RAPPORT FINAL

Vulnérabilités et adaptation aux changements climatiques au Québec au niveau de la ferme: leçons tirées de la gestion du risque et de l'adaptation à la variabilité climatique par les agriculteurs

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À
Ressources Naturelles Canada
Numéro de contrat: **A931**

Et

Ouranos inc.

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Résumé exécutif

Objectifs et contexte du projet

L'objectif principal du projet était de tirer des leçons des expériences passées vécues par les agriculteurs au Québec, face à des conditions climatiques extrêmes et d'évaluer les coûts et bénéfices de l'adaptation versus la non adaptation à ces conditions climatiques changeantes.

Les résultats présentés dans ce rapport final représentent la suite logique d'autres recherches sur l'adaptation agricole que les chercheurs principaux, Bryant et Singh ont entreprises durant les 15 dernières années.

Ceci a été exprimé par les usagers impliqués dans le Comité directeur lors de la préparation de la proposition initiale du projet. Ceux-ci ont insisté sur le fait que le programme de recherche devait mettre l'emphase de manière systématique sur les expériences passées, avant même de considérer les tendances futures et les coûts et bénéfices de l'adaptation versus la non adaptation à la variabilité et changements climatiques.

Méthodologie et données

Le projet était basé sur une approche d'équipe, impliquant deux universités et plusieurs assistants de recherche gradués, des usagers par le biais d'un Comité directeur, et le support financier de Ressources Naturelles Canada (CCIAD) et d'Ouranos. Notre partenaire, La Financière, a joué un rôle particulièrement important dans le succès du projet, à travers la banque de données de réclamation d'assurance récolte qu'il a rendu disponible à l'équipe de recherche.

Le projet a mis l'emphase sur les apprentissages des expériences passées, avant d'explorer les tendances d'adaptation futures. Ceci a été accompli en réalisant une analyse systématique des réclamations du programme d'assurance récolte du Québec (données fournies par La Financière agricole du Québec) et en confrontant cette analyse à l'importance relative des différentes causes climatiques pour ces pertes, ainsi que des données statistiques des conditions climatiques.

Les données d'assurance récolte sont extrêmement riches, couvrent une période relativement longue et constituent une source de données unique pour la recherche sur l'incidence passée des événements climatiques extrêmes sur l'agriculture. Les données sont organisées par type de culture ainsi que par municipalité, permettant ainsi d'agréger des analyses spatiales à n'importe quel niveau considéré comme approprié. De plus, ces données incluent des évaluations des principales causes de pertes de récolte, fournissant une catégorisation détaillée des causes climatiques.

Il faut souligner que ces données de La Financière ne sont pas neutres face à la problématique de l'adaptation aux conditions climatiques (et autres conditions) à cause de :
1) l'intervention, tôt dans la saison de croissance, pour aider les agriculteurs à réduire leurs pertes lorsque de mauvaises conditions sont anticipées;
2) la provision de conseils aux agriculteurs sur les « bonnes pratiques » et
3) la définition de programmes régionaux par types de récolte spécifiques qui reflètent les expériences passées.

Une analyse temporelle et spatiale approfondie des informations sur les pertes agricoles et une analyse des causes climatiques issue des rapports fournis par La Financière ont permis de sélectionner un nombre limité de types de culture (maïs-grain, orge, foin et légumes) et trois régions dans lesquelles entreprendre des analyses plus détaillées des réclamations et données climatiques et d'identifier des « points chauds » pour approfondir les domaines de recherche empirique. Les régions Sud Ouest du Québec, Centre du Québec et Saguenay-Lac-St-Jean ont été choisies. Elles représentent une gamme de conditions agro-climatiques ainsi que des structures de production agricole différentes.

Ensuite, deux groupes de discussion ont été organisés dans chacune des régions, un avec des agriculteurs, et l'autre avec des professionnels en lien avec l'industrie agricole.

Une composante du projet sur la modélisation des fermes a permis d'étudier les bénéfices de l'adaptation aux changements climatiques versus la non adaptation, selon un ensemble de conditions spécifiées.

Résultats

> *Tendances temporelles, inter et intra-régionales des réclamations agricoles pour indemnisation, relative à la variabilité climatique*

Les analyses des réclamations agricoles pour indemnisation au Québec suite à des conditions climatiques dommageables démontrent :

i. Des variations temporelles significatives des conditions climatiques affectant l'agriculture et reflétées dans les réclamations des agriculteurs sous le programme d'assurance récolte;
ii. Des variations interrégionales significatives dans l'incidence de la variabilité climatique, tant entre les différentes régions agricoles du Québec qu'entre les trois régions d'étude ciblées.
iii. Des variations intra régionales significatives des conditions telle que mises en évidence par les analyses de réclamation pour indemnisation des agriculteurs.

Perspectives des agriculteurs et professionnels sur les conditions climatiques et l'adaptation

Dans l'ensemble, et en comparaison avec les deux autres régions (Centre-du-Québec and SO Québec (Montréal)), les agriculteurs des régions agricoles marginales (Saguenay-Lac-St-Jean) étaient plus critiques de leurs propres stratégies du passé récent pour faire face aux événements climatiques extrêmes, et plus enclins à exprimer leur besoin pour développer de meilleures stratégies d'adaptation pour faire face à la suite de l'augmentation de la variabilité climatique.

Bien qu'ils reconnaissent les impacts de la plus grande fréquence d'événements climatiques extrêmes, les agriculteurs de la région Sud-ouest du Québec (Montréal) étaient plus préoccupés par d'autres stress dans leur environnement de prise de décision, tel que les taux d'intérêt, les changements dans les politiques gouvernementales et les échanges internationaux. Ces deux premiers points (parmi beaucoup d'autres) démontrent une des prémisses principales du projet, soit qu'il est nécessaire d'avoir une approche holistique dans un cadre d'environnement décisionnel agricole, variant d'une région à l'autre, si on veut comprendre les adaptations et perceptions des agriculteurs par rapport aux changements climatiques et à la variabilité. *Ceci a des implications importantes pour les politiques publiques en rapport avec les stratégies d'adaptation*.

Parmi les différentes stratégies d'adaptation suggérées par les agriculteurs, les professionnels, et représentants des nombreux acteurs publics, celles impliquant de meilleures stratégies de gestion de l'eau apparaissent comme les plus intéressantes, bien que d'autres soient fréquemment identifiées, comme l'identification et le développement des cultivars mieux adaptés aux conditions climatiques changeantes.

Bénéfices de l'adaptation à la variabilité climatique au niveau agricole

Une analyse a été entreprise, basée sur un modèle « mixed integer linear programming" (MILP), représentant une ferme de culture de rente moyenne et une ferme laitière moyenne, pour chacune des trois régions sélectionnée dans le projet, dans l'objectif de documenter les impacts financiers des changements et de la variabilité climatique pour chaque type de ferme, et comparer la vulnérabilité entre les régions. L'analyse de l'efficacité des stratégies d'adaptation disponibles pour un gestionnaire agricole au Québec est aussi démontrée. Cette recherche est utile dans la mesure où elle informe la communauté agricole sur la façon dont le changement climatique et la variabilité peuvent avoir des impacts sur la santé financière d'une ferme, et en aidant les décideurs a créé et/ou modifié les politiques actuelles et futures pour aboutir à un environnement agricole adéquat pour l'adaptation.

L’impact économique de la variabilité climatique des rendements au niveau de la ferme a été estimé et comparé entre les régions et les productions. La région du SO du Québec (Montréal) présente l’avantage économique le plus important lorsque placée en conditions climatiques futures et la région Centre-du-Québec présente l’avantage relatif économique le plus important lorsque placé en conditions climatiques futures. Les indemnisations d’’assurances influencent souvent la diversification comme moyen d’adaptation. Un résultat inattendu, le changement projeté dans les rendements n’est pas suffisant pour influencer la combinaison optimale de cultures et pour introduire une nouvelle culture comme le maïs-grain au nord de la région de la combinaison de cultures. Dans le futur, la dépendance aux indemnisations d’assurances augmenterait dans la région Centre-du-Québec et diminuerait dans le SO Québec (Montréal). Entre les types d’industries, l’impact du changement climatique est plus prononcé pour les fermes de culture de rente que pour les fermes laitières. Le programme CAIS, n’a toutefois pas pu aider à réduire l’impact des conditions climatiques futures et pourrait même avoir déformé les indemnités d’assurance des agriculteurs dans certains cas.

Implication des politiques pour les politiques publiques et intervention en adaptation aux changements climatiques et à la variabilité

Au cours du projet, un certain nombre de résultats ont suggéré une part importante des politiques publiques et intervention en matière d’adaptation agricole aux changements climatiques et à la variabilité.

Le fil conducteur réside dans la variabilité et la façon dont celle-ci présente un défi et même temps une série d’opportunités pour l’intervention publique. Pendant que de vastes politiques peuvent être mises en place pour aider l’adaptation, le défi significatif réside dans le fait que les décisions finales se prennent au niveau des agriculteurs dans leur communauté. Les politiques publiques et l’intervention doivent être capables de faire face aux schémas de variabilité révélés dans cette étude. Non seulement les conditions climatiques varient significativement entre les régions, mais elles varient aussi significativement à l’intérieur de grandes régions (certaines plus que d’autres). En outre, il ressort des rencontres avec les groupes de discussion qu’il y a aussi des différences entre les agriculteurs dans leurs connaissances et capacité à s’adapter.

De plus, le secteur public fait face à un défi important pour jouer un rôle significatif d’orientation en tant que conseiller des agriculteurs, fournisseur d’information et éducateur, potentiellement en lien avec d’autres institutions et organisations tels que l’UPA et les *Clubs Conseils*.

En outre, il est clair que certaines communautés agricoles sont plus conscientisées que d’autres, et peut être déjà mieux à même de s’adapter à un environnement changeant. Ceci est du en partie au réseau de relations sociales

plus fort dans certaines régions que d'autres. Dans la mesure où certaines stratégies d'adaptation devant être considérées impliquent que les groupes d'agriculteurs travaillent ensemble (certains schémas de drainage par ex), alors ces rôles de conseillers, informateurs, éducateurs nécessiteraient aussi de s'orienter vers la construction du capital social, servant de base à de tels projets collectifs d'adaptation.

Prochaines étapes

Les agriculteurs et professionnels associés à l'agriculture au Québec ainsi que les usagers ont exprimé leur vif intérêt à étendre la recherche pour mieux évaluer la capacité d'adaptation des agriculteurs et impliquer les usagers à toutes les échelles, dans un processus de co-construction de forme appropriée d'intervention pour contribuer à construire la capacité de s'adapter.

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Executive Summary

Project Objectives and Background to the Project

The overall project objective has been to learn from the past experiences of farmers in Quebec in adapting to and coping with extreme climatic conditions, and to assess the costs and benefits of adapting versus not adapting to changing climatic conditions.

The results presented in this Final Report represent a logical extension of other research into farm adaptation that the principal investigators, Bryant and Singh, have undertaken on farm adaptation in Quebec over the last 15 years.

This was reinforced by the need expressed by the stakeholders involved in the Steering Committee in the preparation of the initial project proposal. They stressed that it was essential for the current research program to focus on past experiences in a more systematic way before considering future patterns and the costs and benefits of adapting versus not adapting to climatic variability and change.

Methodology and Data

The project was based upon a team approach involving two universities and several graduate student assistants, the involvement of stakeholders in a Steering Committee, and the financial support from Natural Resources Canada (CCIAD) and Ouranos. Our partner, *La Financière*, was particularly important for the success of the project because of the mine of data on crop insurance claims that was made available to the research team.

The project is focused on learning from past experiences, before exploring future patterns of adaptation. This was accomplished by undertaking a systematic analysis of claims under the crop insurance programs in Quebec (data made available from *La Financière agricole du Québec*) and confronting that analysis with the relative importance of different climatic causes for those losses, as well as statistical data on climatic conditions.

The crop insurance data are extremely rich and cover a relatively lengthy period, and constitute a unique source of data for research into the past incidence of extreme climatic events on farming. The data are organized by crop type as well as by municipality, permitting aggregated spatial analysis to whatever level is considered appropriate. In addition, these data also include assessments of the principal causes of the crop losses, yielding a fairly detailed categorization of climatic causes.

It should be emphasized that these data from *La Financière* are not neutral to the issue of adaptation to climatic conditions (and other conditions) because of: 1)

intervention early in the growing season to help farmers reduce their losses when adverse conditions are anticipated; 2) the provision of advice to farmers on 'good practice'; and 3) the definition of program regions for specific crop types that reflect actual past experiences.

An extensive temporal and spatial analysis of crop loss information and an analysis of climatic causes derived from the reports provided by *La Financière* led to the selection of a limited number of crop types (grain corn, barley, hay, and vegetables) and three regions in which to undertake more detailed analyses of claims and climatic data and to identify 'hot spots' for detailed field investigation. The regions of the S.W. Quebec, the Centre-du-Quebec and the Saguenay-Lac-St-Jean regions were the regions selected. They represent a range of agro-climatic conditions as well as farm production structures.

Then, two focus groups were organized in each of the regions, one with a set of farmers, the other with a set of professionals with links to the agricultural industry.

A farm modelling component of the project investigated the benefits of adapting to climate change versus not adapting, under a set of specified conditions.

Results

Temporal, inter-regional and intra-regional patterns of farmer claims for compensation related to climatic variability

The analyses of farmer claims for crop compensation in Quebec consequent upon damaging climatic conditions demonstrate:

iv. significant temporal variation in climatic conditions as they affect agriculture, and as they are reflected in farmers' claims under the crop insurance program;
v. significant inter-regional variation in the incidence of climatic variability both between the various agricultural regions in Quebec and between the three targeted study regions; and
vi. significant intra-regional variation in conditions as evidenced by the analyses of farmers claims for compensation.

Farmer and Professional Perspectives on Climatic Conditions and Adaptation

Overall, farmers in the more marginal farming region (the Saguenay-Lac-St-Jean region) were more critical of their own strategies for coping with extreme climatic events in the recent past, and were more inclined to express the need to develop better adaptation strategies to cope with the continuation of conditions of increased variability in climate conditions, compared to farmers in the other two regions (Centre-du-Québec and the SW Quebec (Montreal) region).

Farmers in the South-West Quebec (Montreal) region, although they recognized the incidence of greater frequency of extreme climatic events, were more preoccupied by other stresses in their decision-making environment, such as interest rates, changes in government policy and international trade. Both these first two points (among numerous others) demonstrate one of the major premises of the project, namely that to understand farmers' adaptations and perceptions of climate change and variability, it is necessary to take a holistic perspective with respect to the farmers' decision-making environment, the parameters of which vary from region to region. *This has important implications for public policy in relation to adaptation strategies.*

Amongst the various adaptation strategies suggested by farmers, professionals and representatives of various public actors, those dealing with better water management strategies appear to be the most interesting, although others such as identifying and developing better adapted cultivars to changing climatic conditions were also frequently identified.

The Benefits of Farm Adaptation to Climate Variability at the Farm Level

An analysis was undertaken involving a mixed integer linear programming (MILP) model representing the average cash crop farm and the average dairy farm for each of the three regions selected in the project, with the aim of providing information on the financial impact of climate change and climate variability on each type of farm and to provide a vulnerability comparison between regions. The analysis of the effectiveness of the adaptation strategies available to a farm manager in Quebec is also demonstrated. This research is helpful in informing the agricultural community on how climate change and variability might impact the financial health of a farm and in helping policy makers create and/or modify current and future policies in order to create an adequate agricultural environment for adaptation.

The economic impact of climatic yield variability at the farm level was estimated and compared between regions and productions. The SW Quebec (Montreal) region shows the greatest economic advantage when faced with future climatic conditions and the Centre-du-Québec region shows the greatest relative economic advantage when faced with future climatic conditions. Diversification as a means of adaptation is often influenced by the presence of insurance compensation. In an unexpected result, the projected change in yield is not enough to influence the optimal crop mix and to introduce a new crop such as grain corn into the northern region's crop mix. Dependence on insurance compensation in the future time period would increase in the Centre-du-Québec and decrease in the SW Quebec (Montreal) region. Between industries, the effect of climatic change is more pronounced for the cash crop farm than the dairy farm. The CAIS program, however, was not helpful in reducing the impact

of future climatic conditions and might even distort the farmer's insurance compensation in certain cases.

Policy Implications for Public Policy and Intervention in Adaptation to Climate Change and Variability

Throughout the project, a number of results suggest important pointers for public policy and intervention in the field of agricultural adaptation to climate change and variability.

The key thread is that of variability and how this presents both a challenge and a set of opportunities for public intervention. While broad policies can be constructed to facilitate adaptation, the significant challenge is that it is at the level of the farmers in their communities that final decisions have to be taken. Public policy and intervention must be able to address the significant patterns of variability that were revealed by the research. Not only do climate conditions vary significantly between regions, they also vary significantly within broad regions (more so in some regions than in others). Furthermore, it is evident from the focus group meetings that there is also significant variation between farmers in their awareness and ability to adapt.

Thus, there are significant challenges in the public sector, perhaps in conjunction with other institutions and organizations such as the UPA and the *Clubs Conseils*, to undertake significant roles in counselling as advisors to farmers, as information providers and as educators.

Furthermore, it is clear that some farming communities are more aware than others, and therefore perhaps already better able to adapt to the changing environment. Part of this comes from the network of social relationships that is stronger in some regions than in others. Since some of the adaptation strategies that might be considered involve groups of farmers working together (e.g. some drainage schemes), then these advising, information and education roles may also need to be oriented towards building the social capital that underlies such collective adaptation projects.

Future Steps

A great deal of interest has been expressed both by farmers and professionals associated with agriculture in Quebec and the stakeholders that suggests a need to extend this research to better assess adaptive capacity of farmers and to involve stakeholders at all scales in a co-construction process of appropriate forms of intervention to contribute to building the capacity to adapt.

1. Introduction

1.1 Objectives of Project

The purpose of the project as expressed in the initial project proposal is as follows:

> *This proposal focuses on risk management strategies by Quebec farmers, combining historical analyses of significant climatic events, selected crop production enterprises and insurance claims (yield effects) with analyses of farm-level strategies in terms of farm productivity and profitability (e.g. crop combinations and diversification strategies, on-farm resources (soils, water) management strategies, sales strategies) following these events. It then takes this understanding of past climate events, whether and how farmers adjusted to them (and their perceptions of adaptations IF the frequency of these events were to change significantly), and compares them with the frequency and likelihood of these same events projected from the results of several climatic change scenarios. . .*

One of the major contributions of the research by Bryant and Singh over the last 15 years into farm adaptation to climate change and variability has been to emphasize the need to ground explanations and tools for farm adaptation in the reality of farming and farmer decision-making. This conclusion from earlier work, as well as the endorsement of this need by the stakeholders who were integrated into the project's Steering Committee, is the basis upon which the methodology for the project was constructed.

In the early 1990s, much of the work on the impacts of climate change on agriculture centred on climate change modelling. At that point in time – the early 1990s - farmers' perceptions certainly revealed the potential of farmer adaptation to climate change and variability but it was certainly not a major preoccupation for farmers (Appendices D.1, D.2 and D.3).

Indeed, research into farm adaptation from the early to the late 1990s stressed the complexity of the farm decision-making environment, which helps explain why adapting to climate change and variability appeared as an incidental response to other stressors. This early conclusion pointed to the need to assess farmers' perceptions of climate change and variability as well as their adaptation strategies in the context of the whole range of stressors farmers are faced with (Appendix D.1). This requires a holistic approach; it is also one of the principal conclusions of other researchers working in this area in the last 3 to 4 years.

At the same time, research during the 1990s stressed the need to recognize the inherent spatial variability of conditions under which agriculture has developed, and therefore to validate adaptation indicators more broadly and analyze regional

differentiation of agro-climatic conditions in relation to vulnerability and adaptive capacity.

All of these conclusions from the earlier research of Bryant and Singh are reflected in the methodology that was constructed for Project A931.

1.2 The Research Team and the Steering Committee

The research team is comprised of principal investigators from the Université de Montréal and McGill University, together with their graduate assistant research assistants, and a Project Coordinator:

Principal Investigators:

Christopher Bryant, *Laboratoire Développement durable et dynamique territoriale*, Département de Géographie, Université de Montréal.
Bhawan Singh, *Laboratoire de Climatologie*, Département de Géographie, Université de Montréal.

Co-investigators

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Laurie Baker, Department of Agricultural Economics, McGill University

Research Management

Dr. Serge Desroches, Project Coordinator

Graduate Student Assistants

Mr. Kénel Delusca (PhD candidate, Université de Montréal)
Ms Marylène Savoie (MSc candidate, Université de Montréal)
Ms Elsa Da Costa (MSc candidate, Université de Montréal)
Mr Simon-Olivier Côté (MSc candidate, Université de Montréal)
Mr Sébastien Rivest (MSc candidate, McGill University)
Mr Simon Jetté (MSc, graduated, McGill University)

Stagiaire / Intern

Mr. Oumarou Daouda Hamani (MSc candidate, Université de Senghor, Egypt). Mr. Hamani was an intern during the summer of 2006 with the *Laboratoire Développement durable et dynamique territoriale* at the Université de Montréal; he was independently financed and participated in Project A931 as a volunteer. His thesis on adaptation to climatic change in Niger benefited by advice provided by the Principal Investigator and the Project Coordinator.

The Steering Committee:

The Steering Committee was formally created after the proposal had been accepted by the CCIAD program. However, most of the members of the Steering Committee played a significant role in the preparation of the project proposal

before the initial proposal was submitted. Subsequently, meetings were held over the life of the project as required, and communication was maintained with them. In the case of *La Financière agricole*, the communication was extensive because of the data that were prepared by *La Financière agricole* and transferred to the research team.

The Steering Committee was comprised of:

One or more representatives from Ouranos: Alain Bourque, Coordinator, Impacts et Adaptations; Claude Desjarlais, Director, Economic Analysis; Anne Debrabandère; and/or Guillaume Simonet.

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1.3 Methodology and Tasks

Before presenting the steps of the Methodology, it is useful to present the logic of the general conceptual framework upon which the research project was based (Figure 1). First, the bio-physical environment – climate and soil conditions – provides the background for understanding crop potential, taken together with farm structures. Second, adaptation to climate change and variability is seen as part of farmers' risk management strategies. It is important to emphasize that farmers' risk management strategies are made 'in context', i.e. in the context of other actors' decisions which modify farmers' perceptions either by providing farmers with additional information (e.g. the 'good practices' guides of *La Financière*, information provided by the MAPAQ and the UPA) or which determine certain parameters in the farmers' decision-making environment (e.g. definition of crop insurance program regions, participation costs in insurance

programs and other decisions that affect farmers' assessments of costs and benefits). In addition, assessing how farmers perceive and address one particular source of stress, i.e. climate change and variability, must be seen in the context of the broader economic and political context (e.g. interest rates, exchange rates that affect costs of exports and imports and environmental regulation) as well as more regionally-based factors and processes, such as urban sprawl around major urban areas.

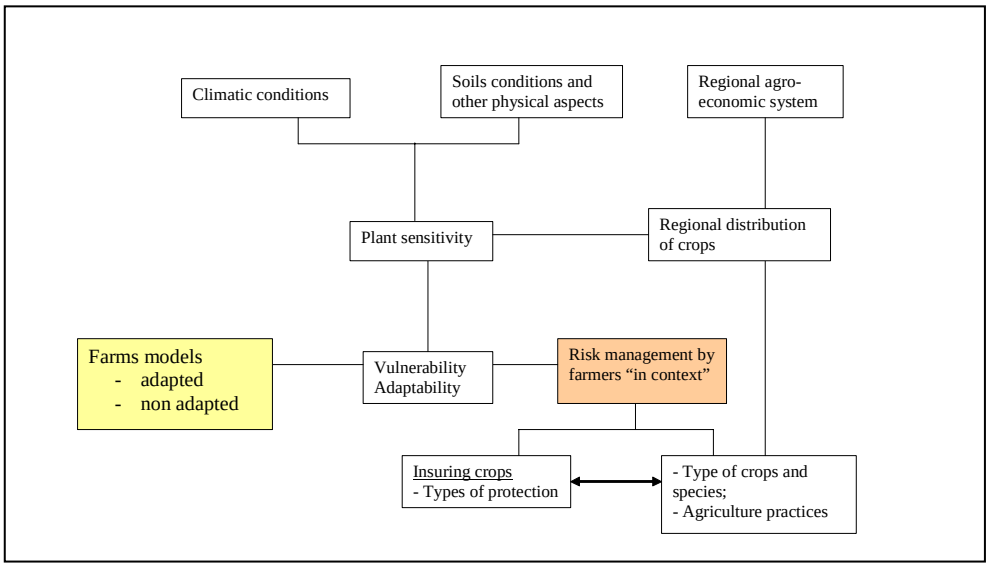


Figure 1 The General Bases of the Conceptual Framework for the Project

The various Tasks or major steps in the Methodology (see summary in Table 1) are now set out, based on their presentation in the revised project proposal submitted to the CCIAD program, as well as indications of the interim results where they allowed the research team to move from one task to another:

Task 1:

Set up the Advisory or Steering Committee from the partners and stakeholders (Ouranos, MAPAQ, La Financière, UPA, Agriculture Canada).

This was achieved in the fall of 2004. Other than meetings with stakeholders and the research team, actual research began in the late fall, 2004, after the agreement between Natural Resources Canada and the Université de Montréal was signed.

Task 2a:

For the whole of Quebec, undertake a temporal analysis of climatic and crop loss information (using yields variability by production type and region relating to drought conditions, and other extreme climatic events (from La Financière), as well as the regular reports of the Financière on crop growing conditions.

Data from *La Financière* were provided for the period 1982 to 2003 (in some instances, the data were for a shorter period of time), showing the value of claims made by farmers by crops, farm location (the municipal level was the smallest geographic level to which access was provided) and the timing of the claim.

The geographic filters from *La Financière* and Statistics Canada allowed the research team to integrate in a compatible manner the data sets from *La Financière* and Statistics Canada. Computer files of the 1981, 1986, 1991, 1996 and 2001 Census of Agriculture were also used. This was necessary because the data from *La Financière* do not include information on the potential base of farms and crop areas that could participate in the different crop insurance programs. The census data allowed the research team to at least provide an order of magnitude to the extent of participation in the crop insurance programs (especially based on the different cropping areas) at each specific census year.

Table 1 Project Tasks: Summary	
Task 1	*Set up the Advisory or Steering Committee from the partners and stakeholders (Ouranos, MAPAQ, La Financière, UPA, Agriculture Canada).*
Task 2a	*For the whole of Quebec, undertake a temporal analysis of climatic and crop loss information (using yields variability by production type and region relating to drought conditions, and other extreme climatic events (from La Financière), as well as the regular reports of the Financière on crop growing conditions.*
Task 2b	*Identification of the three target regions (based on Task 2a)*
Task 3	*For the specific regions retained, undertaking an intra-regional analysis of climate-related claims relating to drought conditions (and other extreme climatic events)/losses/yields, in order to identify any concentrations ('hot spots').*
Task 4a and Task 4b	*Organizing and facilitating focus groups with professionals in the regions retained, as well as farmers in the target regions*
Task 4C	*Analysis of farm models with and without adaptation*
Task 5	*Assessment of vulnerability at farm, sector and region levels*.
Task 6	*Analysis and synthesis*
Task 7	*Production of deliverables*

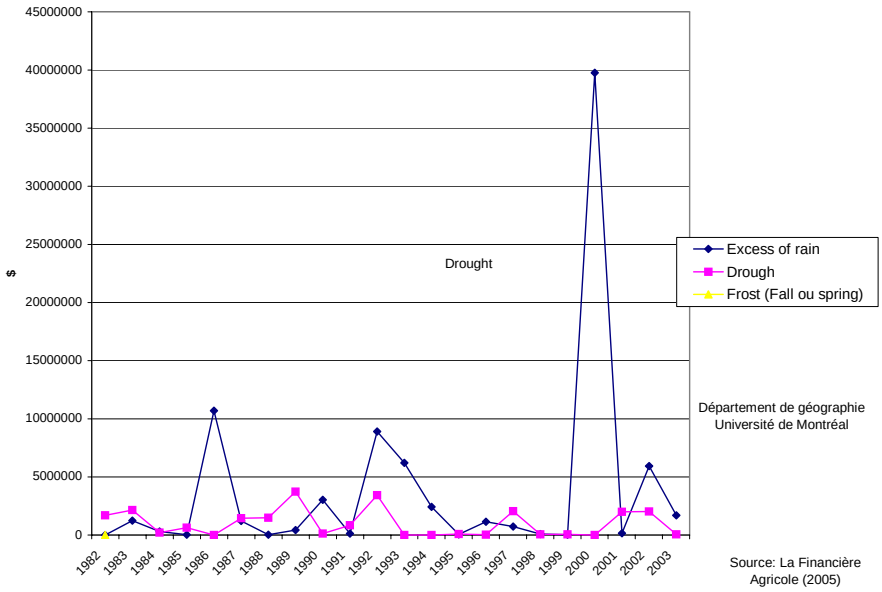


Figure 2 Three Leading Causes of Compensation for Grain Corn Production in Quebec for 1982-2003 (individual protection program)

Figure 2 is provided as an example of the analysis of temporal patterns of crop claims and the causes (as identified in farmers' claims to *La Financière*). This demonstrates the substantial variability in climate conditions over the recent past, and particularly how one of the province's major crops – grain corn – experienced severe damage in 2000. This type of analysis, as well discussions in the research team and with the Steering Committee, led to the selection of the following crops as the target crops for the study (clearly, the selection of crops and regions are interdependent):

a. Grain corn:
   - a major crop in Quebec economically, present especially in the south-west, but also in several other regions;
   - a major crop that has also experienced major crop losses due to different climatic extremes over the recent past.

b. Hay:
   - linked to animal husbandry, which generates another major set of agricultural products for Quebec agriculture;
   - found in most agricultural regions;
   - also susceptible to extreme climatic conditions and can be linked (in some regions) to important 'peaks' in claims.

b. Soy:
   - a more recent crop;
   - one that has experienced expansion;
   - one that has also experienced climatic extremes.

c. One of the vegetable crops:
   - concentrations in the south-west

- several are susceptible to changes in climatic conditions;
- locally they can be very important economically.

Task 2b:

Identification of the three target regions (based on Task 2a)

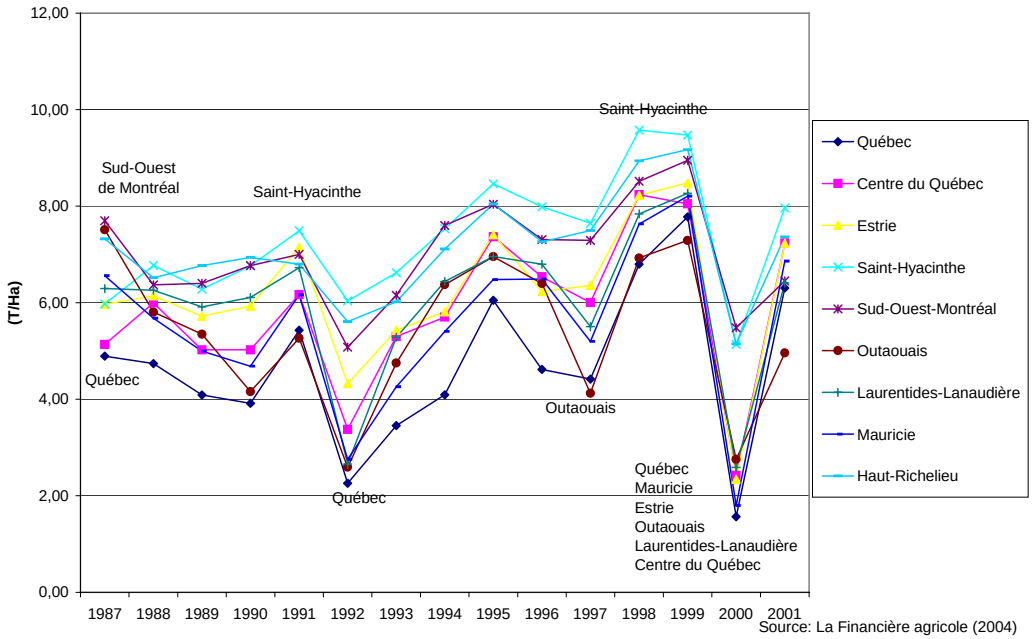
From December 2004 to February 2005, the basic analysis for this was undertaken using data from *La Financière* (see Section 4). Analysis of spatial patterns led to the selection of three regions during March 2005: SW Quebec (Montreal) area in the Montérégie region; the Centre-du-Québec; and the Saguenay Lac St. Jean region. At the scale of the agricultural regions in Quebec, this choice was made based on analyses of grain corn, barley, hay and selected vegetables. Figure 3 provides one of the analyses that contributed to this decision. It deals with the evolution of grain corn yields from *La Financière* data. It demonstrates significant temporal variation in grain corn yields, as well as significant differences between the agricultural regions. The general temporal pattern is common, but the differences between what can be regarded as a more favourable agricultural environment (e.g. the St Hyacinthe region) and less favourably endowed regions (e.g. the Centre-du-Québec) increase substantially under adverse conditions.

The three regions were selected for the following reasons:

1 The SW Quebec (Montréal) region, because it:
   1. is part of the major agricultural region in Quebec;
   2. has extensive acreages of grain corn, soy beans, hay (as in most agricultural regions in Quebec) as well as some specific concentrations of vegetable production;
   3. has experienced several seasons in the last 10 years when crop losses due to specific types of climatic extremes have been substantial (including for grain corn).

2 The Centre-du-Québec region, because it:
   1. is a transitional region between the agricultural core of Quebec and north-central Quebec;
   2. has important acreages of soy beans and hay, and some grain corn;
   3. has also experienced recent climatic extremes linked to crop losses.

3 The Saguenay-Lac-St -Jean-Côte-Nord region, because it:
   1. is viewed as a more marginal region from the agricultural standpoint;
   2. has extensive areas of hay;
   3. and while also experiencing some climatic extremes in the recent past, there is some potential for such regions to benefit from climatic change.



Source: La Financière agricole (2004)

Figure 3 Evolution of Grain Corn Yield by Region, 1987-2001

Task 3:

For the specific regions retained, undertaking an intra-regional analysis of climate-related claims relating to drought conditions (and other extreme climatic events)/losses/yields, in order to identify any concentrations. .

Analysis for this was undertaken using data from *La Financière agricole* and climatic data for each target region, at the municipal level. An example of the research results is given in Figure 4, which demonstrates considerable intra-regional variation in the incidence of losses due to mainly climatic events. Internal variation is much less in the SW Quebec (Montreal) region, the better endowed agricultural region.

Task 4a and Task 4b:

Organizing and facilitating focus groups with professionals in the regions retained, as well as farmers in the target regions

From November, 2005 to December, 2005, 6 focus groups were undertaken in the municipalities of Laprairie (SW Quebec (Montreal)), Drummondville (Centre-du-Québec) and Alma (Saguenay-Lac-Saint-Jean). In those meetings, presentations were made of our analyses both overall for the province and the three regions, as well as specifically for each of the regions (analysis of crop insurance claims, historic climatic events in the last 25 years and climatic scenarios for each region). (An example of a scenario presentation in Alma is given in Figure 5). These analyses were therefore tailored to each region,

involving us in original data analyses, both of crop insurance data and climatic data, including the modelling of future climate scenarios.

Prior to each encounter, meteorological stations were selected in each region and meteorological data (from Environment Canada) were collected for analysis. Agro-climatic indicators (e.g. Crop Heat Units – see Figure 6) were calculated, and the relationship between climate conditions and yield for different crops was analyzed (Figure 7).

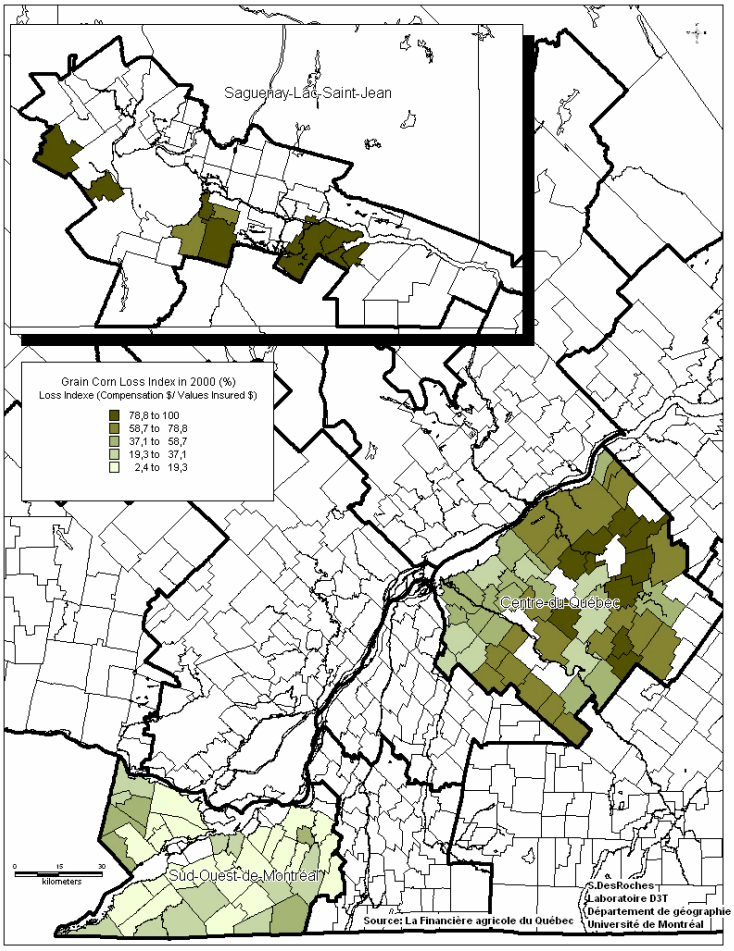


Figure 4 Grain Corn Loss Index (Compensation in $ / Values insured) for the Three Target Regions: Intra-Regional Analysis

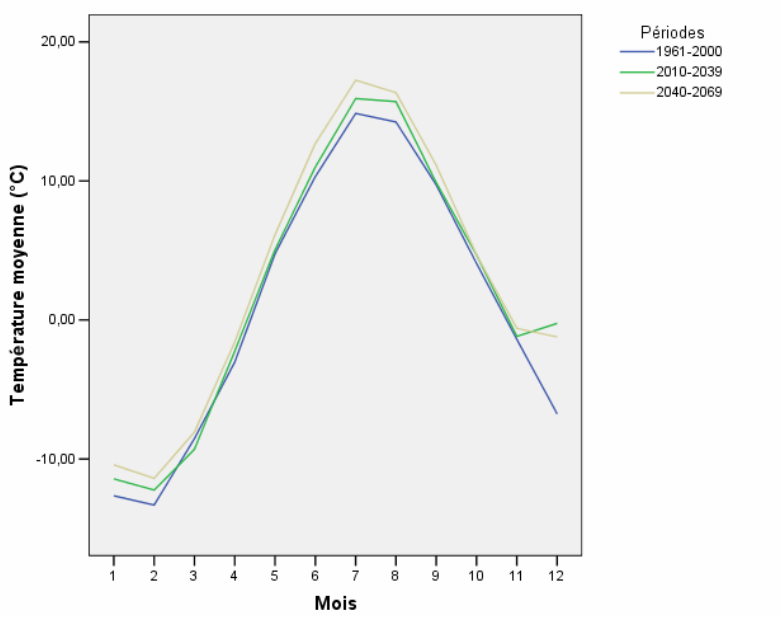


Figure 5 Alma Temperature Scenarios (CGCM1-IS92A)

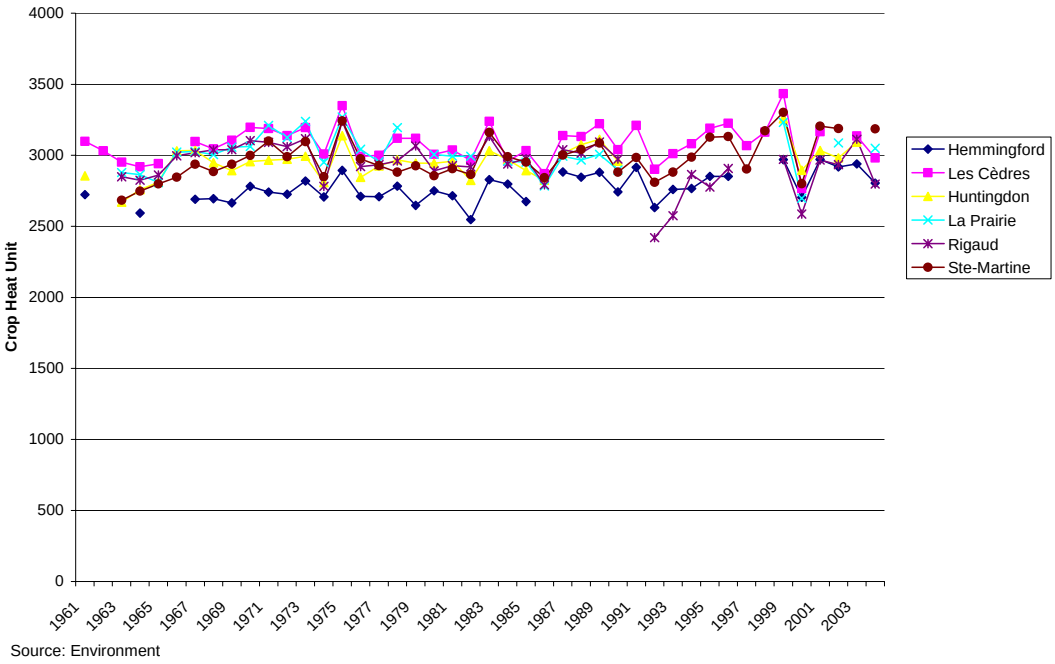


Figure 6 Evolution of Crop Heat Units 1961-2003: South-West Quebec (Montreal)

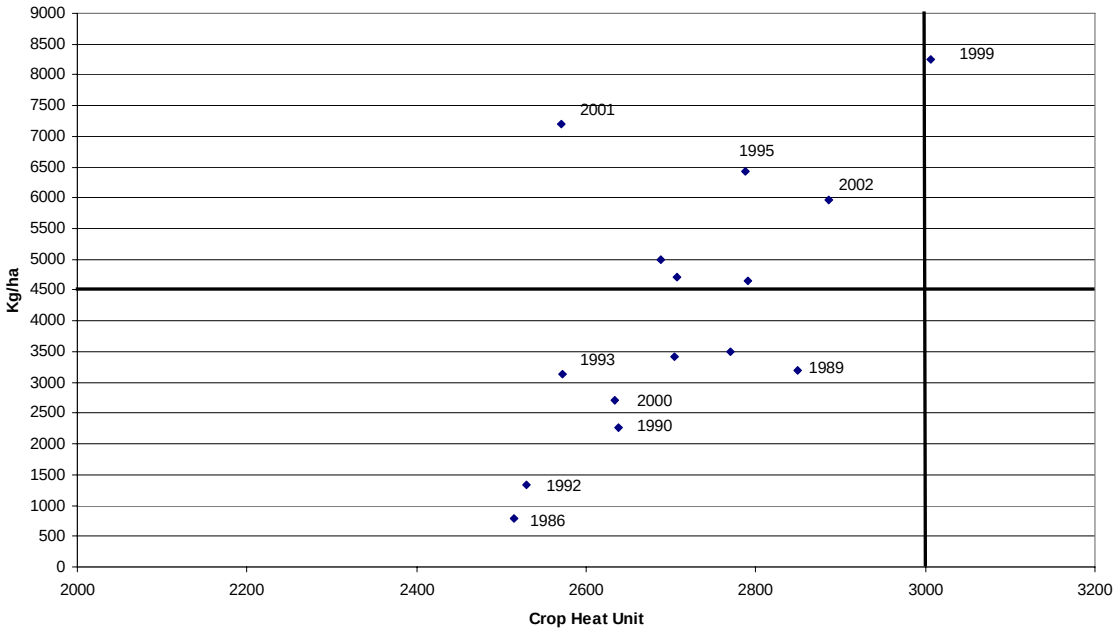


Figure 7 Relation between Crop Heat Units and Grain Corn Yield: Victoriaville (1982-2003)

Participants were also asked to complete a questionnaire at the end of each focus group encounter, concerning climatic issues on their farm or in their localities, their preoccupations and their strategies. Questionnaires were slightly different between farmers and professionals. Appendix C.1 contains a detailed presentation of the approach and the results of the focus group encounters. The presentations were very well received by both professionals and farmers alike, and the research team was even invited back to the Sagenuay region to address over a 100 farmers involved in blue berry production in March 2006 (Appendix B.8). An example of the analysis of farmers' perceptions of climate conditions in relation their farm is presented in Figure 8.

Task 4c:

Analysis of farm models with and without adaptation

The work of modelling at the farm level by investigating the costs and benefits of adopting an adaptation strategy as opposed to not adopting it was undertaken by the McGill University team. The detailed methodology used, and the results are provided in Appendix C.3; some of the climate work that was used to provide the general context within which this farm modelling work was undertaken is provided in Appendix C.2.

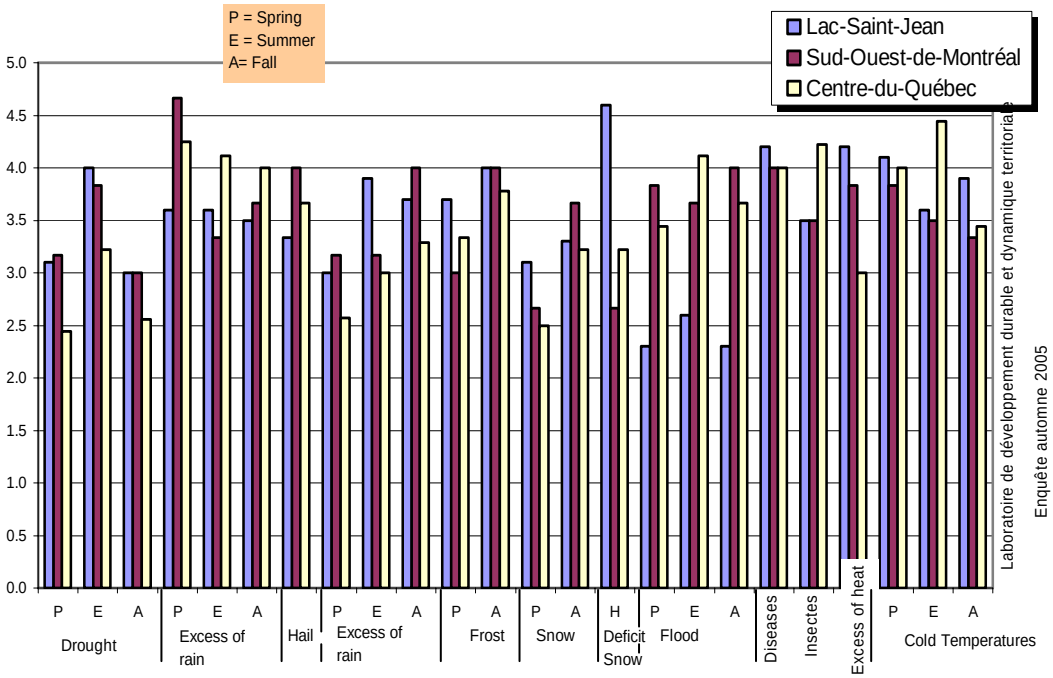


Figure 8 Farmers' Preoccupations about Climatic Conditions: Regional Variation in Perceptions

Task 4d:

Actor-based analysis of strategies. Undertaking a combination of discussions with the Advisory Committee, inviting written reactions and statements from key actors, as well as undertaking interviews with individual experts identified by the Committee.

This was undertaken throughout the project, and included notably a presentation and discussion during the summer of 2006 with representatives from the Steering Committee and particularly from *La Financière agricole du Québec*.

Task 5: *Assessment of vulnerability at farm, sector and region levels*

This task was undertaken during several of the other tasks. Issues of vulnerability at the farm level were addressed particularly through the focus group meetings and the individual questionnaires that farmer participants in those meetings were asked to complete. Vulnerability issues at the sector level and especially at the regional level were partly addressed during the spatial analyses of crop claims regionally and at the intra-regional level for the three targeted regions, and also during the farm level modelling analysis for two farm types in the three target regions.

The whole issue of vulnerability and especially as it relates to the adaptive capacity of farmers and the agricultural sector in general remains an

important research question, as well as a significant challenge for public policy and intervention.

Task 6: *Analysis and synthesis*

This was undertaken first throughout the project through the communication of results and syntheses at various conferences and colloquia (see Appendix B). Syntheses of the focus group discussions and the farm modelling components are included in Appendix C.

Task 7: *Production of deliverables*

After each year, interim reports were produced.

A Web site was produced as a blog site in the winter of 2006: http://agriadaptation.blogspirit.com. Selected aspects of the results have also been posted on the Web site of the *Laboratoire Développement durable et dynamique territoriale*, Géographie, Université de Montréal (http://www.geog.umontreal.ca/Dev_durable/index.htm).

Several Notes de recherché were produced for internal circulation to the Steering Committee and the research team. The initial intention to organize a colloquium on the project was not followed through with because of the large number of communications made throughout the project duration (Appendix B), several of which were invited communications. Another presentation is to be made on April 4th at an Ouranos sponsored seminar.

The production of this Final Report.

1.4 Overview of Final Report Structure

In Section 1.3, the Methodology has been presented together with some of the significant types of results, particularly where these were used in a subsequent phase of the project to make choices, such as to target crops and regions.

The rest of the Final Report is organized in five substantive sections, dealing with the most important questions addressed by the project. Appendices provide detailed analyses or copies of communications and publications accepted for publication. In Section 2, comments are offered on the conceptual framework that has guided the research team in the development of the research into, and the interpretation, of farmers' adaptation to climate change and variability, extending the conceptualization to the question of vulnerability. Section 3 presents the main conclusions regarding the impacts of climate variability on farms in Quebec, using primarily data from *La Financière agricole du Québec*. In Section 4, we pursue this theme, but this time based upon the results of the focus group meetings with farmers and professionals. Section 5 contains a synthesis of the

results of the Task of modelling the costs and benefits of modelling farm adaptation. The implications for public policy regarding intervention in the field of agricultural adaptation to climate change and variability are discussed in Section 6. Finally, some general conclusions are offered, and some suggestions made regarding the logical next steps in this domain in Section 7.

2 A Framework for Investigating Adaptability and Vulnerability

It has become increasingly common to integrate the notion of adaptation into the more general concept of vulnerability to sources of stress, including climate change and variability (Appendix B.7, B.8 and B.9). Vulnerability can be seen as a combination of the severity of the stress itself (here, the intensity of the extreme climate event or change), exposure to the stress (in terms of the potential effects that a given level of stress can bring about for the decision taker, partly a function of the resilience of the decision taker's system of production and investment), and as well the capacity of the decision taker (that thus includes different characteristics of the decision taker, and, in this case, of his or her family) to make preventive or anticipatory decisions about appropriate strategies (see Appendix D.1 for a discussion of some of these factors). What is significant about the emphasis being placed on the individual decision taker is that it provides us with the key to understanding why there is not a linear path between stress, exposure and impact, and adaptation by the farmer.

Vulnerability also encompasses the broader system characteristics, at the community or territorial level, at the region, provincial, federal and broader international levels and recognizing such effects related to multiple sources of stress affecting the farm decision taker. The recognition of the reality of multiple sources of stress affecting the farmers' decision-making environment also provides us with a clue regarding why farmers perceive climate change and variability with different degrees of 'urgency'.

Finally, it is important to note that certain types of institutional intervention that mitigates 'exposure' may lead to non adaptation or mal-adaptation, e.g. crop insurance, unless the institutional framework also adapts to the changing circumstances.

3 The Impacts of Climatic Variability on Farms in Quebec: Temporal and Geographic Patterns of Claims under the Crop Insurance Programs of La Financière agricole du Québec

In this section, evidence regarding climatic variability in Quebec is illustrated for one of the target regions (Centre-du-Québec) for 2 sample years (Figure 9). Then, evidence is shown from the data from La Financière on the temporal patterns of claims made under the crop insurance program, together with the causes identified as underlying those claims as made by farmers. Finally, evidence is offered of the substantial inter-regional variation in farmer claims, a powerful indicator of the underlying climatic causes of these claims.

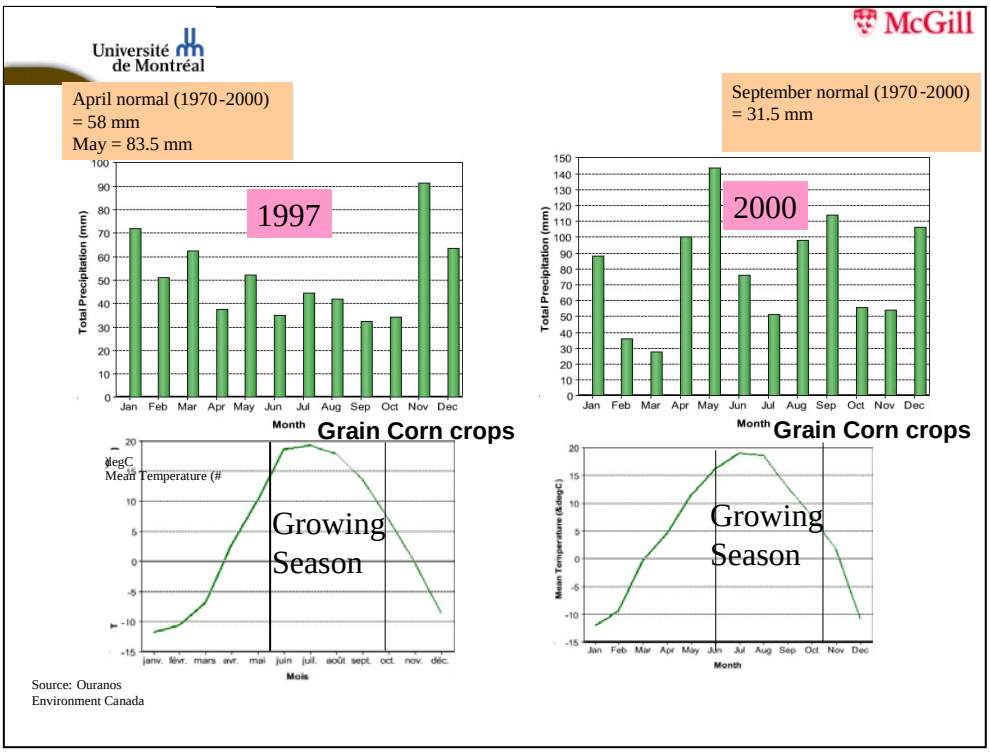
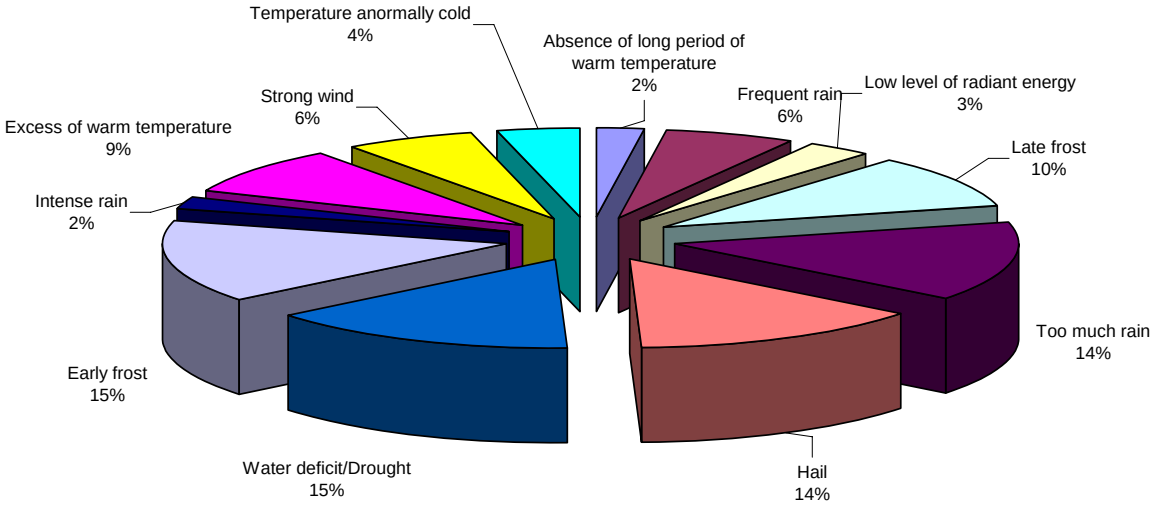


Figure 9 Precipitation and Temperature Data for Nicolet Station (Centre-du-Québec)

As already indicated in the Methodology section (Section 1.3), the year 2000 was a particularly difficult one for grain corn producers in Quebec. In Figure 9, some climatic data for 1997 and 2000 for Nicolet Station are presented. The year 2000 stands out particularly in terms of excess precipitation both early in the growing season with a very wet spring and during the harvest period.

In terms of the causes of farmer claims, *La Financière* - in addition to the individual claims data base, itself an amazingly rich source of information that

has never been systematically exploited for this purpose – also produces reports on the *État de la culture au Québec* (Figure 10), throughout each growing season, identifying climatic causes for losses, problem crops and problem areas. The most recent reports are on-line, but the earlier ones were acquired by visiting *La Financière*'s offices. A systematic analysis of these reports was undertaken for the years 1982 to 2001. While droughty conditions are relatively important, so are early frosts and excess rain.



Source: Compilation of monthly reports '*État de la culture au Québec* from *La Financière*

Figure 10 Relative Importance of Different Climatic Causes for Farmer Crop Claims, Quebec, 1982-2001

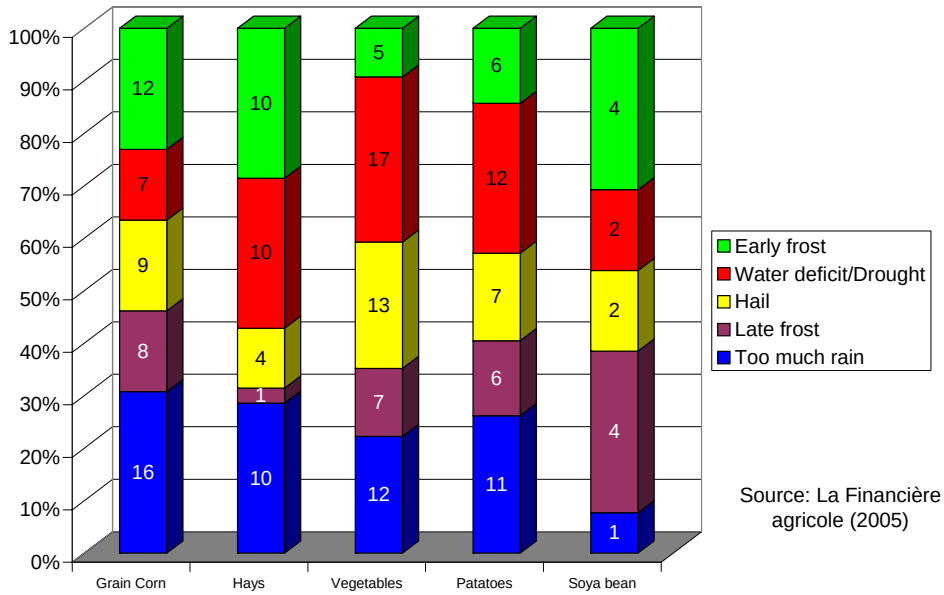


Figure 11 Frequency of Causes Underlying Farmer Crop Insurance Claims, by Selected Crops, 1982-2001

This type of analysis allowed the dominant causes of crop claims to be plotted (e.g. Figure 11). This confirms the patterns that emerged from the analyses of the more detailed data (see below). **Grain corn** was characterized by the importance of excess rain and early and late frosts, as opposed to water deficit/ drought conditions. **Hay** was characterized by the importance of excess rain, drought conditions and early frost. **Vegetables** were characterized by the importance of drought, then hail and excess rain; **Potatoes** by drought and excess rain; and **Soy beans,** for which the period of data availability was limited, by early and late frosts. The experience of the last three crops mentioned relate to the general area of concentration of these three crops (particularly for vegetables in the core area of the SW Quebec (Montreal) region in contrast to the first two crops which extend over a broader territory

The more detailed data from *La Financière* were prepared by the personnel at *La Financière* to generate data files for selected crops for a 20+ year time period (1982-2003). The data base thus constructed permitted the research team to aggregate data from the municipality level, to the MRC (*Municipalité régionale de comté*) level and to the agricultural region level (with a few exceptions).

For grain corn, Figure 12 provides a temporal and spatial analysis of the evolution of grain corn yield as reported to *La Financière* by farmers. The yields are those actually declared by 'all' participants in the crop insurance program. It is noteworthy that there was a general increase in yields over the 1990s, except for 1992 and most especially 2000, when yields experienced a severe drop that was also mirrored in a large volume of claims. The regions follow the general pattern but there are substantial interregional differences (contrast St-Hyacinthe / SW Quebec (Montreal) / Haut Richelieu with their favourable agricultural environments with those of Quebec and the Outaouais)

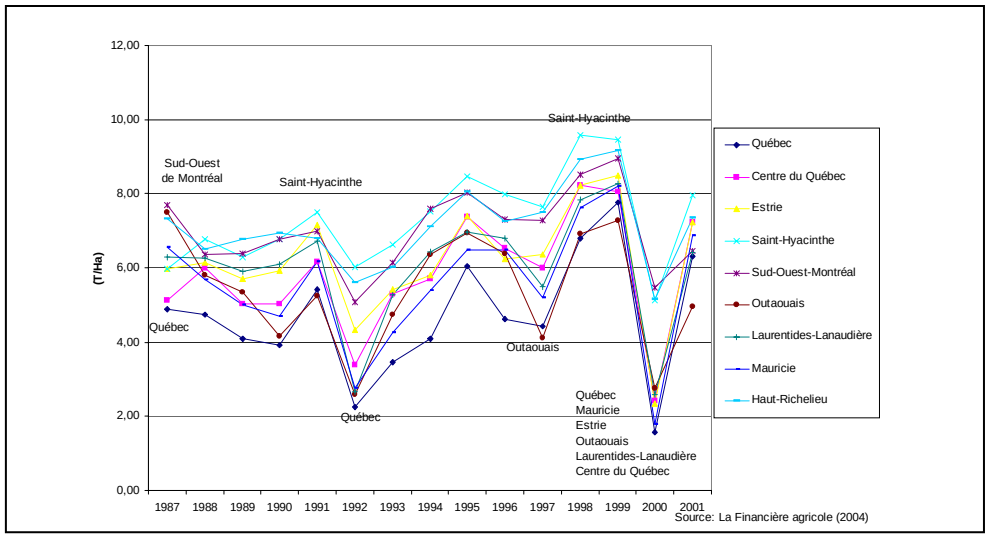


Figure 12 Evolution of Grain Corn Yield (1987-2001) for Most of Quebec's Agricultural Regions

In Figure 13, the pattern of claims by grain corn producers is analyzed against the most important declared causes underlying the claims. The analysis reveals the importance of excess rain as well as early and late frosts. Interestingly enough, this importance of excess rain is worth underscoring because the initial expectation of the Advisory / Steering Committee of the project was that drought conditions would be prominent.

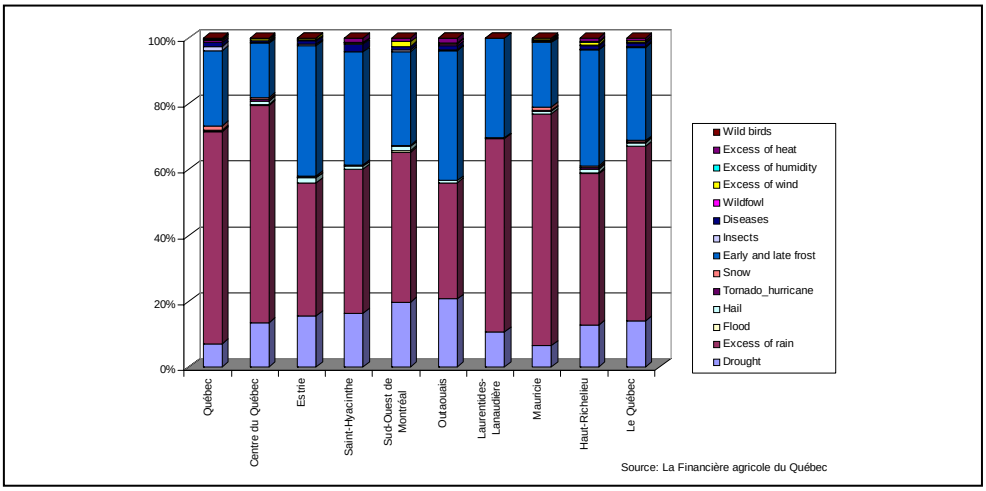


Figure 13 Causes of Claims for Grain Corn Producers (1982-2003) (individual protection, the proportion calculated on the basis of claims paid)

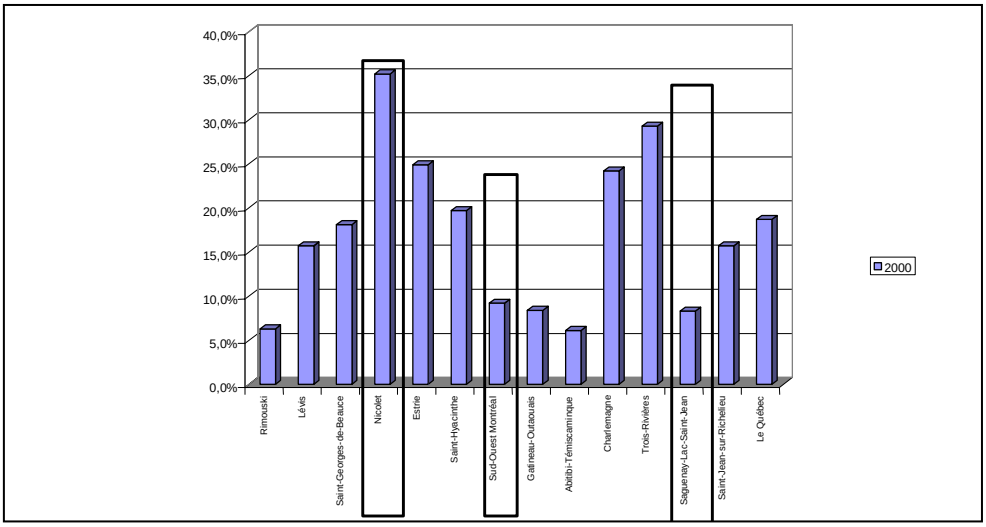


Figure 14 Loss Index in 2000 for all Crops by Region: Claims Paid Out versus Value Insured

The year 2000 was chosen for the calculation of the loss index for **all** crops because 2000 had earlier been identified as a year characterized by significant losses, notably for grain corn producers. There is considerable regional variation

in the crop loss index, with the SW Quebec (Montreal) region being relatively low, while for Nicolet the index was very high.

In Figure 15, the maximum and minimum grain corn yields are presented for the study period 1982-2003 for the three target regions. The maximum difference is substantial for the Centre-du-Québec, even though the maximum yields are close to the maximum yields for the SW Quebec (Montreal) region. For the SW Quebec (Montreal) region, minimum yields experienced are only slightly less than the maximum yields experienced in the Saguenay-Lac-St-Jean region. Thus, the differences between one of the core grain corn producing areas (SW of Montreal) and the other two regions selected are substantial.

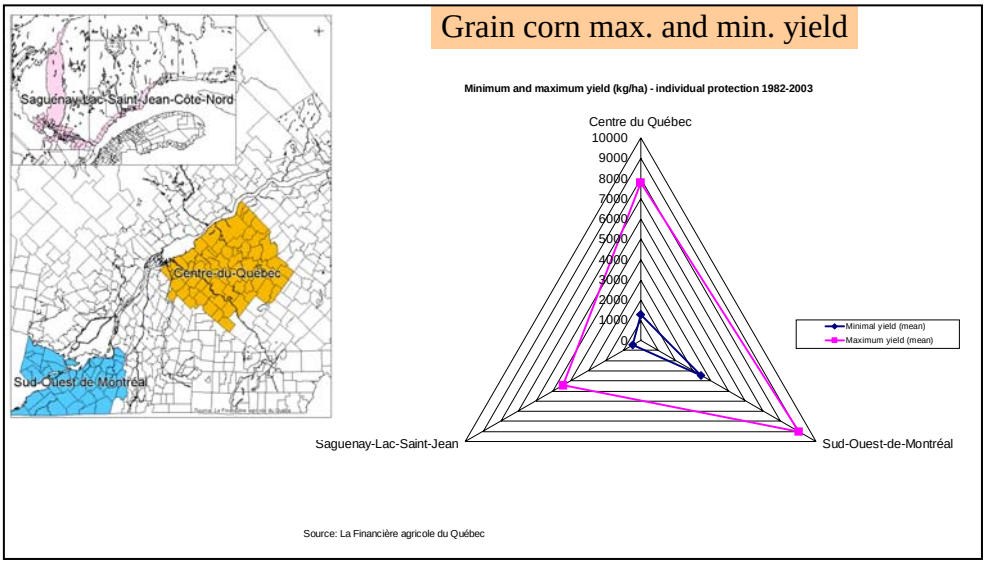


Figure 15 Grain corn maximum and minimum yields – individual protection regime 1982 – 2003

With Figure16, the same data on maximum and minimum yields for grain corn are presented in cartographic form for the three target regions. The patterns underscores the overall significance of the SW Quebec (Montreal) region – even minimum yields are relatively high compared to most localities in the other two regions, converging with other comments made earlier about the importance of grain corn production in this region. Another noticeable point is that in the Centre-du-Québec, there is a ring of municipalities that stand out to the south and south-east of Lac St Pierre as having relatively high minimum and maximum yields

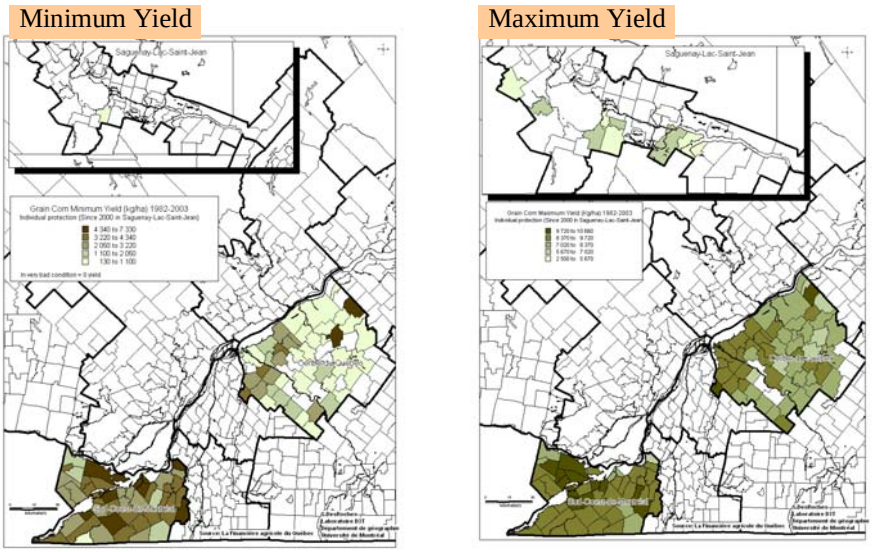


Figure 16 Minimum and Maximum Yields for Grain Corn for the Three Study Regions, 1982 – 2003

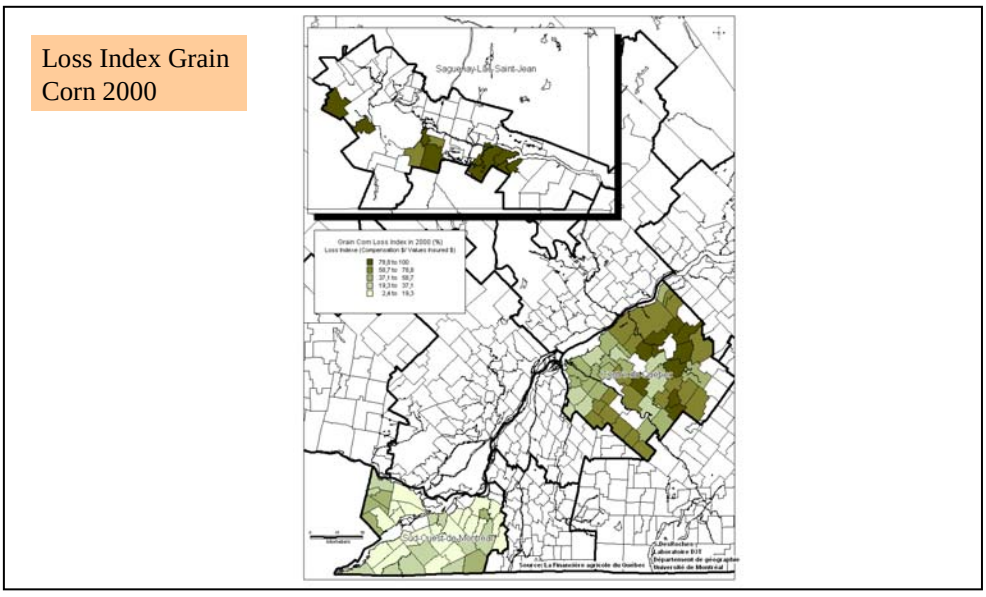


Figure 17 Grain Corn Loss Index for 2000 for the Three Study Regions

It is interesting to note that a similar spatial pattern is represented on the loss index map for grain corn for 2000 (a particularly bad year in terms of claims, it will be remembered) (Figure 17). The municipalities in the SW show loss indices much less than those in the other two regions. In the Centre-du-Québec, the municipalities located close to Lac St Pierre have a loss index less than the municipalities further to the SE in the same region, suggesting a mediating influence of proximity to a larger water body.

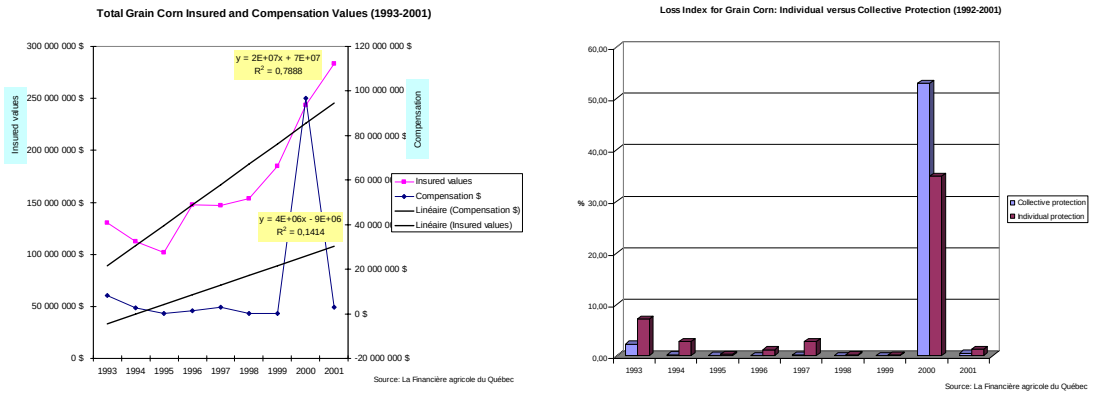


Figure 18 Grain Corn: Insured Values versus Compensation Paid Out, and the Loss Index for Grain Corn, 1992-2001

Finally, Figure 18 (left hand side) shows an overall tendency for increase in insured values for grain corn over the study period; looked at in this perspective, the increase from 2000 to 2001 is probably not an exceptional increase, but rather part of this general pattern, that reflects both inflation and the area devoted to grain corn production.

In order to ensure that the temporal patterns for claims were not widely different under the individual as opposed to the collective regime of crop insurance, Figure 18 (the right hand side) also shows the loss index under each of these regimes. Certainly, the year 2000 shows up with a significantly high level of claims for those under the collective regime, but generally claims were high for farmers under both of the regimes in that year.

The analyses in this section thus demonstrate:

4 significant temporal variation in climatic conditions as they affect agriculture, and as they are reflected in farmers' claims under the crop insurance program;
5 significant inter-regional variation in the incidence of climatic variability both between the various agricultural regions in Quebec and between the three targeted study regions; and
6 of particular interest because of the policy implications, significant intra-regional variation in conditions as evidenced by the analyses of farmers' claims for compensation.

4 The Impacts of Climatic Variability on Farms in Québec: The Perspectives of Farmers and Representatives of Agriculture-related Organizations and Institutions

A detailed report on the results of the focus groups in each region, one each for a set of farmers and a set of professionals associated with the agricultural industry, are presented in Appendix C.1. The focus groups were organized in the fall of 2005 in the three target regions. The objectives were to inform farmers on climate change and to obtain information on past climate events that had affected them and their farms, and to ascertain their reactions to future climate scenarios and adaptations that might be envisioned.

In all, six focus groups were therefore held, involving a total of 61 people. Discussions were recorded and a questionnaire was submitted to each of the participants after each meeting. Participants came from different production sectors.

Main Results

Level of preoccupation regarding excess rain, drought and freezing conditions:

- Generally, excess rainfall represented the primary preoccupation for farmers from the SW Quebec (Montreal) region, while for the Lac-St-Jean farmers it was lack of snow, and for Centre-du-Quebec farmers, the occurrence of low temperatures during the summer.

- For the professionals from the Centre-du-Québec, the preoccupations were mainly those relating to excess precipitation in the spring, summer drought and insects. For those from the SW Quebec (Montreal) region, the preoccupations were mainly centred on excess rainfall (fall and spring), frosts, insects, diseases, excess heat and drought. In the Saguenay-Lac-Saint-Jean region, it was mainly lack of snow, as well as frosts, insects, diseases, excess heat and drought that were the main preoccupations.

- The perceptions of farmers and professionals from the same region were compared. For example, in Saguenay-Lac-Saint-Jean the professional group was not as preoccupied with strong winds, excess heat and temperatures as were the farmers. The presence of blueberry producers in the focus group certainly explains some of this difference.

Practices that had been modified or that were suggested following past events (excess precipitation, drought conditions and frost):

- Above, some slight differences were observed between farmers and professionals in their perception of climatic events. Following past events

of excess precipitation, farmers from the Centre-du-Québec were relatively less inclined to advocate a change in crops (solutions that were proposed by the professionals) and, instead, opted more to change the type of seed used. On the other hand, the solutions and perceptions of farmers and professionals converged in terms of the importance given to changing the timing of farmers' work operations, the method of working the land, drainage and of modifying techniques of soil drainage.

- Generally, farmers had modified different practices in their fields following problems associated with drought (timing, seeding density and choice of seed type). The professionals from the three regions were more inclined to suggest changes in the methods of working the soil. Irrigation was suggested by a minority of participants.

- In relation to past problems with frost, most of the professionals suggested modifying the timing of different practices as well as changing crop type in the three regions. Most of the farmers also noted a change in the timing of different work operations as well as the technique of working the soil following freezing conditions. In the Centre-du-Québec and the Lac-Saint-Jean region, crop protection as well as the modification of wind breaks had also been undertaken. In the Lac-Saint-Jean region, the participants noted they had changed seeds and crops in relatively similar proportions (roughly 50 %).

Most appropriate practices to modify in the future:

- Participants were asked whether climate change was important in their region and to assign a value to the different strategies or practices to follow in the future. Generally, the highest values were obtained from the farmers in the Saguenay-Lac-Saint-Jean region. These emphasized the importance of diversification, of abandoning certain types of crops considered to be vulnerable, and as well of changing crops in order to profit from any rise in temperatures. Farmers in the Lac-Saint-Jean and SW Quebec (Montreal) regions thought it was more important to obtain government assistance but also that it was important to modify agricultural tools and seeds. Diversification of activities was considered in all three regions.

- Among agricultural professionals, diversification of activities was of interest in all three regions, as well as modifying ways of working the soil and also soil drainage. Those from the Saguenay-Lac-Saint-Jean region assigned much more importance to abandoning vulnerable crops and to changing crops in order to benefit from climate warming and government aid.

- Professionals from the SW Quebec (Montreal) region appear to want to

have farming profit from methanol and ethanol production. Those from the Centre-du-Québec expressed the desire to adjust irrigation techniques to the imperatives of climate change as much as drainage techniques.

Vision for the future:

- Farmers were asked whether their farm was adapted to climate change, while for the professionals, the question was posed in terms of the degree to which farms in their region were adapted. Generally, farmers held a positive vision concerning their level of adaptation to climate change while that of the professionals was much more nuanced.

- In an open question, the professionals were asked to identify gaps in adaptation in the agriculture in their regions. In all three regions, at least one participant noted that monoculture or the level of intensification was an obstacle for agricultural adaptation. The lack of awareness and education by agricultural actors was also identified as an issue in all three regions.

- The professionals were asked to identify opportunities for agriculture in their regions related to climate warming. In the Centre-du-Québec and SW Quebec (Montreal) regions, the development of consulting services and the communication of information were considered by at least one participant as a regional opportunity. Along the same lines, research and development, increasing the adaptability of crops and techniques also represented a regional opportunity. This has to do with opportunities for agricultural counsellors while the opportunity for diversification represents an opportunity for the regional collectivity.

- Farmers were asked to identify their most important concerns regarding the effects of climate change. In the three regions, at least one participant identified a concern related to insecurity and uncertainty. In the Saguenay-Lac-Saint-Jean and the Centre-du-Québec regions, participants identified the difficulties of planning agricultural operations in relation to extreme variations on climate conditions.

- Farmers and professionals were questioned about the relative importance of challenges other than climate change. In the SW Quebec (Montreal) region, farmers were unanimous in considering political challenges to be of greater importance. In relation to the intergenerational survival of farming, farmers in the SW Quebec (Montreal) region and the Lac-Saint-Jean region said this was not more important than climatic change, while the situation was reversed in the Centre-du-Québec.

Effects of climate change on neighbours and on water usage:

- A question was posed concerning whether the participants felt that climate change might have an impact on the local use of water resources. Most of the farmers and professionals anticipate some repercussions on the future use of water. In the Saguenay-Lac-Saint-Jean region, most farmers thought that climate change would affect their relationships with their neighbours while the professionals were more divided on this subject. In the Centre-du-Québec, the situation was reversed since all the professionals anticipated repercussions on neighbours. In the SW Quebec (Montreal) region, most of the farmers and professionals perceived that there would be some risks that might affect the social dynamic of the areas, but not to the same extent as the specific question of water use.

Anticipated impacts of decisions by *La Financière agricole*:

- Farmers were asked whether the removal of crop insurance coverage by *La Financière agricole* would lead to the abandonment of certain crops. The farmers in the Saguenay-Lac-Saint-Jean region reacted most to this hypothesis, compared to those from the Centre-du-Québec. It is worth noting that all of the participants from Saguenay-Lac-Saint-Jean were insured at the time of the focus group meeting.

The role of agricultural counsellors and the need for meteorological information:

- The research team explored the question of whether the professionals played a role in the transmission of information on climate change. Most of the farmers from the SW Quebec (Montreal) region and the Centre-du-Québec responded affirmatively while those in the Lac-Saint-Jean mainly responded negatively.

- In terms of needs for meteorological information, most of the farmers from the Centre-du-Québec and the SW Quebec (Montreal) regions considered that meteorological information lacked adequate precision to help them in the scheduling of work operations.

- An open question was also asked of the professionals to identify the nature of the meteorological information that appeared to be wanting. They identified specifically short term forecasts (24 hours) and long term forecasts (4 days or seasonal). In particular, gaps were identified in relation to local and regional variability. In the Centre-du-Québec, one of the participants noted a lack of information in terms of wind velocity on an hourly basis.

Overall, farmers in the more marginal farming region (the Saguenay-Lac-St-Jean region) were more critical of their own strategies for coping with extreme climatic events in the recent past, and were more inclined to express the need to develop better adaptation strategies to cope with the continuation of conditions of increased variability in climate conditions, compared to farmers in the other two regions (Centre-du-Québec and the SW Quebec (Montreal) regions).

Farmers in the SW Quebec (Montreal) region, although they recognized the incidence of greater frequency of extreme climatic events, were more preoccupied by other stresses in their decision-making environment, such as interest rates, changes in government policy and international trade. Both these first two points (among numerous others) demonstrate one of the major premises of the project, namely that to understand farmers' adaptations and perceptions of climate change and variability, it is necessary to take a holistic perspective with respect to the farmers' decision-making environment, the parameters of which vary from region to region. *This has important implications for public policy in relation to adaptation strategies.*

Amongst the various adaptation strategies suggested by farmers, professionals and representatives of various public actors, those dealing with better water management strategies appear to be the most interesting, although others such as identifying and developing better adapted cultivars to changing climatic conditions were also frequently identified.

5 Modelling the Benefits of Farm Adaptation to Climate Variability at the Farm Level

Agriculture is an industry that is naturally sensitive to climate and among the most likely to be affected by changing climatic conditions in the future. However, agriculture under certain conditions has the capacity to deal with and adapt to various challenges. As a result, modern farm managers are now trying to incorporate climatic uncertainty in their decision-making procedures with the objective of minimizing the adverse effects of changing climatic conditions or taking advantage of them on their farm by adopting wise practices and strategies. In this part of the Final Report, a summary is given of an analysis involving a mixed integer linear programming (MILP) model representing the average cash crop farm and the average dairy farm for each of the three regions selected in the project, with the aim of providing information on the financial impact of CC (climate change) & CV (climate variability) on each type of farm and a vulnerability comparison between regions. Also, analyzing which adaptation strategies the representative farm models select when constrained to different yield scenarios permit the analysis of the effectiveness of the adaptation strategies available to a farm manager in Quebec. This research is designed to inform the agricultural community on how CC & CV might impact the financial health of a farm and to help policy makers create and/or modify current and future policies in order to create an adequate agricultural environment for adaptation.

Based on the above procedure, the economic impact of climatic yield variability at the farm level was estimated and compared between regions and productions. Means of adapting to climate change variability are discussed as well as the impact of insurance programs on farmers' adaptive behaviour to CC & CV (see details in Appendix C.3). It is demonstrated that the SW Quebec (Montreal) region shows the greatest economic advantage when faced with future climatic conditions and that the Centre-du-Québec region shows the greatest relative economic advantage when faced with future climatic conditions. It is also demonstrated that diversification as a means of adaptation is often influenced by the presence of insurance compensation, and that contrary to what was anticipated, the projected change in yield is not enough to influence the optimal crop mix and to introduce a new crop such as grain corn into the northern region's crop mix. It is also demonstrated that the dependence on insurance compensation in the future time period would increase in the Centre-du-Québec and decrease in the SW Quebec (Montreal) region. Between industries, the effect of climatic change is more pronounced for the cash crop farm than the dairy farm. The CAIS program was not helpful in reducing the impact of future climatic conditions and may even distort the farmer's insurance compensation in certain cases.

6 Implications for Public Policy and Agricultural Adaptation to Climate Variability and Change

A number of results suggest important pointers for public policy and intervention in the field of agricultural adaptation to climate change and variability.

The key thread is that of variability and how this presents both a challenge and a set of opportunities for public intervention. While broad policies can be constructed to facilitate adaptation, the significant challenge is that it is at the level of the farmers in their communities that final decisions have to be taken. Public policy and intervention must be able to address the significant patterns of variability that were revealed by the research. Not only do climate conditions vary significantly between regions, they also vary significantly within broad regions (more so in some regions than in others). Furthermore, it is evident from the focus group meetings, that there is also significant variation between farmers in their awareness and ability to adapt, and to recognize the benefits of adapting through integrating appropriate strategies into their farm operations.

Thus, on the one hand there are significant challenges in the public sector, perhaps in conjunction with other institutions and organizations such as the UPA and the *Clubs Conseils*, to undertake significant roles in counselling as advisors to farmers, as information providers and as educators.

Furthermore, it is clear that some farming communities are more aware than others, and therefore perhaps already better able to adapt to the changing environment. Part of this comes from the network of social relationships that is stronger in some regions than in others. Since some of the adaptation strategies that might be considered involve groups of farmers working together (e.g. some drainage schemes), then these advising, information and education roles may also need to be oriented towards building the social capital that underlies such collective adaptation projects.

One of the challenges in this is that adaptation may be partly a cultural phenomenon. Other research by the Université de Montréal research team had earlier emphasized that adaptive capacity was strongly related to farmers' ability to be self-critical and question their current ways of managing and planning their farm operations (Appendices B.2 and D.1). If this is indeed the case, then the challenge for governments is even greater, since bringing farmers to the point where they can be self-critical (those that do not already have this capacity) requires the representatives providing the advice, the information and the on-going support to be respected by the farmers and to be present in the farmers" regions in a permanent way.

7 Conclusions and Next Steps

It is evident that there are significant spatial variations both at the interregional and intra regional patterns due to climatic extremes. The variation spatially appears to be as significant as the substantial variation in temporal patterns. Furthermore, there are significant differences between farmers in their level of awareness and adaptive capacity to deal with climate change and variability.

On the other hand, in the course of the many meetings with farmers and professionals, and the stakeholders, it is clear that most people recognize that the last 10 years have been different to the preceding decade in terms of the stresses posed by climate variability. This has not always led to conscious adaptations, partly because crop insurance programs to some extent shield some farmers for a period of time, but also because the perception by farmers for a long time was that while each event was real, it was not perceived to be part of a longer term process by which the probabilities of more extreme and different events were changing. This general level of awareness seems to have increased in the last 1 to 2 years due to increasing media coverage and political debate over the issues.

If the prescriptions identified in Section 6 concerning the implications for public policy and intervention are accepted, it is clear that a variety of tools is necessary both for public sector representatives and for farmers and their counsellors. An important next step will be to construct those tools so that they can be appropriated by decision-takers, be they the farmers themselves or representatives of the various stakeholders in relation to the agricultural industry.

Appendices

A. List of Project Events and Interviews

Year 1: Meetings Held:

A meeting of the university researchers held at MacDonald Campus in October, 2004.

A meeting with La Financière personnel, December 15th 2004.

A meeting of researchers and assistants at Ouranos, January 25th 2005.

Regular meetings involving different combinations of the Principal

A meeting of the Steering Committee and the research team: February 25th at Ouranos, to discuss findings to date.

A meeting of researchers, and an Ouranos representative, at the Université de Montréal: March 24th 2005, to discuss results that permitted the selection of the target regions and crops.

Year 2: Meetings Held:

A meeting at the Université de Montréal of the research team, September 9th 2005, to discuss work progress and future plans

A seminar at Ouranos, October 28th 2005, to present preliminary results

Presentation of results and *focus group*: meeting with professionals, Laprairie, SW Montreal region, November 10th 2005

Presentation of results and *focus group*: meeting with professionals, Drummondville, Centre-du-Quebec, November 17th 2005

Presentation of results and *focus group*: meeting with farmers, Alma, Saguenay-Lac-St-Jean region, December 1st 2005

Presentation of results and *focus group*: meeting with professionals, Alma, Saguenay-Lac-St-Jean region December 2nd 2005

Presentation of results and *focus group*: meeting with farmers, Laprairie, SW Montreal region, December 8th 2005

Presentation of results and *focus group,* meeting with farmers, Drummondville, Centre-du-Québec, December 9th 2005

Year 3: Media Reports, Interviews and meetings:

A meeting of the research team at the Université de Montréal to discuss work progress and work plans, April 3rd 2006

Université de Montréal Forum, June 12, 2006, p. 7: *'Les agriculteurs craignent davantage l'OMC que le réchauffement climatique'*. Based on an interview with Daniel Baril.

A meeting at La Financière agricole du Québec to present preliminary findings of the farm modelling component of the project, June 15th 2006.

Interview on Radio Canada between Christopher Bryant, Bhawan Singh and Serge Desroches, and Étienne Leblanc for the scientific program *'Les années lumières'*. The hyperlink for the interview is: http://www.radio-canada.ca/actualite/v2/anneeslumiere/niveau2_10461.shtml

Interview on Ztélé: with Christopher Bryant on the program *'La revanche des nerdz'*. August 2006.

B. Presentations

1 June 2004. C.R. Bryant, B. Singh, C. Madramootoo, P. Thomassin and L. Baker. *La vulnérabilité des exploitations agricoles et l'adaptation au changement climatique au Québec: la gestion des risques et les adaptations à la variabilité climatique : une proposition de projet*. Invited poster presentation to colloquium on *Climate Change and Adaptation*, Ouranos, Montreal, June 9th and 10th, 2004. (Presentation of the Project while waiting for final decision from Natural Resources Canada). **(Not included in the paper version because the format is too large to print)**

2 February 2005. C. Bryant, B. Singh and P. André. *The perception of risk to agriculture and climatic variability in Quebec.* Invited paper to the colloquium *Climate Change Adaptation and Canadian Agriculture: Impacts and Capacity*, C-CIARN, Edmonton, February 17th 2005. (This did not use funds from the Project.)

3 May 2005. C. R.Bryant, B. Singh, S. DesRoches, P. Thomassin, L. Baker, C. Madramootoo, K. Delusca, M. Savoie. *Climate Variability and Quebec: Lessons for Farm Adaptation from an Analysis of the Temporal and Spatial Patterns of Crop Insurance Claims in Quebec*. National Conference on *Adapting to Climate Change in Canada 2005: Understanding Risks and Building Capacity*, Natural Resources Canada, Montréal. May 4th to 7th 2005.

4 November 2005. C. Bryant. *The Agricultural Sector and Adaptation to Climate Change.* Presentation at McGill University (MacDonald Campus) 6th Annual Symposium of the Brace Centre (McGill University), *Water, Agriculture and Climate,* November 2005.

5 March (2006) K. Delusca, C. Bryant, B. Singh, L. Baker, P. Thomassin, M. Savoie, E. Da Costa, S. Jetté and S. Rivest. *Projet adaptation de l'agriculture aux changements climatiques.* Agriculture, Pêcheries et Alimentation Québec, *Journée informations bleuet nain semi-cultivé au Québec*.14th March 2006, St. Félicien.
www.agrireseau.qc.ca/petitsfruits/documents/conf%C3%A9renciers.pdf

6 May 2006, S. Rivest, S. Jette-Nantel, L. Baker, P. Thomassin, S. Desroches, C. Bryant, K. Delusca, E. Da Costa, S.-O. Côté.*Vulnérabilité économique et adaptation des fermes québécoises aux changements climatiques.* Presentation made to the 74th Congress of ACFAS, McGill University, May 18th, 2006.

7 May 2006, S. Desroches, C.R. Bryant, B. Singh, K. Delusca, M. Savoie, E. Da Costa, S.-O. Côté, P. Thomassin and L. Baker. *Vulnérabilité des agriculteurs québécois aux risques climatiques.* Presentation made to the 74th Congress of ACFAS, McGill University, May 17th, 2006.

8 May 2006. K. Delusca, C.R. Bryant and B. Singh. *Vulnérabilité aux changements et variabilités climatiques: une analyse critique*. Presentation made to the 74th Congress of ACFAS, McGill University, May 17th, 2006.

9 July 2006. C. R. Bryant, B. Singh, S. Desroches, K. Delusca, E. Da Costa, M. Savoie, P. Thomassin, L. Baker and S. Rivest. *Adaptation of Farming and Farming Communities to Extreme Climatic Events: Looking at the Past to Understand Adaptation to Climatic Change.* Presentation made to the 2006 Colloquium of the International Geographical Union Commission on the Sustainable Development of Rural Systems, Cairns, Australia, July 14th, 2006. (An activity that did not use any project funds.)

10 November 2006. C. R. Bryant, B. Singh, S. Desroches, K. Delusca, M. Savoie, E. Da Costa, S.-O. Côté, P. Thomassin, L. Baker and S. Rivest. L'Agriculture face au changemebt et à la variabilité climatiques du Québec: Une analyse des risques et adaptations. Poster presentation to the Ouranos Symposium in Montreal, November2nd and 3rd, 2006. **(Not included in the paper version because the format is too large to print)**

C. Interim Detailed Reports on Key Tasks

1 Report on Focus Group Results with Farmers and Representatives of Agriculture-related Organizations and Institutions (in French: Serge Desroches et al. : *Rapport des rencontres avec les agriculteurs et les professionnels agricoles du Sud-Ouest de Montréal, du Centre-du-Québec et du Saguenay-Lac-Saint-Jean*)

2 Summary of Climate Indicators used in Farm Level Modelling (in French: Marylène Savoie: *Indices des conditions futures pour l'agriculture au Québec*)

3 Report on Farm Level Modelling of the Benefits of Farm Adaptation at the Farm Level (Sébastien Rivest, under the supervision of Paul Thomassin and L. Baker: *Farm Impact and Adaptation to Climatic Change in Quebec, Canada*)

D. Publications

1 Fall, 2007 (in press). C. Bryant, B. Singh and P. André. *The Perception of Risk to Agriculture and Climatic Variability in Quebec: Implications for Farmer Adaptation to Climatic Variability and Change.* Chapter for a C-CIARNS book, to be published by UBC Press. In press. NOTE: This chapter is a synthesis of all of the research projects undertaken by the Université de Montréal team since the mid-1990s, mostly financed by the CCIAD, and is not just based on the current project (A931). (Included copy of final text submitted)

2 May 2007 (in press). C. R. Bryant, B. Singh, S. Desroches, K. Delusca, E. Da Costa, M. Savoie, P. Thomassin, L. Baker and S. Rivest. *Adaptation of Farming and Farming Communities to Extreme Climatic Events: Looking at the Past to Understand Adaptation to Climatic Change.* Chapter for the Proceedings of the 2006 Colloquium of the International Geographical Union Commission on the Sustainable Development of Rural Systems, Cairns, Australia. Being published by the University of New England, New South Wales, Australia. (Included copy of final text submitted attached)

3 Fall, 2007. C. R. Bryant, B. Singh, P. Thomassin, L. Baker, S. Des Roches, M. Savoie, K. Delusca, E. Da Costa, S.-O. Côté, S. Rivest and S. Jetté-Nantel. *The Agricultural Sector and Adaptation to Climate Change.*Chapter for a publication through McGill University based on the presentation made by Christopher Bryant at McGill University (MacDonald Campus) in November 2005, to be published as part of a Proceedings that will draw together papers from the Brace Centre 2005 symposium and the April 2007 symposium on the same theme. (Included copy of final text submitted)

E. Masters Theses and Research Reports and PhD Theses Completed or Nearing Completion, March 30th, 2007 (texts not attached)

1 Elsa Da Costa. Le rôle du capital social dans la capacité adaptative des pomiculteurs de la Municipalité de Saint-Joseph-du-Lac au changement climatique. MSc thesis. Géographie, Université de Montréal. First draft submitted end of March, 2007; final submission expected April, 2007.

2 Oumarou Daouda Hamani. *Adaptation de l'agriculture aux changements climatiques :Cas du département de Téra au Niger.* MSc thesis, Département Environnement (Spécialité : Gestion de l'environnement) Université de Senghor, Égypte. An intern during the summer of 2006 with the Laboratoire Développement durable et dynamique territoriale; he was independently financed and participated in Project A931 as a volunteer. His thesis benefited by advice provided by the Principal Investigator and the Project Coordinator.

3 Marylène Savoie. MSc by Research Reports, MSc. Géographie, Université de Montréal. Final Research Reports expected to be submitted April, 2007.

F. Other Related Publications Not Directly Related to the Project Funding (texts not attached)

1 Brassard, J-P. and Singh, B. (2007) Impacts of climate change and CO2 increase on crop yields and adaptation options: Québec, Canada). *Mitigation and Adaptation Strategies for Global Change.* To appear.

2 Brassard, J-P. and Singh, B. (2007) Assessing the impacts of climate change and CO2 increase on potential crop yields in Southern Québec, Canada. *Climatic Research*. To Appear.