Farm-Level Adaptation to Multiple Risks: Climate Change and Other Concerns

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Abstract

The impacts of, and responses to, climate change have been of recent interest to social scientists. The purpose of this paper is to present results from a case study examining farm-level adaptation, within the relevant social, political, and economic context, to risks and opportunities presented by climate change in one region of Manitoba, the Parkland region. This was pursued by soliciting opinions and impressions from farmers in the Parkland region of Manitoba regarding a variety of questions relating to previous and future farm-level adaptations to multiple risks and opportunities with a particular emphasis on climate change. The paper begins by drawing upon the research literature in developing a model of farm-level adaptation. This model is then applied to the Parkland region in Manitoba through a survey of farmers in the region.

1.0 Introduction

Climate change, and with it, increasing variability in weather, could impose both positive and negative impacts on agricultural areas (Lemmen & Warren, 2004, p. xii). As agricultural practices are constrained and shaped by climate (Mooney & Arthur, 1990, p. 685), it is likely that climate change will result in the need for agricultural producers to adapt in order to “reduce impacts and even capitalize on new opportunities” (Chiotti, 1998, p. 381). We anticipate that because agriculture is an important part of its economic and social structure, the Province of Manitoba, located on the eastern Canadian prairie, could see a range of effects brought about by a changing climate.

This paper presents findings from a study examining farm-level adaptation (within the relevant social, political, and economic context) to risks and opportunities presented by climate change in one region of Manitoba, the Parkland region. Through interviews with farmers in that region, the authors sought answers to a variety of questions relating to previous and future farm-level adaptations to multiple risks and opportunities with a particular emphasis on climate change.

ISSN: 1712-8277

The paper begins with a review of climate change adaptation literature to develop a conceptual model of farm-level adaptation. The study area and research methods are then outlined. In essence, the conceptual model is applied to the Parkland region in Manitoba by exploring the following questions: (a) What do farmers think of climate change? (b) What are the farm-level adaptations made by farmers in the Parkland region to the risks and opportunities presented by the forces of change on agriculture? Results are analyzed within the context of the model developed and form the basis for conclusions regarding future changes in Manitoba agriculture, particularly those changes associated with climate change and variability.

2.0 Context

2.1 Impacts and Adaptation to Climate Change in Manitoba

In 2002, Agriculture and Agri-Food Canada and the Prairie Farm Rehabilitation Administration released a report titled *An Assessment of Climate Change on the Agricultural Resources of the Canadian Prairies* (Nyirfa & Harron, 2002). In this study, a Land Suitability Rating System (LSRS) was developed to evaluate the ability of soils, landscapes, and climate to sustain agricultural crops by adopting "specific climate parameters that can be calculated from existing or climate model data, linking predicted climate change with the Soil Landscapes of Canada (SLC) to determine potential impacts" (International Institute for Sustainable Development [IISD] & Manitoba Clean Environment Commission [MCEC], p. 2). A Global Circulation Model (GCM) was then utilized to apply climate change to the LSRS system of prairie agricultural resources (Canadian Global Coupled Model 1 [CGCM1]), which predicted a doubling of atmospheric carbon dioxide by the middle of the 21st Century (IISD & MCEC, 2001, p. 4). The CGCM1 model also predicted above-normal spring temperature increases, most significantly affecting the Canadian North and the Prairies (IISD & MCEC, 2001, p. 5). Summer temperatures are expected to increase by 3 to 4 °C. Although fall temperature increases are expected to be less significant, winter temperatures are predicted to increase between 5 and 8 °C. Precipitation in Manitoba is expected to increase in the spring and decrease 10% to 20% in the summer. Effects of climate change may include more frost-free days, more spring flooding and an increase in summer droughts.

Nyirfa and Harron's LRSC study (2002, p. 14) predicts a soil moisture deficit for the growing season in southern Manitoba despite greater spring precipitation. The study also predicts longer growing seasons comparable to those experienced in present-day southern Ontario. The most dramatic change might be that the most suitable agricultural land for the growth of seeded small grains shifts from the southern prairies into the central and northern portions of the provinces in areas where soil type and landscape permit. The present-day grain-growing areas in the southern prairies are predicted to face severe climate limitations due to aridity. These drier conditions will result from increased loss of water through evapotranspiration from the soil and bodies of water and increased transpiration from plants (Senate of Canada, 2003). However, Manitoba stands to suffer the least and the province's northern areas will see the greatest increase in agriculturally suitable areas. While the southern Canadian prairie landscape may appear relatively homogenous, there are a number of biophysical features that alter agro-climatic and soil patterns. In western Manitoba, the Manitoba escarpment separates the more ubiquitous prairie landscape (MMAFRI, 2005). The differences associated with the escarpment are addressed in the farm samples selected for the case study research described in this paper.

In a concurrent study that utilized newer versions of Canadian GCMs that was completed for the Climate Change Action Fund (McGinn, Shepherd, & Alinremi, 2001), researchers drew similar conclusions. For Manitoba, these include increased minimum and maximum annual average temperatures, an increase in average annual precipitation, earlier seeding and harvesting dates, and more growing degree days. Unlike the Nyirfa and Harron study, these researchers predict a slight increase in soil moisture throughout the Manitoba growing season and less arid conditions than the present. McGinn et al. (2001) conclude that Manitoba will, given the best-case climate change scenario, see a more conducive growing environment for crops, with increased production potential and crop diversity; under the worst-case scenario, they predict there will be little change from the present production situation. These conclusions are consistent with Mooney and Arthur (1990), whose model suggested that although yields for traditionally grown crops would decrease, climatic warming would economically benefit the cropping sector in Manitoba when new species and crop locations were taken into consideration, that is, if risks were managed and adaptations made. The Mooney and Arthur study also pointed out that predicted changes would have important implications for all agricultural practices involving crop species, rotations, chemical use, timing, technology, and transportation and that these effects would be felt throughout the prairie economy and beyond.

2.2 Adaptive Capacity for Dealing with Climate Change

Adaptive capacity in rural contexts has been of recent interest in the literature. Wall and Marzall (2006), for example, developed a framework for assessing community capacity in a climate change context for rural communities in Canada. Their framework includes five “resources” for analyzing the impacts of climate change on rural communities, namely, social, human, institutional, natural, and economic. From this framework, a series of indicators was identified for measuring adaptive capacity, which was then applied to a community in central Canada. Similar to the “resources” identified by Wall and Marzall (2006), response to change can be analyzed based on the concept of capital (e.g., human, economic, environmental). For examples, farmers’ capacity to adapt is based on their individual reserves of human capital, which includes such attributes as the skills, education, and general abilities of individuals (Gauthier & Diaz, 2005; Gauthier & Weiss, 2005).

In the public policy domain, the Intergovernmental Panel on Climate Change (IPCC) defines adaptive capacity as “the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences” (IPCC, 1995). These systems can be identified at various scales: national, regional, or farm. At the farm level, as with the other scales of system definition, farms are seen as entities operating within the political economy framework, functioning within external economic, institutional, technological, and social environments, as well as within the natural environment (Smithers & Smit, 1997). Operating within the supports of this framework, Canadian farmers could generally be defined as having a high adaptive capacity (Chiotti, 1998). Sauchyn (2007) concludes that since Prairie farmers have always operated within the extreme variability of a northern, continental climate and constantly fluctuating markets, they are capable of adopting new technologies and cropping options regardless of the climatic situation.

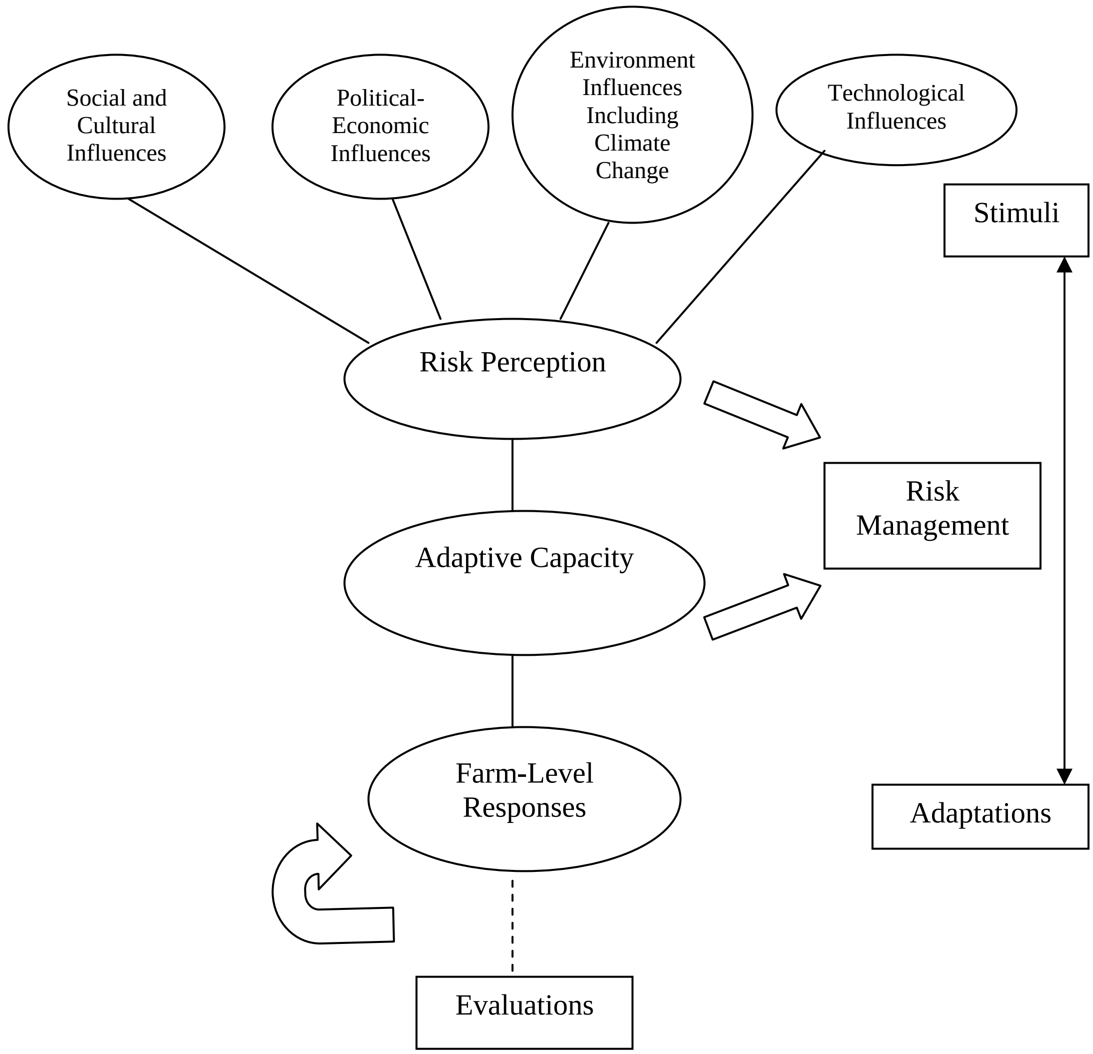
In this paper, *adaptation* is the term used to describe the adjustments made by individual producers to reduce the risks or take advantage of the opportunities provided by climate change, variable climatic conditions or weather events (Kandlikar & Risbey, 2000; Smit, 1993; Smit, Burton, Klein, & Street, 1999). To investigate the adaptive capacity of agricultural systems to potential changes in climatic and other conditions that influence agriculture, there is a need to revise conventional research frameworks and place climatic change research into the broader context of agricultural decision making (Brklacich, McNabb, Bryant, & Dumanski, 1997). The farm decision-making scenario is multidimensional, with economic, financial, sociocultural political, and environmental considerations (Bryant et al., 2004).

Although adaptations to climatic conditions are quite common in the agricultural sector, adaptive decisions are unlikely to be made in response to climatic conditions or risks alone; such decisions are likely to be made as part of integrated risk management strategy, driven by the joint effects of multiple forces (Smit & Skinner, 2002). It should be noted that despite the fact that adaptation to climate change may in some cases be a secondary consideration when dealing with farm-level risk management, farmers' actions may have the effect of reducing or increasing their vulnerability to climate change anyway (Bryant et al., 2004). Nonclimatic farm-level stimuli may amplify or exacerbate climate-related risks, or they may dampen, counteract, or overwhelm the climatic effects (Smit & Skinner, 2002).

3.0 Model of Farm-level Adaptation

Conceptualizing response to decision making in agriculture is not new. Gasson (1973), in a seminal work in the agricultural social sciences, makes the distinction between decisions made by the so-called rational economic man and decisions made for sociocultural (e.g., familial, lifestyle) reasons. Similarly, work-related agricultural restructuring is explicitly about change, with decision making and response representing the turning point for change (Ilbery, 1985). More recently, models have been constructed that identify three essential elements of change: force or stress, change itself, and response to change (Smithers & Smit, 1997). Examples include models that have been applied to environmental stressors (Spaling & Smit, 1993), and changing economic conditions and policies (Ramsey & Smit, 2002). Models such as these have since been applied to explain adaptation to climate change and variability (Belliveau et al., 2006; Belliveau, Smit, & Bradshaw, 2006; Bradshaw, 2007; Reid, Smit, Caldwell, & Belliveau, 2007). Building on this work, the model illustrated in Figure 1 provides a conceptual framework for analysis. The predominant assumption is that climate change risks are experienced in the context of a wide range of other influences or conditions (Bradshaw & Reid, 2007; Dolan, Smit, Skinner, Bradshaw, & Bryant, 2001; Smit & Skinner, 2002; Smithers & Smit, 1997). Four influences are identified in Figure 1. Social-cultural influences can include community demographics and dynamics, educational levels and opportunities, and generational histories. Political-economic influences can include commodity prices, input costs, mortgage and lending rates,

Figure 1. A Framework of Farm-Level Adaptation to Risk Influences



agricultural support programs, and levels of taxation. In addition to climate change and weather variability, environmental influences can include crop disease and depletion of soil quality and quantity. Technological influences range from crop variety availability to mechanical innovations. These conditions or stimuli are experienced by farmers to varying degrees, at varying times, independently or in conjunction with each other. Their effects may be positive (e.g., increasing commodity prices) or negative (e.g., decreased productivity levels or increasing input costs).

The model builds upon those of others (e.g., Belliveau, Smit, & Bradshaw, 2006; Brklacich et al., 1997; Brklacich, Bryant, Veenhof, & Beauchesne, 2000; Bradshaw, Dolan & Smit, 2004) by specifying adaptation as a response to perceptions of risk brought about by external stimuli as evidenced by farm-level responses to risk. That is, farmers' ability to manage risk, once perceived, is an element of their adaptive capacity. Bradshaw, Dolan and Smit (2004), for example, detailed crop diversification in Saskatchewan, Canada, as one example of farm-level adaptation to risk (climate change and variability). The model specifies that responses can be taken and that farmers may also evaluate the success or failure of those responses. Whether successful or not, the model argues that the response is an attempt to manage risk.

Whether these stimuli present a risk or an opportunity to a particular farmer depends largely on his perception or subjective view of the situation. Once a stimulus has been perceived, the farmer can choose to manage the situation, depending on his or her levels of adaptive capacity. Although Canadian farmers operate within a highly developed safety network that includes research, government, financial, and interest group supports, inadequacies in the responses of these institutions coupled with environmental uncertainty often require farmers to rely on themselves to respond appropriately. A farmer's personal capacity to adapt to a farm-level change is determined by the relevant skills (human capital) he or she possesses, among other factors. The adaptations farmers make to stimuli are part of an integrated risk management strategy in order to respond to multiple influences. A farmer's evaluation of the success of an adaptation will be based on several indicators. The adaptations can have many different characteristics and, like the stimuli that necessitated an adaptation in the first place, might be technological, financial, social, or environmental, or any combination of these.

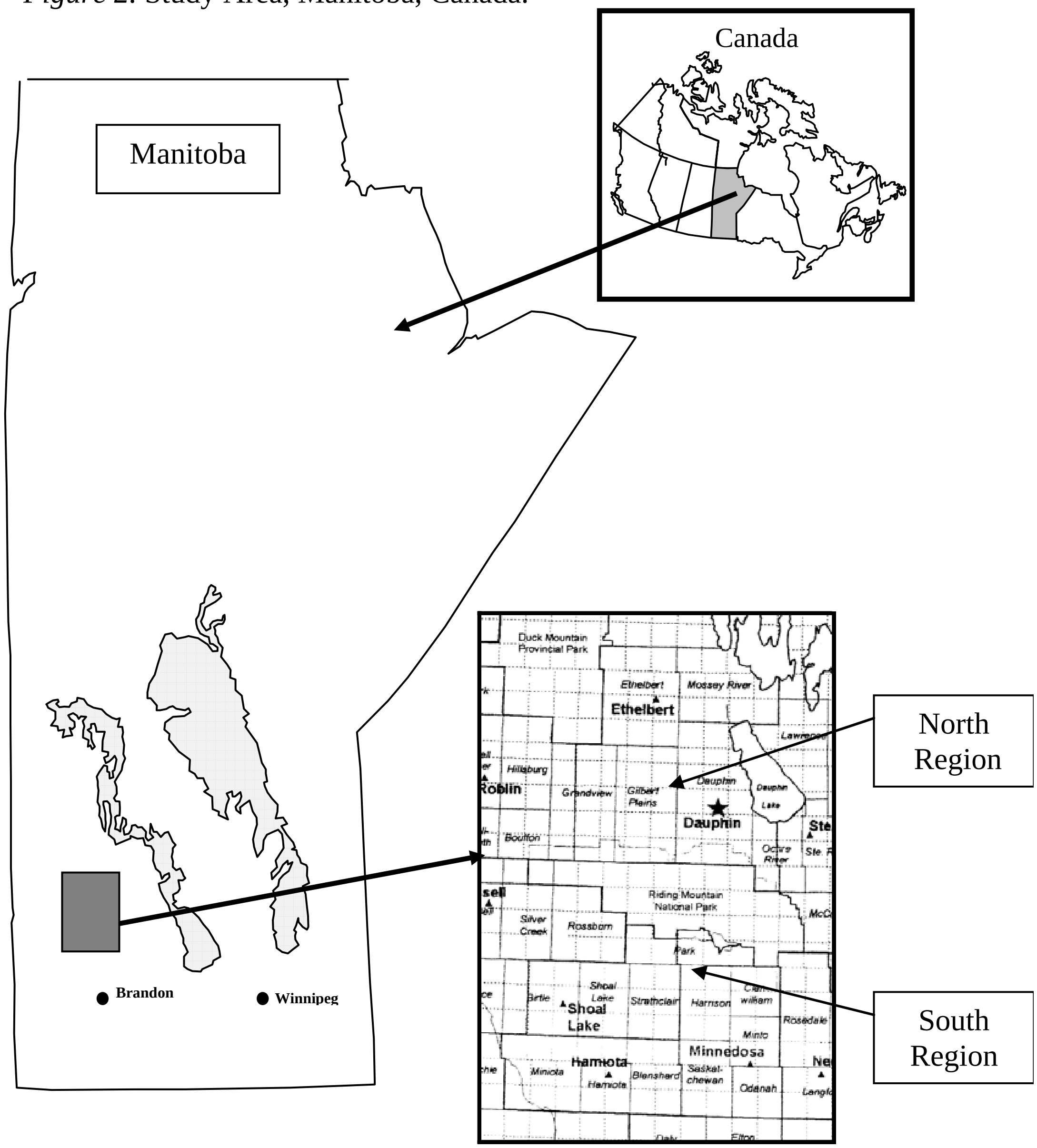
For farmers to adapt, there must have been a change. Thus, returning to the research questions, it is important to first understand what farmers think of climate change and how it fits into their risk management strategies. Following the development of such a baseline, it is then possible to identify and describe the farm-level adaptations made in the Parkland area of Manitoba to the risks and opportunities presented by the forces of change.

4.0 Applying the Model: Case Study in Rural Manitoba

4.1 Study Area

The most significant elevation change in southern Manitoba is located within the Riding Mountain region, home to Riding Mountain National Park (RMNP), in the southern part of the Parkland region. The study area includes farmers located both north and south of RMNP (Figure 2). This region has a continental climate, the distinguishing feature of which is great temperature differences between summer and winter. Seasonal climatic conditions vary from year to year. The study area has the only terrain feature, located within RMNP, that has a slight significance on climate control throughout the province. The Manitoba escarpment is a series of minor upland areas that rise between 700 and 1200 metres above sea level. Water and relief features outside the province actually have a much greater influence on the province's climate. The northern and southern sections of the study area are located in the same ecozone referred to as the Parkland, which is also the transition zone between the prairie and the boreal forest, areas that stretch from northwestern Minnesota, USA, through Manitoba as far west as the Rocky Mountains. The varied Parkland landscape was formed by the advance and retreat of the last continental glacier. It is a combination of forest, prairie, and wetlands that covers 5.3% of Manitoba and is heavily used for agriculture. Although close in proximity,

Figure 2. Study Area, Manitoba, Canada.



the agro-conditions south of RMNP are different from those in the north. According to the Manitoba Ministry of Agriculture, Agrifoods and Rural Initiatives (MMAFRI, 2005), the area south of RMNP has lower corn heat units, earlier first frosts, short frost-free periods, greater impacts of irrigation, more days with precipitation, more complex soil classes, more need for land management considerations, better drainage, and less sensitivity to wind erosion.

4.2 Methods

Thirty face-to-face interviews were conducted with farmers using a semistructured interview script so that each respondent could expand upon areas most relevant to their individual farming situation. Sixteen interviews were conducted in the northern part of the study area and 14 in the southern part. The sample, which included a range of farm types (see Table 1), was obtained using a snowball sampling technique (Jackson, 1999) based on local contacts with farmers in the study area. Respondents were visited in their homes. In some cases both husband and wife participated, but most often it was a single male farm operator. Interviews were tape-recorded and later transcribed by the researchers. Respondents were asked questions under a number of key headings: (a) background information, (b) description of the good and bad years and how they responded; (c) identification of potential future risks and opportunities in agriculture, and (d) definitions and impacts of climate change and how they have responded. Thus, adaptation was assessed by having respondents view the past, present, and future in the light of risks and opportunities identified, including climate change and weather variability.

Table 1. *Types of Farms Represented in the Study (n=30)*

Farm Type	Number
Dairy	2
Mixed cattle/grain	9
Grain/seed	9
Cattle	4
Organic	1
Pregnant mare urine	1
Horticulture	3
Cattle/apiary	1
Total	**30**

5.0 Findings: The Importance of Climate and Weather Conditions

The model (see Figure 1) suggests that farmers perceive risk from a range of external stimuli and utilize their adaptive capacity to manage that perceived risk. While five stimuli are acknowledged in the model, the analysis in this paper focuses on two specific environmental influences: climate change and weather variability. As noted earlier, climate change predictions for Manitoba indicate that the mean average temperatures will likely increase along with a decrease in summer precipitation. The data from the survey suggest that climate and weather are important factors for farming operations (see Table 2). Farmers were first asked what climate change meant to them. Ninety percent had an opinion, but these opinions varied widely from no change to both warming and cooling climates in the future.

Table 2. *Farmers' Perceptions of Climate Change (n=30)*

Perception	Number (%)
Concern about climate change	25 (83.3)
Climate change to impact parkland	25 (83.3)
Positive impacts	4 (13.3)
Negative impacts	11 (36.7)
Positive and negative impacts	6 (20.0)
Changes to moisture regime	14 (46.7)
Longer growing season	20 (66.7)
Longer frost-free period	20 (66.7)
Increase in erratic weather patterns	5 (16.7)

Each farmer was asked if climate and weather had any influence on farming operations over the past 10 years. Eighty-seven percent of farmers surveyed answered positively. As an illustration, one farmer replied: "You go out every morning and the first thing you do is look up at the sky; that's a typical farmer." Twenty-five (83%) farmers indicated they were concerned about climate change (see Table 2). The same number indicated they felt that climate change would affect the Parkland region. Respondents were divided as to whether climate change would result in positive or negative effects for the Parkland. Four farmers said the changes would be positive, compared to 11 who believed the effects would be negative. Twenty percent (6) said there would be both positive and negative impacts.

Having said this, 27% of farmers seemed to be less aware of what the potential effects of climate change might be, as these farmers gave no response or indicated they did not know what the effects would be. A farmer's adaptive capacity to respond to climate change as a stimulus may be diminished if he does not understand or know what those effects might be. Almost half of the farmers perceived climate change as a change in the climate variance, particularly in the length of the growing season. Four farmers had no opinion or could not define climate change, whereas four emphasized the need to adapt when defining what climate change meant to them.

Four specific effects of climate change were identified: changes in moisture regimes, growing seasons, frost-free periods, and weather patterns. Almost half (14) of the respondents said that the major effect would be to the moisture regime. A typical comment was, “Drought would be the biggest problem; maybe less rain, hotter, drier summers; could be longer periods of dry weather; drought conditions.” Two thirds said the growing season would get longer and there would be more frost-free days. Five farmers mentioned the possibility of an increase in erratic weather patterns (see Table 2), a phenomenon that is one of the predicted effects of global warming (IISD & MCEC, 2001).

Respondents were then asked their perceptions of change in five weather conditions: drought, flooding, winter temperature, summer temperature, and length of growing season. As summarized in Table 3, views were variable. Farmers indicated that true drought conditions did not exist in the Parkland region; rather they described conditions in terms of levels of dryness. Twelve farmers said that growing conditions were becoming drier. Only 2 farmers in the study area, both located south of RMNP, indicated they perceived a greater incidence of flooding in the last 10 years. Flooding is not a major issue in the Parkland area, because of the topography. Water moves downstream and downhill in the spring, off the elevated areas of the Manitoba escarpment.

Table 3. *Perceptions of Change in Weather Conditions Over the Past 10 Years (n = 30)*

Incidence of drought	No change	Drier	Wetter	No drought in area	Doesn’t know	Total
	7	12	1	8	2	30
Incidence of flooding	No change	More flooding	Less flooding	No flooding in area	Doesn’t know	Total
	12	2	5	10	1	30
Winter temperature changes	No change	Warmer	Colder	Doesn’t know	Other	Total
	12	12	2	1	3	30
Summer temperature changes	No change	Warmer	Colder	Doesn’t know	Other	Total
	12	6	2	4	6	30
Length of growing season	No change	Shorter	Longer	Doesn’t know	Other	Total
	15	3	10	0	2	30

As one farmer indicated when asked about flooding occurrence, "[Flooding does not happen] in this rolling land." Twelve farmers said that winter temperatures were rising, although the same number of farmers believed there had been no change. Two farmers perceived that winter temperatures were getting colder, while 6 respondents believed that summer temperatures were getting warmer, compared to 12 who said there was no change. Perceptions of changes to the length of growing season were clearer, with half of respondents indicating no change compared to 10 who said it was getting longer (see Table 3). For example, one farmer stated that an increase in the length of the growing season was the only climate-related change he had noticed. He reported that he had not seen an early fall frost over the past 10 years. In summary, while the farmers interviewed provided a range of changes to a number of aspects of weather and climate, there were also many who said there were little or no changes. Of those that did note changes, most had provided examples of adaptation.

6.0 Findings: Adaptations and Climatic Variability

Not all of the farmers who answered positively to questions about specific adaptations provided explanations as to why they had made a change. Some farmers gave explanations but not all adaptations were made for weather-related reasons but rather as a result of other stimuli. This is consistent with the model. The introduction of a specific adaptation as a result of a specific stimulus does not always follow a simple cause-and-effect scenario. Sometimes farmers find themselves making one adaptation for reasons other than weather-related issues only to find themselves accepting or initiating another one because of a different stimulus, including the weather. For instance, one farmer reported that one year he had rented a zero-till seeder to plant a field to a new variety of crop, alfalfa (technological stimulus with a production practice adaptation but not weather related). He got on the field very early in the spring. However, that seeding season became very wet and the soil was too soft and the seed was planted too deep. The prognosis for the crop was poor so he sprayed it out. The government offered a disaster relief payment for his area for acres not planted because of excessive moisture. He went on to cultivate the land and reseed it with another crop.

Farmers identifying changes in weather and climate were asked to identify how they adapted to such changing conditions over a 10-year period. The changes specified included incidence of drought, incidence of flooding, winter temperature changes, summer temperature changes, and changes to the length of the growing season (see Table 4).

6.1 Drought

One farmer's perception of drought was related to lower water tables. He indicated that his response was to introduce zero-till practices to conserve soil moisture (see Table 4). Another farmer who perceived drier conditions, particularly noted in lower levels to the lake and sloughs on his property, responded by acquiring more pastureland in order to have enough feed for his horses. One farmer, who spoke of increased levels of dryness over the last few years, had not made any changes to respond to this condition. He said that while the solution would be to move from minimum till to zero-till production, he was not sure his soil was suited to zero till or that he could afford the equipment. He will take his cue from other successful local farmers who are still using more conventional production techniques before

Table 4. *Adaptations to Changing Climate and Weather (n = 30)*

Change in weather/climate	Adaptation
Drought	Zero-till to conserve soil moisture
	Acquire more pasture land
	Change herd type to increase profit with fewer animals
Flooding	Build culverts to direct water
	Small dam/dyke construction for spring runoff
	Move fencing to limit animal access
	Planting hay in problem areas
Winter temperature	Change pasture patterns
	Outside calving with warmer winters
Summer temperature	Introduction of hybrid crop varieties
Growing season	Introduction of hybrid crop varieties
	Different seeding schedule

he invests in changes that might provide more soil moisture conservation. One farmer had developed a contingency plan to respond to what he sees as increasing drought conditions by specializing his cattle herd in order to make the same amount of money from fewer cattle, thus requiring less production of pasture and hay from his land base.

6.2 Flooding

One farmer said the issue was not really flooding but rather that spring water ran over his fields. His response has been to work with the conservation district to place larger culverts on his property (see Table 4). He indicated that farmers south of his property had difficulty maintaining the culverts on their properties because the rate of flow there was so great. He would consider holding back spring water on his property with a small dam or a series of dykes but he would like to be paid for this contribution to spring runoff management. Another farmer described the effects of decreased spring runoff:

> [W]e have hay meadows along the river and I would say maybe we've had one or two in the last 10 years and it used to flood every spring.… We can't source much hay off the meadows, because we don't get the moisture to make it grow, so I'm relying more on other crops to source my feed for the livestock.

Another farmer who answered positively to a perceived increase in flooding actually described a higher water table and river levels: "We had to move some fences up on to higher ground. The sloughs have moved out."

Still another farmer reported that while he did not really have flooding on his farm, spring washouts that cause soil erosion were a concern. He has responded by planting a hay crop in those areas prone to erosion in the hopes that this will combat the problem. A farmer located north of RMNP had an interesting take on flooding in the north Parkland. He indicated that runoff was coming off of Riding Mountain and moving to Lake Dauphin faster than in previous years. He felt that this increased water movement was a result of ditching done by farmers. Because water is not allowed to sit on fields and over the long term, he believes that this has caused lower water table levels. A farmer, also located north of RMNP, had the opposite opinion. He indicated that spring water was being held on the fields more efficiently, even though it was his perception that there was less precipitation.

6.3 Temperature

Responding that winter temperatures were getting warmer, one farmer stated that he might be able to pasture his cattle year-round because snow cover might be minimized (see Table 4). Similarly, another farmer indicated that outside calving was an adaptation to warmer winter temperatures he had made on his operation. In terms of crop production, a farmer located north of RMNP noted that he had seen corn hybrids being grown in his area as a result of higher corn heat units in recent years. Corn heat units are an indexing system that is used to identify which crop varieties and hybrids are most suitable for a given area (Smit, Blain, & Keddie, 1997).

6.4 Growing Season

One farmer has taken advantage of what he sees as a longer growing season by introducing a longer-maturing canola crop that also produces a higher yield. One farmer located south of RMNP discussed the possibility of eventually adding a longer-growing variety such as peas to his rotation because of the perception of a longer growing season (see Table 4). Another farmer indicated that he had made adjustments to his seeding schedule because of changes in the growing season. One of the three farmers who said the growing season was shortening had responded by keeping his crop (strawberries) covered as long as possible early in the spring to protect them from frost.

The majority of farmers who responded to questions about climate-related influences said there had been no average change in these climate-related measurements. However, many farmers indicated that they felt there had been an increase in erratic or extreme weather events related to these measurements. The majority of farmers did not indicate the type of adaptations they had made, if any, to perceived changes in climate. As one farmer explained, however, farmers often adapt to negative weather-related issues during the growing season in which they occur. He spoke of changing an oat field production strategy because of unexpectedly cold temperatures:

> It was too cold, the crop didn't get going and didn't … wasn't as vigorous and competitive the way it should have been and therefore we had more wild oats that came out. So we had to draw up a different strategy. I just decided, Okay, I'm not happy with leaving this field and harvesting the oats, so we'll forage it. So we round- baled it and sold it that way. Didn't make as much. No, I would not have made as much money as if I'd had a hundred-bushel crop of oats, but I didn't have the expense and the work, plus it gave me an ideal place to sow winter wheat because it (the crop) was out of the way early. So, you know, you just have to adapt. I mean

> we'll find ways to…. When a problem develops, and it will in farming, we'll find a way around it somehow.

Two farmers pondered whether their perception regarding more favourable growing conditions in the last few years was erroneous and that the real reason for better and quicker harvests was actually related to the use of more effective and efficient technology. In summary, just as there were differences in whether farmers perceived changes in weather conditions, and if so, how, their responses also varied. This further illustrates the complexities inherent to farming, particularly with a large range of farm types and sizes.

7.0 Conclusions

The purpose of this paper was to assess what farmers think of climate change and how it fits into their risk management strategies. A better understanding of how farmers adapt to risk and/or opportunity at the farm-level was sought. Although the conceptual framework developed in this paper included a range of external stimuli (political-economic, sociocultural, environmental, and technological), the discussion focused on climate change and variability as examples of environmental stimuli. Farmers generally believe that the growing season is getting longer and that there is less precipitation in the summer. These are predicted climate changes for Manitoba. Farmers defined climate change as a variance from the means. Farmers in both areas reported a close relationship between weather and other types of environmental influences. Farmers seem most confident and knowledgeable about environmental stimuli. With respect to weather and climate, they noted a number of adaptations to risk associated with drought and flooding conditions, changes in summer and winter temperatures, and changes in the length of the growing season.

The most frequently practiced farm production adaptations made by both groups were changes in types and varieties of crops. A change in crop hybrids was the only adaptation made by farmers that was related almost exclusively to climate. Of the total responses made by farmers in both areas in regard to climate change, the majority said there had been no average change in the climate, with the exception of an increase in erratic weather events. When asked specifically about summer or winter temperature, the majority of farmers said it was getting warmer or that no change in mean temperatures was occurring. When asked about drought conditions, more farmers said it was becoming drier. Questions about flooding were mostly irrelevant as the Parkland is not a flood-prone area because of topography.

An important consideration for farmers relates to the limitations of the physical environment. Limitations include the length of the growing season, precipitation levels, soil fertility, and the area's topography. Climate change is projected to alter some of the physical limitations of a region's agricultural capacity, thereby challenging the capacity of farm-level producers to recognize, manage, and ultimately adapt to either the risks or opportunities introduced by new climatic regimes.

8.0 Acknowledgments

This project was funded by the Climate Change Action Fund with Dr. Barry Smit at the University of Guelph, Canada, as the primary investigator. The authors thank

Barry for his support and encouragement. The authors also thank the two reviewers for their critique and insight. The final thank-you is for the farmers who agreed to take part in the survey.

9.0 References

Belliveau, S., Smit, B., & Bradshaw, B. (2006). Multiple exposures and dynamic vulnerability: Evidence from the grape industry in the Okanagan Valley, Canada. *Global Environmental Change, 16,* 364–378.

Belliveau, S., Bradshaw, B., Smit, B., Ramsey, D., Tarleton, M., & B. Sawyer. (2006). *Farm-level adaptation to multiple risks: Climate change and other concerns* (Occasional Paper No. 27). Guelph, Ontario, Canada: University of Guelph, Department of Geography.

Bradshaw, B. (2007). Climate change adaptation in a wider context: Conceptualizing multiple risks in primary agriculture. In E. Wall, B. Smit, & J. Wandel (Eds.), *Farming in a changing climate agricultural adaptation in Canada* (pp. 103–114). Vancouver, British Columbia, Canada: UBC Press.

Bradshaw, B., Dolan, H., & Smit, B. (2004). Farm-level adaptation to climatic variability and change: Crop diversification in the Canadian prairies. *Climatic Change,* 67, 119–141.

Brklacich, M., Bryant, C., Veenhof, B., & Beauchesne, A. (2000). Agricultural adaptation to climatic change: A comparative assessment of two types of farming in central Canada. In H. Millward, K. Beesley, B. Ilbery, & L. Harrington (Eds.), *Agricultural and environmental sustainability in the new countryside* (pp. 40–51). Brandon, Manitoba, Canada: Brandon University, Rural Development Institute.

Brklacich, M., McNabb, D., Bryant, C., & Dumanski, J. (1997). Adaptability of agriculture systems to global climate change: A Renfrew County, Ontario, Canada pilot study. In B. Ilbery, Q. Chiotti, & T. Rickard (Eds.), *Agricultural restructuring and sustainability* (pp. 185–199). Wallingford, Oxon, UK: CAB International.

Bryant, C., Andre, P., Thouez, J.P., Singh, B., Frej, S., Granjon, D., et al. (2004). Agricultural adaptation to climate change: The incidental consequences of managing risk. In D. Ramsey & C. Bryant (Eds.), *The structure and dynamics of rural territories: Geographical perspectives* (pp. 260–271). Brandon, Manitoba, Canada: Brandon University, Rural Development Institute.

Chiotti, Q. (1998). An assessment of the regional impacts and opportunities from climate change in Canada. *The Canadian Geographer, 42,* 380–393.

Dolan, A., Smit, B., Skinner, M., Bradshaw, B. & Bryant, C. (2001). *Adaptation to climate change in agriculture: Evaluations of options* (Occasional Paper No. 26). Guelph, Ontario, Canada: University of Guelph, Department of Geography.

Gasson, R. (1973). Goals and values of farmers. *Journal of Agricultural Economics, 24,* 521–542.

Gauthier, D. A., & Diaz, P. (2005). Rural adaptation and social cohesion for sustainable development of the prairies. *Prairie Forum*, *30*(2), iii.

Gauthier, D. A., & Weiss, S. (2005). Assessing performance: Indicators, social cohesion and community sustainability. *Prairie Forum*, *30*(2), 313–328.

Ilbery, B. (1985). *Agricultural geography: A social and economic analysis*. Oxford, England: Oxford University Press.

International Institute for Sustainable Development (IISD) and Manitoba Clean Environment Commission (MCEC). (2001). *Manitoba and climate change: A primer*. Winnipeg, Manitoba: Manitoba Clean Environment Commission.

International Panel on Climate Change. (1995). Climate change: A glossary by the Intergovernmental Panel on Climate Change (1995). Retrieved May 28, 2008, from http://www.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf

Jackson, W. (1999). *Methods: Doing social research* (2nd ed.). Scarborough, Ontario: Prentice Hall Allyn and Bacon.

Kandlikar, M., & Risbey, J. (2000). Agricultural impacts of climate change: If adaptation is the answer, what is the question? *Climatic Change*, *45*, 529–539.

Lemmen, D., & Warren, F. (Eds.). (2004). Climate change impacts and adaptation: A Canadian perspective. Ottawa, Ontario, Canada: Government of Canada Climate Change Impacts and Adaptation Program. Retrieved July 9, 2008, from *http://adaptation.nrcan.gc.ca/perspective_e.asp*

Manitoba Ministry of Agriculture, Food and Rural Initiatives. (2005). Agri-Maps. Retrieved July 14, 2008, from *http://geoapp2.gov.mb.ca/website/mafri/index3.html*

McGinn, S. M., Shepherd, A., & Alinremi, O. O. (2001). *Assessment of climate change and impacts on soil moisture and drought on the Prairies*. Lethbridge, Alberta, Canada: Agriculture and Agri-Food Canada, Lethbridge Research Centre.

Mooney, S., & Arthur, L. M. (1990). The impact of climate change on agriculture in Manitoba. *Canadian Journal of Agricultural Economics*, 685–694.

Nyirfa, W., & Harron, B. (2002). Assessment of climate change on the agricultural resources of the Canadian Prairies. Regina, Saskatchewan, Canada: Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration.

Ramsey, D., & Smit, B. (2002). Rural community well-being: Models and application to changes in the Ontario tobacco-belt. *Geoforum*, *33*(3), 367–384.

Reid, S., Smit, B., Caldwell, W., & Belliveau, S. (2007). Vulnerability and adaptation to climate risks in Ontario agriculture. *Mitigation and Adaptation Strategies for Global Change*, *12*, 609–637.

Senate of Canada. Parliament. Standing Committee on Agriculture and Forestry. *Climate Change Impacts and Adaptation in the Prairie Provinces: Hearing before the Standing Committee on Agriculture and Forestry*. 37th Parliament, 2nd sess., Feb. 4, 2003. Witness testimony: D. Sauchyn.

Sauchyn, D. (2007). Climate change impacts on agriculture in the Prairies. In E. Wall, B. Smit, & J. Wandel (Eds.), *Farming in a changing climate agricultural adaptation in Canada* (67–80). Vancouver, British Columbia, Canada: UBC Press.

Smit, B. (Ed.). (1993). *Adaptation to climatic variability and change: Report of the task force on climatic adaptation* (Occasional Paper No. 19). Guelph, Ontario, Canada: University of Guelph, Canadian Climate Program.

Smit, B., Blain, R., & Keddie, P. (1997). Corn hybrid selection and climatic variability: Gambling with nature? *The Canadian Geographer, 42,* 429-438.

Smit, B., Burton, I., Klein, R. & Street, R. (1999). The science of adaptation: A framework for assessment. *Mitigation and Adaptation Strategies for Global Change, 4,* 199–213.

Smit, B., & Skinner, M. (2002). Adaptation options in agriculture to climate change: A typology. *Mitigation and Adaptation Strategies for Global Change, 7,* 85–114.

Smithers, J., & Smit, B. (1997). Agricultural system response to environmental stress. In B. Ilbery, Q. Chiotti, & T. Rickard (Eds.), *Agricultural restructuring and sustainability: A geographical perspective* (pp. 167–183). New York: CAB International.

Spaling, H., & Smit, B. (1993). Cumulative environmental change: Conceptual frameworks, evaluation approaches, and institutional perspectives. *Environmental Management, 17,* 587–600.

Wall, E., & Marzall, K. (2006). Adaptive capacity for climate change in Canadian rural communities. *Local Environment, 11,* 373–397.