command and control refers to regulations. Regulations can be implemented with or without compensation to the producers. Cross compliance falls between regulations and market based instruments.

If society is going to pay, then, the choice will normally go towards instruments based on voluntary action and incentives. Society can provide incentives in many ways (Table 11). It can use technical assistance, insurance programs, market based instruments such as auctions and offsets, and subsidies that can take the form of annual payments or one time payments.

Between those two broad categories, are regulations for which producers are compensated. Producers are required to comply with regulations, but also receive a monetary incentive at the same time.

TABLE 11: SOME EXAMPLES OF POLICY OPTIONS

Policy Option	Examples
Instruments based on obligations	
Regulation	• Ban on spreading manure on a frozen soil without compensation. • Manitoba Nutrient Management Regulation – ban on application of fertilizers near waterways
Cross-Compliance	• Obligation to respect riparian buffer zone regulation in order to be eligible for crop insurance programs in Quebec. • France's agri-environmental measures (AEMs).
Market Friction	• Higher prices for organic products if standards are respected.
Cap and Trade	• Maximum Daily Load in South Nation River Basin in Ontario.
Offsets	• Alberta offsets program in the climate change regulation.
Instruments based on voluntary action	
Insurance/Risk premiums	• Crop insurance programs usually impose limits to producers in the adoption of new practices. Changing the rules of those programs could favour the adoption of BMPs.
Technical assistance	• University extension programs in the U.S.
Subsidies	• Alternative Land Use Services (ALUS) pilot project in Manitoba. • U.S.'s Conservation Reserve Program (CRP).
Market based instruments	• Australia's BushTender and EcoTender programs. • Alberta offsets program in the climate change regulation.

Economists have always been interested in how to best formulate public policy. Over time, certain principles have been developed in relation to the implementation of policies. Recent work conducted by Australian researchers introducing a policy instrument selection framework and rules based on net public vs. private benefits serves as a useful guide to investigate appropriate policy instruments to influence land use practices (Pannell (2008). Many of these principles have been grouped under the term "smart regulation" (OECD, 2001; Latacz-Lohmann, 2001; Howlett and Rayner, 2003; Gunningham and Sinclair, 1999 and Nolet *et al.* 2004, all cited in Nolet *et al*., 2007). Thus following these precepts, a smart policy must be efficient (the goal), effective in the economic sense (to reach the objective at the lowest possible cost or maximize profits), be easy to implement, transparent, equitable and consistent with the context of broader government decision. Finally, a policy should not provide an incentive to behave in ways that are otherwise ineffective in a societal perspective.

These principles will need to be taken into account in the choice that will be made between the different policy instruments.

1) Flexibility

The concept of flexibility in the approach is based on the idea that the emphasis of a policy should be placed on results rather than means. Flexibility is considered desirable because it opens the door for technological innovations to achieve and exceed environmental objectives at lower costs, notably by means unknown at the time of the adoption of the regulation. By comparison, a regulatory approach that would require the use of a certain technology could have the impact of suppressing further technological innovation.

2) Ease of implementation

Ease of implementation is a consideration for the analysis of the “smartness” of a policy. If the policy is difficult to implement it may never be fully enacted and therefore will not achieve the desired level of results.

3) Transparency

Transparency of a policy or regulation is essential for instilling confidence in its effectiveness with the stakeholders who are impacted by it. Ultimately, transparency can have an impact on the usefulness and longevity of the policy or regulation.

4) Equity

An important element of the acceptability of a policy or regulation is its impact in terms of equity for the stakeholders. Eventually, legislation that is seen as unfair may open the door to a public discontent and rejection.

5) Consistency

For a program to be “smart”, we must design it so it does not result in ineffective or undesirable behaviour. Specifically, we need the program or regulation to be consistent with other government policies or regulations.

6) Efficiency

Regulations that generate more welfare to society than cost would meet the criterion of cost effectiveness. This is a key criterion for defining the "smartness" of a regulation. Indeed, the criterion of economic efficiency is that a project should be undertaken if the net discounted benefits exceed the net discounted cost (OECD, 2001, in Nolet *et al.*, 2007).

10. Testing the policy development framework

At this stage, the policy development framework presented in the previous section is applied to the example of the creation of riparian buffer zones in the Prairies and Central Canada.

On the first step (Step 1) of the decision making framework, the selected policy goals have been: 1) food sustainability, 2) adaptation to climate change, 3) making environmental improvements and 4) positioning Canadian producers to align with North-American climate change policy development in the context of the Canadian prairies and Central Canada. The priority EG&S to be produced through agricultural BMPs (Step 2 of the policy development framework) are those outlined in Table 5. On the next step (Step 3) we have chosen to implement riparian buffer strips, as it produces one or several of the selected EG&S, along with fostering adaptation to climate change and being favoured by future North America climate change policy.

The fourth step of the policy development framework is to determine the reference level, that is, "what society is entitled to ask from producers". Three reference level scenarios are presented here to test the framework. For each scenario, a cost-benefit analysis of the implementation of riparian buffer zones in Quebec and in Manitoba is carried out (Step 5 of the policy development framework). In the case that producers would theoretically assume costs of producing EG&S, other aspects may be taken into consideration (Step 6). This directs us to Step 7, which involves deciding whether producers or society should pay for BMP implementation. Finally, Step 8 of the framework consists of identifying the appropriate policy responses, which depends on who (society or producers) should bear the implementation costs.

10.1 The reference level scenarios

The three reference level scenarios are as follows:

Scenario 1: Farmers' practices are below the reference level and the reference level is the existing norm;

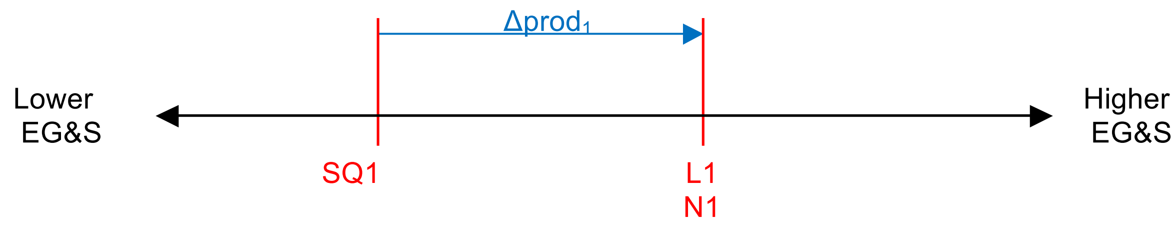
Scenario 2: Farmers' practices are below the reference level and the reference level is higher than the existing norm;

Scenario 3: Farmers' practices are above the reference level and below the existing norm.

In each scenario, we will use the assumption of the implementation of one-km in length of buffer strip in order to provide a comparable basis for our analyses in Quebec and in Manitoba.

10.1.1 Reference Level Scenario 1: Farmers' practices are below the reference level and the reference level is the existing norm (Step 4)

The first scenario under consideration occurs when the existing norm is equal to the reference level and the *status quo* is lower. This represents a case where existing legislation reflects public demand, but producers are not in compliance with legislation. In this scenario the challenge is to close the gap between the *status quo* and the existing norm.



SQ1 *Status quo* EG&S level

L1 Reference level EG&S level

N1 Existing norm EG&S level

Δprod1 Producers' gap for Reference Level Scenario 1

In Québec

Reference level and status quo levels in Québec (QC) – Scenario 1 (Step 4)

Considering the implementation of riparian buffer zones, in Quebec it is widely assumed that existing norms are not presently fulfilled in intensive agricultural areas. The Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains (PPRLPI) of the Government of Quebec and its Agricultural Operations Regulation (Gouvernement du Québec, 2002) have established a 3-meter wide riparian strip along watercourses, lakes, swamps having a minimum area of 10,000 m^2, or ponds. However, in most cases riparian buffer zones in agricultural intensive areas are only 1-meter wide. Therefore producers' *status quo* is under the reference level, which is represented here by the norm level.

In this case, the implementation of riparian buffer zones is associated with a "catching up" or bringing up to the existing standard.

Costs-benefits analysis – Scenario 1 QC (Step 5)

In this scenario, we will estimate the cost from passing from the *status quo* (1-meter grassed riparian strip) to the reference level (3-meter grassed riparian buffer strips). This means that producers' land loss corresponds to a 2-meter strip along watercourses. In order to make our analyses comparable, in each Quebec scenario we will calculate the cost for a producer to implement one km of buffer strip. In scenario 1 this corresponds to 0.3 ha of buffer strip.

Respecting riparian buffer zones implies not cropping in certain areas currently used for agriculture. Our objective is to assess the cost of buffer strip implementation for the farmer, i.e. the income reduction associated with the loss of cultivable area.

Costs associated with loss of cultivable area

Costs associated with loss of cultivable areas are calculated through potential contribution margins with crops included in a typical rotation in Québec, that is, grain corn - grain corn - soybean. Grain corn and soybean margins were used in a tool developed jointly by CEPAF (*Centre d'expertise sur les produits agroforestiers*) and Agriculture and Agri-Food Canada (AAFC) to simulate the economic impact of agroforestry management measures: $294.47/ha/year and $275.13/ha/year, respectively (CEPAF, 2010).

Costs are calculated on a unitary basis: 1 km riparian buffer strip. A period of 18 years has been chosen to calculate the net present value. This period corresponds to the difference between the average age of farm operators and the retirement age. Using the CEPAF calculator, the result of the calculation of the net present value of costs associated with loss of cultivable areas is $841/km of riparian buffer strip.

Therefore, the total private costs assumed by producers for this first scenario rise to $841/km, i.e. $4205/ha, of riparian buffer strip.

In the case of buffer strips, lost acreage means lost income for farmers, while the benefits of buffer strips are, for the most part, external to the farm. We may conclude from this that, barring certain exceptions, buffer strips represent a net cost to farmers. As costs are higher than benefits for the farmers, we have to move to Step 6 of the policy decision framework in order to complete the decision process.

Foreseeability, reasonableness and negative impact analyses – Scenario 1 QC (Step 6)

In order to be compensated, a cost has to meet one of the two criteria set out in Doyon's classification grid (Doyon, 2003, in Nolet, 2004): foreseeability and reasonableness.

Assessing foreseeability

One question that could be used to assess the foreseeability of an environmental constraint is: when farmers purchased farmland, could they have predicted the buffer strip width requirements that they would face in the future?

Debailleul's (2004) analysis on this point is unequivocal (*In* Nolet 2004). In his opinion, as of 1981 and until the new regulations were introduced (2002), spreading was prohibited within a 30-m strip along protected watercourses and within a 5-m strip along unprotected watercourses. In 2002, the distinction between the two types of watercourses was eliminated and the distance within which spreading is prohibited was reduced to 3 meters from watercourses and 1 meter from agricultural ditches. Moreover, the Quebec Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains (the Policy) has been in effect since 1987. In other words, farmers faced more stringent requirements 20 years ago than they do today. In this context, it could hardly be argued that the current standard represents a requirement that exceeds what one would have expected when purchasing land 10 years ago. Since there was nothing unforeseeable about the current standard, it will be deemed that farmers could have prepared for this and amortized the costs over time. Consequently, they should not be compensated on the basis of the unforeseeable burden.

Assessing the reasonableness of the burden imposed

Given that the average size of a farm in Quebec is 106 ha, the total annual margin per farm is estimated at $30,225/year. We assume that the actualised value of the total margin is constant over the years. Therefore, the total margin per farm for the 18 year period, i.e. the period considered in calculating the net present value of the net costs, equals $544,050. In scenario 1, the net present value of the net costs of implementing the BMPs rises to $841/km of riparian buffer strip, that is, 0.15% of the total margins over the period. On this basis, we may conclude that the burden imposed on farmers as a whole is reasonable and, consequently, they should not receive compensation. However, these impacts may not be distributed equally among farmers.

Assessing the negative impact on food sustainability and competitiveness

The implementation of a 3-meter wide buffer strip along watercourses in Québec may not have any significant negative impact on food sustainability and/or competitiveness.

Who should pay? – Scenario 1 QC (Step 7)

The results of the analysis conducted at the previous steps of the policy development framework lead to the following conclusion:

- The producers' practices are below the reference level;
- Producers' costs are higher than producers' benefits;
- The imposed burden was foreseeable;
- The imposed burden is reasonable;
- The imposed burden does not have any significant negative impacts on food sustainability and competitiveness.

Then producers should pay for the implementation of 3-meter riparian buffer strips.

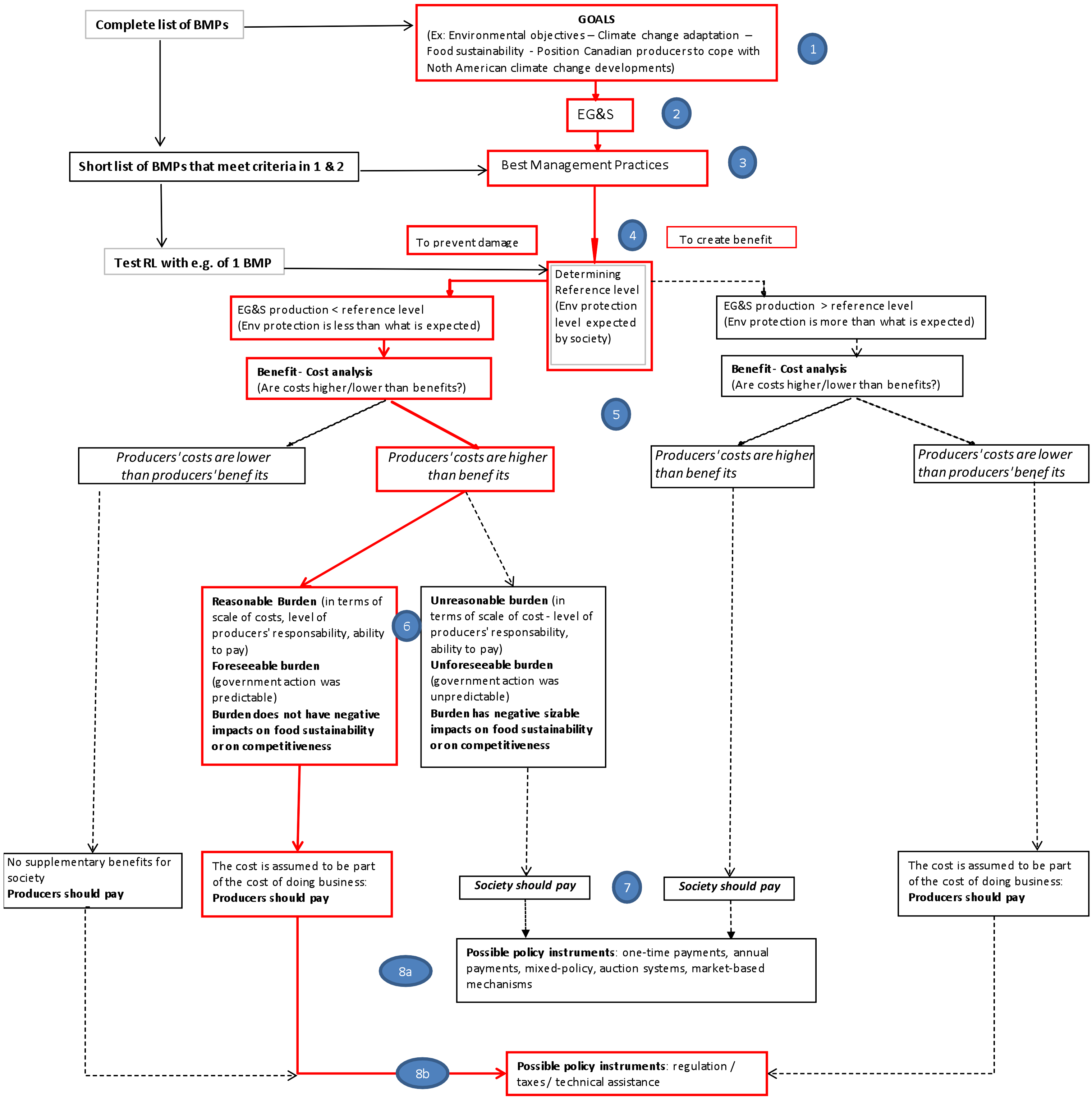
Policy responses – Scenario 1 QC (Step 8)

Some possible policy responses to this scenario are a stricter enforcement of legislation or the provision of practical information to producers who require technical assistance in order to bring their operations into compliance.

In this case the cost of raising the *status quo* to reflect the reference level, which is the existing norm, would be borne entirely by the producers. However some public costs would be entailed through enforcement and extension.

The eight steps of Scenario 1 are presented in red below:

Figure 6: Policy Development Framework: Scenario 1 - Farmers' practices are below the reference level and the reference level is the existing norm



In Manitoba

Reference level and status quo levels in Manitoba

The situation in Manitoba differs considerably from that of Quebec. Firstly in Manitoba, there is no legislation preventing cultivation in riparian areas. The Manitoba Nutrient Management Regulation (C.C.S.M. c W64) sets out rules for applying fertilizer and manure in riparian areas, but permits cultivation in riparian buffer zones[27], making the existing norm in Manitoba 0 m. Secondly; most riparian areas in Manitoba have natural buffer zones on them. Despite the lack of buffer zone regulations, the banks around rivers are generally covered with native vegetation. Responses to the 2006 Census of Agriculture (Statistics Canada 2007) indicate that over 38% of Manitoba farms have riparian buffer zones. This is particularly significant considering most farms do not have waterways running through them. The *status quo* for riparian buffer zones in Manitoba may be the result of geography, where slopes can be steep and highly erodible it may not be feasible to manoeuvre farm machinery in these areas. Riparian areas are also prone to flooding, potentially increasing the risk of loss from farming in these areas. Riparian buffer zone uptake could also be a function of several successful voluntary programs to offset the costs of buffer zone implementation; however the impact of these programs does not appear to be responsible for the large scale implementation of riparian buffer zones. Programs such as the Environmental Farm Action Program, Manitoba Habitat Heritage Corporation's Riparian Conservation Agreements and the Manitoba Riparian Tax credit compensate producers for taking this sensitive land out of production.

Since the implementation of buffer zones by producers in Manitoba is long established, we assume that, generally, they do not take on a burden in doing so (with recognition that each situation will be unique depending on circumstances). Consequently, producers do not need to be compensated for what they do normally.

10.1.2 Reference Level Scenario 2: Farmers' practices are below the reference level, and the reference level is higher than the existing norm

This scenario represents a situation where the reference level, that is, what society has a right to expect from agricultural producers in terms of environmental protection, is higher than the existing norm's level of producing EG&S.

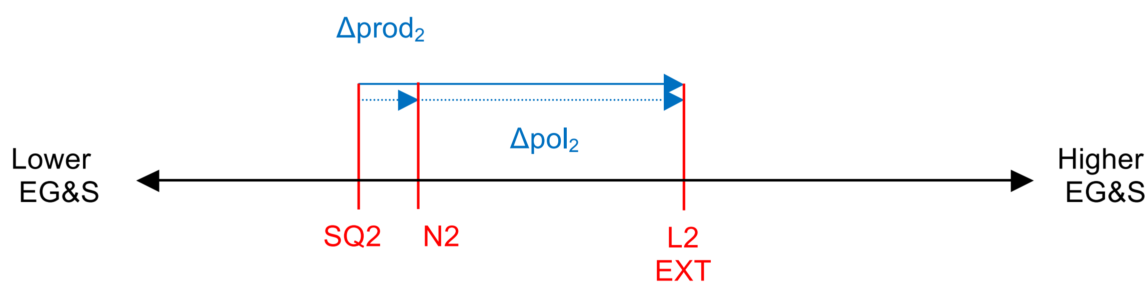
It may occur, for example, when the reference level corresponds to the competitor standard and this standard is higher than existing norms. With American agriculture being the main competitor of Canadian agriculture, we chose to focus on the riparian buffer width required as a minimum in the U.S. conservation programs which support the implementation of riparian buffer strips on agricultural land.

[27] Implementation of Nutrient Buffer Zones (i.e. buffer zones to protect surface waters) under the Nutrient Management regulation has been in effect as of Jan 1, 2009 in Manitoba, but are required only if nutrients are being mechanically applied. The buffer zones vary based on whether or not the buffer is permanently vegetated, the type of water feature that is adjacent to the buffer and, in the case of manure, the method of application. Manitoba Water Stewardship (2010).

In the United States, the Conservation Reserve Enhancement Program (CREP) focuses on the environmental concerns of agriculture and fosters agricultural management practices that contribute to conserving the environment. This program is the result of a partnership between federal and state governments and both provide financial incentives to participants to implement eligible management practices. One of the eligible practices is the implementation of forested riparian buffer strips i.e. CP22 practice in the Conservation Reserve Enhancement Program (USDA, 2005).

To be eligible for program subsidies, riparian buffer strips must be at least 35 feet (10 meters) wide. Most non-forested croplands, hay lands, or marginal pasturelands are eligible. They must be no farther than 180 feet (55 meters) from of a stream, river or other water body. In some states, the riparian buffer has to be a minimum width of 50 feet (15 meters) to be eligible for state financial incentives, in addition to the federal payments.

Therefore, for this scenario, we chose to consider a 10-meter wide wooded riparian buffer strip as the reference level.



SQ2	Status quo EG&S level
N2	Existing Canadian norm EG&S level
L2	Reference level EG&S level
EXT	Existing foreign (U.S.A) norm EG&S level
Δprod2	Producer gap for Reference Level Scenario 2
Δpol2	Policy gap for Reference Level Scenario 2

This situation might represent a transitory period before the existing foreign norm level is enforced in Canada to make the reference level compulsory for producers.

In Québec

Reference and status quo levels in Québec – Scenario 2 (Step 4)

In this scenario, the reference level is the competitor standard, i.e. a 10-meter wide wooded buffer strip, whereas the *status quo* level is a 1-meter wide buffer strip and the existing norm is a 3-meter buffer strip. Therefore, the reference level is significantly above existing practices.

Costs-benefits analysis – Scenario 2 QC (Step 5)

The implementation of wooded riparian buffer zones implies changing farmers' usual practices. The economic implications of these changes are evaluated using the partial budget method. Under this methodology, four basic elements must be considered:

a. The cost associated with plantation and periodic maintenance of the riparian buffer strip;
b. The avoided costs: purchase of seeds, fertilizer, etc.;
c. The additional income: wood harvesting, berry harvesting, improved crop yields and carbon credits;
d. The lost income: loss of income associated with non cultivable areas.

In this scenario, involving wooded buffer strips, trees are protected by plastic mulch at planting, which is a widely used technique fostering better growth and quicker plant establishment (see www.wbvecan.ca). In the case of wooded strips with several parallel rows, spacing between rows is three meters.

The woody species used in Scenario 2 were selected based on location, climate zone and soil characteristics of the area. The species chosen are as follows:

- Hybrid poplar (*Populus hybr*.) (HPO);
- Shrubs (SHR) such as the highbush cranberry (*Viburnum trilobum*), elderberry (*Sambucus canadensis*) and black chokeberry (*Aronia melanocarpa*).

The proposed 10-meter wooded buffer strip would have the following characteristics:

TABLE 12: WOODED-BUFFER STRIP CHARACTERISTICS FOR SCENARIO 2 IN QUEBEC

Row[28] #	Species	Spacing between plants (m)	Spacing between rows (m)
Row 1	SHR	2	3
Row 2	HPO	3	3

Total private cost of establishing a wooded buffer zone (purchase of trees, maintenance, etc.) was calculated using a tool developed jointly by CEPAF (*Centre d'expertise sur les produits agroforestiers*) and Agriculture and Agri-Food Canada[29] to simulate the economic impact of agroforestry management measures. This simulation software was specifically designed to provide landowners with economic information when establishing shelterbelts or wooded riparian buffer zones. Specifically, the model determines an actualized margin for a buffer zone between the cost of establishing and maintaining it over the years and the revenue generated and the costs prevented by its implementation. In order to estimate these parameters, the model incorporates an inflation rate based on the consumer price index (2%), and an actualization rate (4%) for calculating the Net Present Value (NPV) of costs and benefits. A 40-year actualisation period has been chosen for the calculation, in order to take into account the growth period of the trees.

It takes into account the following elements: the costs of establishing the buffer, the costs of maintenance, the loss of cultivable area, revenues from wood and small fruit harvesting, improved yields associated with crop protection provided by the buffer and potential carbon credits.

[28] The CEPAF calculator does not indicate which row is closer to the river
[29] This tool is available on the CEPAF website at: http://www.wbvecan.ca/francais/index.html

To maintain the buffer zones, we assume that trees which die during the first year of planting will be replaced, that weeds and grass around the young trees will be cut twice a year during the first five years of growth and that a phytosanitary inspection of the trees will also be performed as part of this biannual maintenance process. As well, trees will be pruned for shaping each year from the second to the tenth year and the more mature trees will be pruned until harvested.

Table 13 shows the summary results from the simulation made using CEPAF's tool. The loss of income associated with the loss of cultivated area is reduced by taking into account the *status quo* 1-meter wide riparian buffer zone. More detail about costs and benefits for each year are presented in Appendix 1.

TABLE 13: ECONOMIC IMPACTS OF 1 KM OF A 10-M-WIDE WOODED RIPARIAN BUFFER ZONE OVER 40 YEARS ($/HA) IN QUEBEC.

	Cost of establishing wooded buffers	Costs associated with loss of cultivable area	Maintenance costs for wooded buffers	Income from timber	Income from non-timber forest products	Income associated with carbon credits
Net Present Value (NPV)	-4,417	-6,930	-2,072	1,266	497	914
TOTAL NPV						- 10,742

The total net cost of establishing and maintaining 1 ha (1 km long, 10m wide) wooded riparian buffer zone is evaluated at $10,742. The highest costs are the income reductions associated to the loss of cultivated surface, i.e. $6,930/ha or km. The establishment costs are estimated at $4,417/ha or km) and the maintenance costs are $2,072/ha or km. On the benefit side, incomes from: timber sales (hybrid poplars are harvested at the 21st year and not replaced afterwards) total $1,266/ha or km, selling non-timber forest products (primarily berries) amounts to $497/ha or km, and carbon credit sales amount to $914/ha or km[30]. The CEPAF calculator presents the net benefits of selling non-timber forest products. It takes into account the costs associated with these products and estimates them on the basis of previous work made by the CEPAF (field research on production costs and marketing studies on berries).

Therefore, net costs for this second scenario rise to $10,742/ha or km for a 10 meter wide riparian buffer strip.

As costs are higher than benefits, we have to move to Step 6 of the policy development framework to complete the decision process.

Foreseeability, reasonableness and negative impact analyses – Scenario 2 QC (Step 6)

Assessing foreseeability

We seek to answer the question: when farmers purchased farmland, could they have predicted the buffer strip width and vegetation-type requirements they would face 10 years later?

Even if farmers faced more stringent requirements 20 years ago than they do today in terms of loss of cultivable areas, as mentioned by Debailleul (2004) in Nolet (2004), implementing a wooded riparian buffer

[30] The price is assumed to be $7.5/ton. The CEPAF (2010) mentioned that the selected methodology will have to be validated by the authorities should a carbon credit system be implemented.

strip entails other important costs associated with their establishment and maintenance. In this context, it could be argued that the 10-meter standard represents a requirement that exceeds what one would have expected when purchasing land 10 years ago. Since there was unforeseeability about this standard, it cannot be deemed that farmers could have prepared for this and amortized the costs over time. Consequently, they should be compensated on the basis of the unforeseeable burden.

Assessing the reasonableness of the burden imposed

The total net present value of the costs rises to $10,742/ha or km. As in Scenario 1, we assume that the actualised value of the total margin per farm is constant, and equals $30,225/year. The total margin per farm therefore rises to $1,209,000 for the 40-year period. The net present value of the costs associated with implementation of a 10-meter wide wooded riparian strip is estimated at 0.9% of the total margin of the farm. However, we assume that the costs of establishing the buffer zone vegetation, i.e. $4,417/ha or km, is borne by the producer in totality during the first year of the implementation. This cost represents 14.6% of the annual total margin of the farm. On this basis, we may conclude that the burden imposed on farmers as a whole is unreasonable and that, consequently, they should receive compensation.

Assessing the negative impact on food sustainability and competitiveness

As mentioned before, costs of implementing 10-meter wide riparian buffer zones in Quebec represents an unreasonable burden for producers. We may question whether this burden could affect the competitiveness of the agricultural sector in Quebec. Furthermore, assuming these significant costs would be reflected in the final price of products this would affect the competitiveness of agricultural goods produced in Quebec.

Who should pay? – Scenario 2 QC (Step 7)

The results of the analysis conducted at the previous steps of the policy development framework lead to the following conclusion:

- Producers' practices, generally, are below the reference level;
- Producers' costs are higher than benefits;
- The burden imposed was unforeseeable;
- The burden imposed is not reasonable;
- The burden imposed may have significant negative impacts on food sustainability and competitiveness.

In this case, producers should be compensated for implementation of a 10-meter wooded riparian buffer strip. We have seen in scenario 1 that farmers should pay for the implementation of a 3-meter wide grassed buffer strip, as this corresponded to the existing norm and this did not seem to be an unreasonable burden for farmers. Therefore, we conclude that in the current scenario the cost of raising the *status quo* to reflect the reference level should be shared between producers and the society:

- Producers should pay to enlarge the grassed buffer strip up to 3 meters. Cost are calculated for 40 years (instead of 18 years as in scenario 1), because of the deciduous species involved in this scenario. The net present value of costs being assumed by producers is estimated at $1,540/km of riparian buffer strip;
- Society should pay costs associated with converting a 3-meter grassed buffer strip to a 10-meter wooded buffer strip. These costs are estimated for Quebec at $9,202/km. The income reduction associated with the loss of cultivable areas rises to $5,390/km of riparian buffer zone.

Policy responses – Scenario 2 QC (Step 8)

Producers should assume the costs of moving from the *status quo* to the existing 3-meter grassed buffer norm level. As in scenario 1, policy options to foster this situation include stricter enforcement of legislation or the provision of practical information to producers who require technical assistance to bring their operations into compliance.

Once producers have implemented a 3-meter wide grassed buffer strip and comply with the norm, they do not have any incentives to improve their practices beyond the norm level. The switch from the existing norm to the reference level (foreign competitor norm) could best be achieved through the implementation of policy measures (i.e., incentives) inducing producers to raise standards voluntarily: annual payments, one-time payments, auctions[31], offsets, etc.

In Manitoba

Reference and status quo levels in Manitoba (MB) – Scenario 2 (Step 4)

As in the Quebec example, the reference level for Scenario 2 is set at the competitor standard, i.e. a 10-meter wide wooded buffer strip. Riparian area cultivation is allowed in Manitoba, but restrictions are placed on fertilizer and manure application thus the existing norm is 0m. However, despite the lack of mandated legislation, riparian buffer zones are prevalent in Manitoba and we assume the existing *status quo* to be a 3-meter wooded buffer strip. Consequently, the reference level is 7m greater than the existing buffer strips.

Costs-benefits analysis – Scenario 2 MB (Step 5)

The extension of wooded riparian buffer zones has economic implications for producers. As in the Quebec example, economic impacts are evaluated considering the following:

1. The cost associated with plantation and periodic maintenance of the riparian buffer strip;
2. The avoided costs: purchase of seeds, fertilizer, etc.;
3. The additional income: wood harvesting, small fruit harvesting, improved crop yields and carbon credits;
4. The lost income: loss of income associated with non cultivable areas.

[31] Auctions refer to a market mechanism being used more frequently in environmental policies. The idea is for the state to ask for the provision of EG&S from farmers for payments. Instead of offering a fixed amount of money for a service, the government uses an auction system and farmers through this process offer EG&S for a certain amount of money. Contracts are offered to farmers who present the best deal (i.e., most benefits for lowest price) to the state.

This scenario also assumes that costs are incurred through the use of plastic mulch to enhance tree growth. The use of plastic mulching at planting improves the soil moisture balance, consequently assisting with plant establishment and growth. Plastic mulch is available from the AESB Shelterbelt Program at $150 per 1500ftx4ft roll. Spacing between rows is consequently 2.5 meters, 4 rolls are needed for the additional 7 meters of buffer zones along 1km.

The locally adapted Manitoban woody species included in scenario 2 are:

- Trees (TRE); American Elm (*Ulmus americana*); Green Ash (*Fraxinus pennsylvanica*); and Manitoba Maple (*Acer negundo*);
- Shrubs (SHR) such as highbush cranberry (*Viburnum trilobum*), pincherry (*Prunus pensylvanica*) and chokecherry (*Prunus virginiana*).

For scenario 2, the 7 m extension of the existing 3 m buffer zone would have the following characteristics:

TABLE 14: TREE PLANTING OUTLINE FOR SCENARIO 2 IN MANITOBA

Row #	Species	Spacing between plants (m)	Spacing between rows (m)
Row 1	SHR	2	2.5[32]
Row 2	TRE	2.5	2.5
Row 3	SHR	2	2.5

According to the tree planting outline above, 1333 plants are required. Assuming the costs per sapling are approximately $1.00[33], the cost for plants is $1333. Site preparation and planting costs are approximately $2,310 based on partial costs calculated by Manitoba Agriculture, Food, and Rural Initiatives (MAFRI 2010) for the establishment of a Saskatoon orchard plus $600 for plastic mulching. Consequently the total cost to create the buffer zone expansion is $4,243 per km. Maintenance costs include $65/year to purchase additional trees to replace dead/harvested trees plus $38/year to cover fuel for weeding, pruning, monitoring and harvesting. Maintenance costs over 40 years at an interest rate of 2% yield a net present value of $2,817.61. Costs associated with loss of cultivable areas are calculated through potential contribution margins for crops grown in Manitoba. Typical Manitoba crops and their areas are included Table 15.

Based on crop acreages from 2006 (the last Census of Agriculture) and 2009 Manitoba yields and commodity prices, the average opportunity cost per acre of Manitoba cropland is $23.04 per acre, or $56.93 per hectare. In the case of buffer strips, lost acreage means lost income for farmers, while the benefits of buffer strips are, for the most part, external to the farm.

[32] The first row would commence 1 meter from the existing edge of the riparian buffer zone.

[33] The Manitoba Forestry Association offers coniferous seedlings for $0.65 each when purchased in bundles of 20. Cost for purchasing plants could be greatly reduced by the AESB Shelter Belt Program. Seedlings are offered free to rural producers as long as they cover shipping expenses (approximately $200.00/shipment).

TABLE 15: ESTIMATED FARMLAND RETURNS FOR 2009 IN MANITOBA

Crop	2006 acreage (Statistics Canada 2007)	total costs (Operating, fixed and labour costs) (MAFRI 2010)	2009 Average MB yield (t/ac) (MASC 2010)	Sept 2009 price ($/t) (AAFC 2010)	Revenue ($/ac)	Margin ($/ac)
Spring wheat	2,980,272	250.87	1.404	207.68	291.58	40.71
Canola	2,278,634	290.90	0.96	396.00	380.16	89.26
Alfalfa and alfalfa mixtures	1,695,865	170.98	1.258	78.00	98.12	-72.86
Oats	945,844	222.79	1.54	159.00	244.86	22.07
Flaxseed	383,508	205.10	0.685	360.00	246.60	41.50
Soybeans	350,565	260.96	0.81	285.00	230.85	-30.11
Winter wheat	299,162	242.34	1.678	202.73	340.18	97.84
Sunflower	190,228	306.69	0.656	452.00	296.51	-10.18
Corn for grain	150,420	419.63	0.954	154.00	146.92	-272.71
Average margin per acre						**$23.04**
Average margin per hectare						**$56.93**

Total revenue from the riparian buffer zone is estimated based on income from timber, non-timber forest products, and carbon credits. Selective logging could yield up to 20 trees from each hectare per year (after 20 years) and assuming that each tree would be worth $5, income from timber in 2010 dollars would be $1,167.70. Markets for non-timber forest products are poorly developed for Manitoba riparian buffer zone species, as such, revenues would likely not exceed more than $10.00/hectare each year, totalling $273.55 over the 40 years. (This value would represent savings incurred by consumption of non-timber forest products (NTFP's) by the producer's family since NTFP would not likely be commercialized.) To estimate carbon credits, a carbon sequestration rate of 1.5 tonnes of carbon/year/hectare was assumed (as determined by the Alberta Agriculture and Rural Development[34]) and carbon was allocated a value $20 per tonne, which is approximately the average price paid to Manitoba farmers for implementation of other BMPs under the Manitoba Sustainable Agricultural Practices Program[35], to be paid in one lump sum at the end of the 40-year commitment, resulting in a NPV totalling $543.47 (See Table 16).

[34] Alberta Rural Development lists several rates for different species, a value of 1.5 tonnes per hectare was determined to be a realistic number to use, available: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl3018

[35] Under the MSAPP program , a reduction of 82,000 tonnes of carbon was estimated for $2M, for an average price of $24.40 per tonne [Manitoba News Release, April 22, 2010; MANITOBA SUPPORTS SUSTAINABLE AGRICULTURE PRACTICES: STRUTHERS: Over 180 Projects Approved for 2009-10 and 2010-11, available: http://news.gov.mb.ca/news/index.html?archive=2010-4-01&item=8304]

TABLE 16: ECONOMIC IMPACTS OF 1 KM OF A 10-M-WIDE WOODED RIPARIAN BUFFER ZONE OVER 40 YEARS ($/HA) IN MANITOBA

	Cost of establishing wooded buffer	Costs associated with loss of cultivable area	Maintenance costs for wooded buffer	Income from timber	Income from NTFPs	Income associated with carbon credits
Net Present Value (NPV)	-4,243	-1,557.35	-2,817.61	1,167.70	273.55	543.47
TOTAL NPV						**- 6,633.24**

The total net cost of establishing and maintaining 1 ha (or 1 Km) of a 10-meter wide wooded riparian buffer zone in Manitoba is $6,633.24.

As costs are higher than benefits, we have to move to step 6 of the policy development framework in order to complete the decision process.

Foreseeability, reasonableness and negative impact analyses – Scenario 2 MB (Step 6)

Assessing the foreseeability

To determine foreseeability, we need to examine if farmers could have predicted increased buffer zone requirements when they purchased the land. As identified in Scenario 1, concerns about the quality of Manitoba's lakes and rivers have been raised for many years, particularly in the past decade as water quality degradation has been manifest through beach closures and algal blooms in Lake Winnipeg. Also the rapid expansion of the pork industry in southern Manitoba has increased public concerns about water quality. Riparian areas have long been valued, not just for their potential to reduce nutrient loading, but also for their benefits in providing habitat for aquatic and terrestrial species. The Lake Winnipeg Stewardship Board report madeboard 135 recommendations in 2006 (Lake Winnipeg Stewardship Board 2006). Since the Lake Winnipeg stewardship board's release four years ago, it is reasonable to assume that landowners in Manitoba could have seen the need for governments to require greater nutrient management measures, i.e. increasing the area of riparian buffer zones.

Assessing the reasonableness of the burden imposed

As noted in Scenario 1, the average area of Manitoba farms as reported in the 2006 Census of Agriculture is approximately 392 ha. With an average margin of $56.93 per hectare, each farm will return on average over $22,300 per year. If we assume a constant annual margin, the total margin per farm will therefore rise to $892,000 over the 40 year period considered in this scenario. If it is assumed that on average, each farm will have 2km of riparian shoreline on its property (one side of a 392 ha square farm), the total cost over 40 years is $13,266, which is approximately 1.5% of the total farm margins. However, the establishment of the wooded buffer at $4,243/km would incur a total cost of $8,486 per farm in the first year of implementation. This cost represents 38.1% of the annual total farm margin. Consequently, the burden imposed on farmers is considerable and since it is unreasonable, they should receive compensation. Nevertheless, these impacts may not be distributed equally among farmers.

Assessing the negative impact on food sustainability and competitiveness

As mentioned previously, the implementation of a 10-meter wide wooded buffer strip along watercourses in Manitoba is an unreasonable demand and may thus have a significant negative impact on food sustainability and/or competitiveness.

Who should pay? – Scenario 2 MB (Step 7)

The results of the analysis conducted for the previous steps of the policy development framework lead to the following conclusion:

- Producers' practices, generally, are below the reference level;
- Producers' costs are higher than benefits;
- The burden imposed was foreseeable;
- The burden imposed is not reasonable;
- The burden imposed may have significant negative impacts on food sustainability and competitiveness.

Consequently, the producers should be compensated for the implementation of a 10-meter wooded riparian buffer strip. As in scenario 1, Manitoba producers already likely have a 3-meter wide riparian buffer zone, for which they have incurred the costs and may have invested time to seek and secure financial assistance from publicly funded programs. Consequently, producers that have yet to establish a 3m buffer zone should also be expected to incur the costs to pay for the implementation of a 3-meter wide grassed buffer strip, as this corresponds to the *status quo* and does not appear to be an unreasonable burden for farmers. Therefore, we conclude that in the current scenario, the cost of raising the *status quo* to reflect the reference level may be shared between producers and the society:

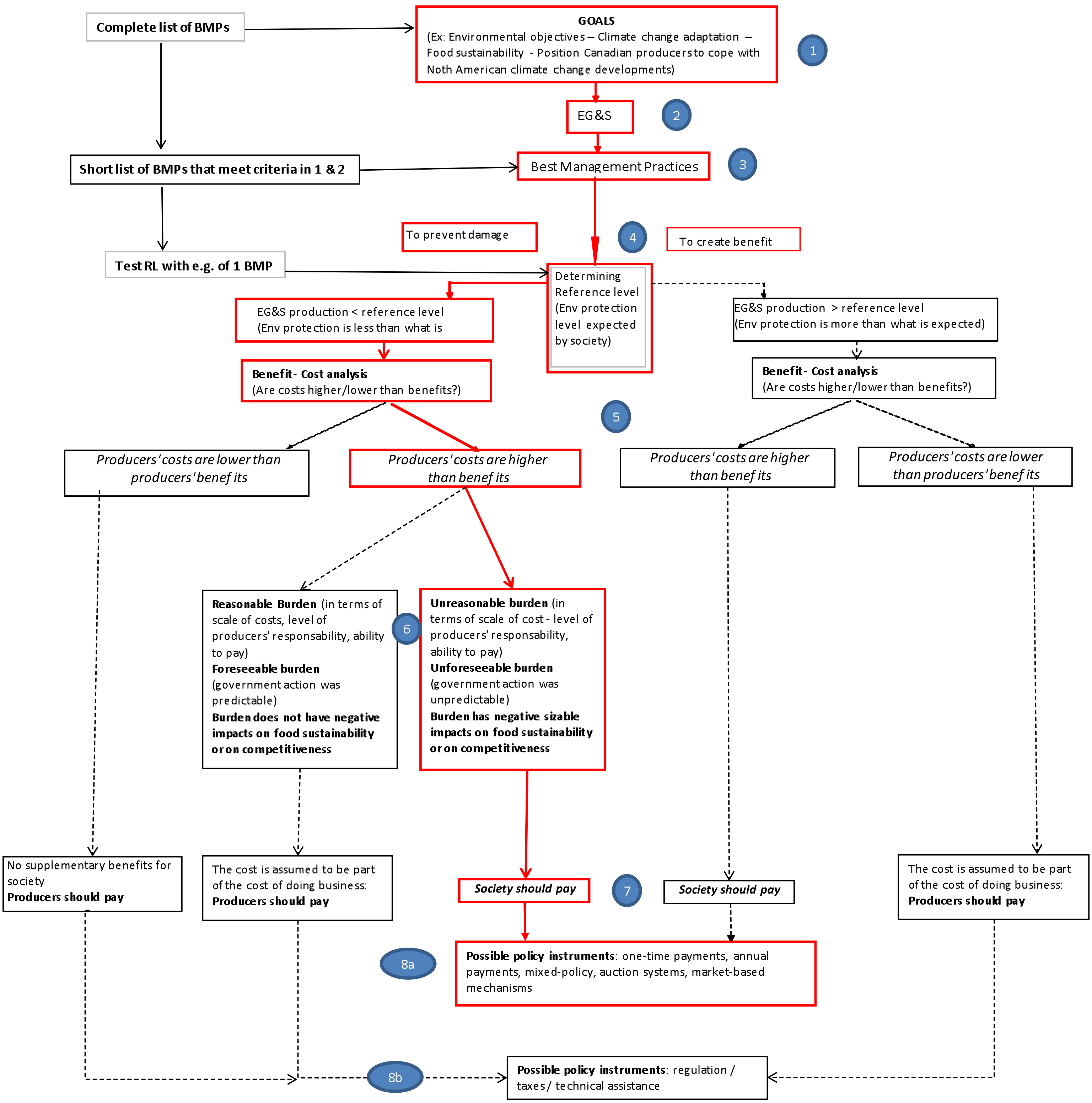
- If producers have not already, they should pay to enlarge the buffer strip up to 3 meters ($394/km of riparian buffer strip);
- Society should pay to progress from a 3-meter buffer strip to a 10-meter wooded buffer strip. These costs have been estimated for Manitoba at $6,633.24/km of riparian buffer strip.

Policy responses – Scenario 2 MB (Step 8)

As in scenario 1, some possible policy responses to this scenario are a strengthening of riparian land management legislation. This could be complemented with extension services and the provision of practical information to producers who require technical assistance to bring their operations into compliance. Producers may assume costs to establish a 3 meter grassed buffer strip, yet receive compensation to expand the buffer zone by an additional 7 meters to achieve the new reference level of a 10 meter wooded riparian buffer zone. Moreover, additional public costs would be incurred through enforcement and extension.

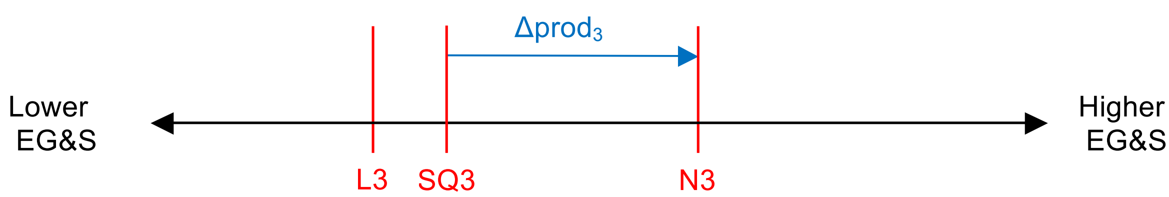
The eight steps of Scenario 2 for both Quebec and Manitoba are presented in red in Figure 7.

FIGURE 7: POLICY DEVELOPMENT FRAMEWORK: SCENARIO 2 - FARMERS' PRACTICES ARE BELOW THE REFERENCE LEVEL, AND THE REFERENCE LEVEL IS HIGHER THAN THE EXISTING NORM



10.1.3 Reference Level Scenario 3 : Farmers' practices are above the reference level and below the existing norm

The third policy option occurs when the reference level is below the *status quo* level and both levels are below the existing norm. A situation like this could arise when regulations are changed to anticipate future social demands or environmental problems, like climate change impacts, for instance. In this case governments are more aware or have more information than the public and the reference level is lower than the new existing norm.



SQ3 *Status quo* EG&S level

N3 Existing Canadian norm EG&S level

L3 Reference level EG&S level

Δprod3 Producer gap for Reference Level Scenario 3

In Québec

Reference level and status quo levels – Scenario 3 QC (Step 4)

In this case, we assume that:

- The reference level corresponds to the absence of riparian buffer strips;
- The *status quo* level corresponds to the current practice, i.e. 1-meter buffer strip along watercourses;
- The norm level corresponds to the existing norm level in Québec, which requires a 3-meter wide buffer strips along watercourses.

Therefore, producers' practices are above the reference level.

Costs-benefits analysis – Scenario 3 QC (Step 5)

As agricultural producers already respect a 1 meter riparian buffer strip, the net cost of complying with the norm will be the same as in the first scenario, that is, $841/km of riparian buffer strip.

Who should pay? – Scenario 3 QC (Step 7)

As farmers' practices produce EG&S above the reference level and costs are higher than benefits for the farmers, we conclude that society should pay for the implementation of a 3-meter wide riparian buffer strip: governments should compensate producers to comply with the norm.

Policy responses – Scenario 3 QC (Step 8)

In this scenario the challenge is to bring the producers up to the legislated norm when there is no public demand for doing so. There are costs incurred to attain the new level of EG&S established by the existing norm that should not be assumed by producers, as the reference level is lower than the *status quo*. In this case total costs should be borne by government as the practices imposed by the norm are above what the society is entitled to require from the producers. Some policy measures such as incentive payments could be used in order to help producers to comply with the norm: annual payments, one-time payments, auctions, offsets, etc.

In Manitoba

Costs-benefits analysis – Scenario 3 MB (Step 5)

In this scenario it is assumed again that existing (*status quo*) riparian buffer zone widths in Manitoba are 3m, while there is no riparian buffer zone requirement under the reference level (0m). In this scenario we assume legislation is changed in response to concerns about surface water quality in Manitoba, and that producers are required to increase buffer zones to 10m (Norm).

Foreseeability, reasonableness and negative impact analyses – scenario 3 MB (Step 6)

Who should pay? – Scenario 3 MB (Step 7)

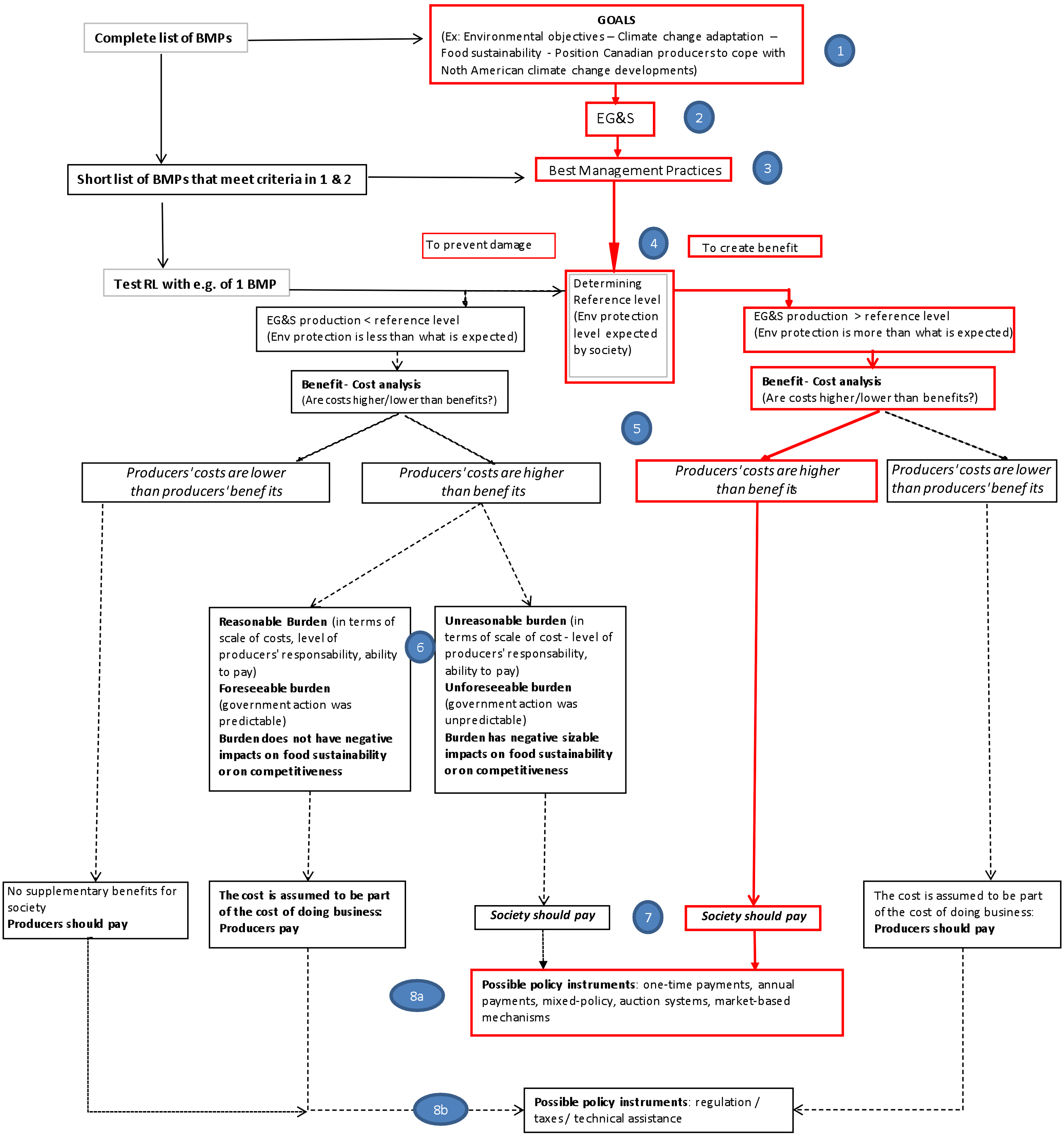
As farmers' practices are generally higher than the reference level in Manitoba, and costs are higher than benefits for the farmers, we conclude that society should pay for respecting the norm. This implies payment for the additional 7m buffer zones. Assuming a grassed buffer zone is required, the payments to farmers would amount to $1,089 per km of 7m buffer zone over 40 years. For an average farm with 2 km of riparian area, the 40 year compensation would be $2,179.

Policy responses – Scenario 3 MB (Step 8)

Again with this scenario, the challenge is to bring farmers to a legislated norm when there is no public demand for doing so. There are costs incurred to attain the new level of EG&S established by the existing norm that should not be assumed by producers, as the reference level is lower than the *status quo*. In this case total costs of the additional 7m buffer zones should be borne by government as the practices imposed by the norm are above what society is entitled to require from producers. Policy measures such as incentive payments could be used to help producers comply with the norm: annual payments, one-time payments, auctions, offsets, etc.

The eight steps of scenario 3 are presented in red in Figure 8:

FIGURE 8: POLICY DEVELOPMENT FRAMEWORK: SCENARIO 3 - FARMERS' PRACTICES ARE ABOVE THE REFERENCE LEVEL AND BELOW THE EXISTING NORM



11. Conclusion

Policy-makers are increasingly confronted with the difficult public policy challenge of fostering climate change adaptation in the agricultural sector. The first challenge is to identify technically and economically viable Beneficial (or Best) Management Practices (BMPs) that provide Ecological Goods and Services (EG&S) that foster adaptation to climate change. The second challenge is to determine financing arrangements for the implementation of these BMPs (i.e., "who pays, how much, to whom, and for what?").

Developing clarity for policy-makers on "who should pay, how much, to whom and for what" is essential for EG&S produced through agricultural BMPs programming to:

- Ensure agriculture adapts successfully to a changing climate; and therefore
- Ensure long-term food sustainability;
- Meet society's environmental objectives; and
- Position Canadian producers successfully within the context of emerging North American climate policy norms.

Addressing these inter-connected policy objectives, this report delivers the following key messages:

Versatile BMPs are needed to achieve multiple societal objectives: To adapt to a changing climate, adhere to environmental requirements and maintain agricultural production, there is a need to identify the most versatile BMPs. In this study the broad BMP categories that meet the identified criteria include livestock management, and various land management BMPs such as:

- Rangeland management;
- Riparian management;
- Conservation tillage;
- Establishing permanent grass and shelterbelts; and
- Nutrient management.

- **EG&S bridges agricultural and environmental opportunities:** Such BMPs can advance objectives in both agriculture and the environment domains.
- **Clear process is needed to decide on "who should pay":** A new tool, *a decision framework*, facilitates the decision on "who should pay" for EG&S. It is based on several steps. This framework enhances the transparency and clarity of the decision process for government, society and producers.
- **Balancing societal and producer interests:** The decision framework clarifies the circumstances under which society should support producers and their capacity to adapt to a changing climate. It recognizes that society should not impose an unfair burden on producers that would compromise their capacity to produce food but also recognizes that producers have to do their fair share in meeting environmental obligations. The framework outlines a process to help determine the balance point between these interests.
- **Decisions are region/geography dependent:** Decision-making depends on local or regional considerations since climatic, environmental, political and agricultural factors vary by geography. The decision framework can be applied to any region in the country.

- **Selection of appropriate policy instruments:** Once it is determined who should bear the cost of BMP implementation, the most cost-effective policy options should be considered following "Smart Regulation Principles": 1) Flexibility, 2) Ease of Implementation, 3) Transparency, 4) Equity, 5) Coherence with other Objectives and Policies, and 6) Efficiency. Selection of appropriate policy instrument types will differ depending on whether it is society or producers who should be responsible for the costs of BMP implementation, and also on other factors.
- **Case studies confirm the approach:** The research tested this decision framework for two case studies, one in Manitoba and one in Quebec. Firstly, the work identified "riparian buffer strips" as one of the key BMPs to achieve multiple objectives. As such, the logic framework was applied to the implementation of riparian buffer strips in Québec and in Manitoba to explore the decisions taken on implementing this BMP in two different contexts. In both provinces, we used three different reference level scenarios for comparison. It was found that:

(i) The choice of the reference level has an impact on who should pay and the amount that should be paid;
(ii) The same reference level does not have the same implications in the two provinces in terms of who should pay and how much should be paid.

A further fundamental consideration is that the "reference level" may change temporally or spatially. The policy-making challenge in the context of climate change adaptation is to define an appropriate reference level in the near-term and use the appropriate instruments, be they extension, regulation or compensation, to implement the necessary level of BMP adoption. As climate change is manifested through weather extremes, adaptation requirements will also shift and policy-makers should recognize that the reference level for BMP implementation may also need to be revised. Similarly, the reference level will vary regionally depending on the required level of EG&S as determined by the public.

In the course of the preparation of this report, we note two key research gaps; the first operational, and the second concerning EG&S policy development. Firstly, although the impacts of climate change will vary geographically, regional adaptation planning is difficult since consolidated resources do not exist, such as an "Atlas of Climate Impacts on Canadian Agriculture" or a comprehensive catalogue of regionally appropriate BMPs.

Secondly, although we have demonstrated that in some circumstances society should compensate producers for agricultural adaptation, an area of policy debate that is missing in the discussion is what to do about the "good actors". If the framework determined that producer A, whose riparian buffers are smaller than the reference level, should be compensated for the implementation of a wider buffer what should done with producer B who, without policy intervention, has managed their riparian buffer areas to be greater than or equal to the reference level. Within a region the framework could direct significant payments to producer A to expand buffer width to, for example 10 meters, while producer B, who already has well established, well functioning 12 meter buffer zones, receives no compensation.

Without appropriate instruments this can establish perverse incentives which may encourage producer B to actively decrease riparian buffer width on their land in order to be eligible for compensation.

We therefore recommend a research agenda that is essentially three-fold and comprised of:

- A geographic analysis of climate adaptation priorities in the various agricultural regions of Canada, with associated analyses of priority BMPs by region.
- Research to further develop our understanding of reference levels for different BMPs in different context and the factors that led to their definition and recognition.
- Policy research on the cost-efficiency of alternative EG&S instruments with a focus on those of greatest importance to adaptation, including:

1. Analyses of the fiscal capacity and budgetary implications, and revenue generation options within the agri-food sector.
2. Implications for federal EG&S policy development in Canada given shared jurisdiction with the provinces.
3. Analysis of the available policy options to take into account the need not to establish negative perverse incentives with early adopters of BMPs.

This report marks the beginning of a challenging and critical dialogue on agricultural adaptation in Canada that is necessary to ensure long-term food sustainability, address society's environmental objectives, and to position Canadian producers successfully within the context of emerging North American climate policy norms.

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Appendix 1: Net costs of establishing and maintaining a 10-m wooded riparian buffer zone for Scenario 2 in Quebec.

Year	Cost of establishing wooded hedges	Costs associated with loss of cultivable area	Maintenance costs	Income from timber	Income from non-timber forest product	Income associated with carbon credits
1	-4417,60	-256,63	-130,60	0,00	0,00	74,96
2		-261,76	-125,58	0,00	0,00	72,08
3		-267,00	-120,75	0,00	44,45	69,31
4		-272,34	-116,11	0,00	42,74	66,64
5		-277,78	-111,64	0,00	41,10	64,08
6		-283,34	-68,65	0,00	39,52	61,61
7		-289,01	-66,01	0,00	38,00	59,24
8		-294,79	-63,47	0,00	36,53	56,96
9		-300,68	-61,03	0,00	35,13	54,77
10		-306,70	-58,68	0,00	33,78	52,67
11		-312,83	-52,21	0,00	32,48	50,64
12		-319,09	-50,20	0,00	31,23	48,69
13		-325,47	-48,27	0,00	30,03	46,82
14		-331,98	-46,41	0,00	28,87	45,02
15		-338,62	-44,63	0,00	27,76	43,29
16		-345,39	-42,91	0,00	26,70	41,62
17		-352,30	-41,26	0,00	25,67	40,02
18		-359,34	-39,68	0,00	24,68	38,48
19		-256,63	-38,15	0,00	23,73	37,00
20		-261,76	-36,68	0,00	22,82	35,58
21		-366,53	-35,27	2774,28	21,94	34,21
22		-373,86	-33,91	0,00	21,10	32,90

Year	Cost of establishing wooded hedges	Costs associated with loss of cultivable area	Maintenance costs	Income from timber	Income from non-timber forest product	Income associated with carbon credits
23		-381,34	-32,61	0,00	20,29	31,63
24		-388,96	-31,36	0,00	19,51	30,41
25		-396,74	-30,15	0,00	18,76	29,24
26		-404,68	-28,99	0,00	18,03	28,12
27		-412,77	-27,88	0,00	17,34	27,04
28		-421,03	-26,80	0,00	16,67	26,00
29		-429,45	-25,77	0,00	16,03	25,00
30		-438,04	-24,78	0,00	15,42	24,04
31		-446,80	0,00	0,00	14,82	23,11
32		-455,73	0,00	0,00	14,25	22,22
33		-464,85	0,00	0,00	13,70	21,37
34		-474,14	0,00	0,00	13,18	20,55
35		-483,63	0,00	0,00	12,67	19,76
36		-493,30	0,00	0,00	12,18	19,00
37		-503,17	0,00	0,00	11,71	18,27
38		-513,23	0,00	0,00	11,26	17,56
39		-523,49	0,00	0,00	10,83	16,89
40		-533,96	0,00	0,00	10,41	16,24
Net Present Value	-2279,03	-6930,13	-2072,17	1266,15	497,19	913,94
TOTAL $/ha						-10,742

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