Living With Climate Change:
How Prairie Farmers Deal with Increasing Weather Variability

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Chapter 1: INTRODUCTION

1.1 Background

The effects of climate change have become a relevant and important issue of national concern in the past decade. While significant debate remains over the extent to which humans have induced climate change, it has generally been accepted that the effects of climate change are manifested in terms of increased weather variability, a higher frequency of extreme weather events and decreased predictability (Berkes and Jolly 2001; Smit et al. 2003; Venema 2005). This increased frequency of climate related shocks and stresses and difficulty in predicting growing conditions poses a significant threat to the livelihood of producers in the Canadian Prairie agroecosystem (IISD 1997). The success or failure of agriculture is intimately tied to weather conditions. It is the ability of producers to deal with climate-related shocks and stresses and adapt to change that is essential for their survival (Turner et al. 2003; Wall et al. 2004; Venema 2005).

Successful adaptations to climate change are accomplished through actions that reduce vulnerabilities and build resilience. Generally speaking, increasing options and diversifying activities are two of the main ways producers can increase resilience (Berkes & Jolly 2001; Turner et al. 2003; Walker et al. 2004). While this is not a new concept, its applicability to agricultural climate change adaptation has yet to be thoroughly explored. There already exists a wealth of knowledge on prairie agroecosystem resilience within the collective knowledge of producers. Producers may not describe their actions as building resilience however they have been adjusting their operations to changes in climate and advances in technology for generations. The nature of agriculture requires producers to be keen observers of change and have an intimate connection to their land. Building resilience into current agricultural operations may be a significant aid to producer's abilities to adapt to weather unpredictability associated with climate change.

1.2 Purpose and Objectives

The propose of this research was in part to meet the objectives of a larger collaborative effort including the International Institute for Sustainable Development (IISD), Agriculture and Agri-

Food Canada-Prairie Farm Rehabilitation Administration (AAFC-PFRA), and the University of Manitoba (U of M). The project was titled "Adaptation as Resilience Building: A policy study of climate change vulnerability and adaptation on the Canadian Prairies". It consisted of three phases including a vulnerability analysis, a resilience analysis and an adaptation priority analysis (Venema 2003).

This research helped fulfill the University of Manitoba's resilience analysis phase of the project, focusing on Saskatchewan and helping to build on the information gathered in Manitoba by Peter Myers. The specific objectives of this research were:

- To determine how producers responded to weather related shocks and stresses
- To determine commonalities between successful area farmers and to highlight their actions
- To Modify CRISTAL[1] as a research tool

1.3 Methods

Research Areas

Research was concentrated around a north and south study area. These research areas were determined through the use of a vulnerability map produced by the IISD and PFRA and split into a northern and a southern study area. The northern study area was centered around rural municipalities (RM's) of Pense #160 and Redburn #130. The southern study area was centred around the RM's of Benson #35 and Estevan #5. The research areas where chosen based on their past exposure to precipitation variability and their relative adaptive capacity as assessed using existing agriculture census data (Venema 2005). Both study areas were similar with respect to their past exposure, but differed in their relative adaptive capacity. The research performed in this thesis was blind to the differing adaptive capacity potential of the two areas.

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[1] Crystal is a tool developed by consortium of organizations including the International Institute for Sustainable Development for purposes of helping development assistance agencies to better understand the climate change adaptation needs of their projects (http://www.iisd.org/security/es/resilience/climate_phase2.asp)

Northern Study Area

Research began in the northern study area shortly before Christmas of 2006. The first research activity consisted of touring the district and speaking to local residents about the general characteristics of the region and topography.

The eastern edge of the RM's of Pense and Redburn begin approximately twenty kilometers west of the city limits of Regina (figure 1-2). This area of the province is considered to be ideal for the growth of cereal crops and is known provincially as the Southern grain belt. A general scan of the area revealed very little in the way of trees, natural wind barriers, wetlands or significant changes in elevation(Figure 1-1). Exploring the area further revealed that farming practices in the area are fairly uniform. The more southerly RM of Redburn is almost completely dominated with grains, oil seed and pulse crops production. There is the occasionally sheep and cattle operation however mixed farms in the area are rare. As one area producer put it "the soil conditions here are excellent for grain production, you don't have rocks or any real obstacles, using it as grazing land would be a waste" (RM of Redburn Resident, January 2007).

Figure 1-1- Example of terrain in the Northern Study area

The main service centre in the RM of Redburn is the town of Rouleau, Saskatchewan. Rouleau is known nationally to Canadians as the fictional town of Dog River in the popular television show Corner Gas. Like Dog River, Rouleau, Saskatchewan is representative of many small towns in the area. As of 2006, its population was 400 residents, a 0.9 decrease from the 2001 census (Statistics Canada, 2006). Rural depopulation and its close proximity to Regina (approximately 40 kilometers) have had an obvious effect on the community's economy. While the community still had a school, post office, bank, hardware store and gas station, it was apparent that the area is close enough to Regina that most of the area residents make the trip to the city for the majority of their larger purchases. As with many of the other existing communities in the RM, Rouleau's grain elevator has been decommissioned and is now used as a private grain storage facility for one area producer. Drinkwater, Briercreast, Hearne and Pittman are the other small communities in the RM of Redburn.

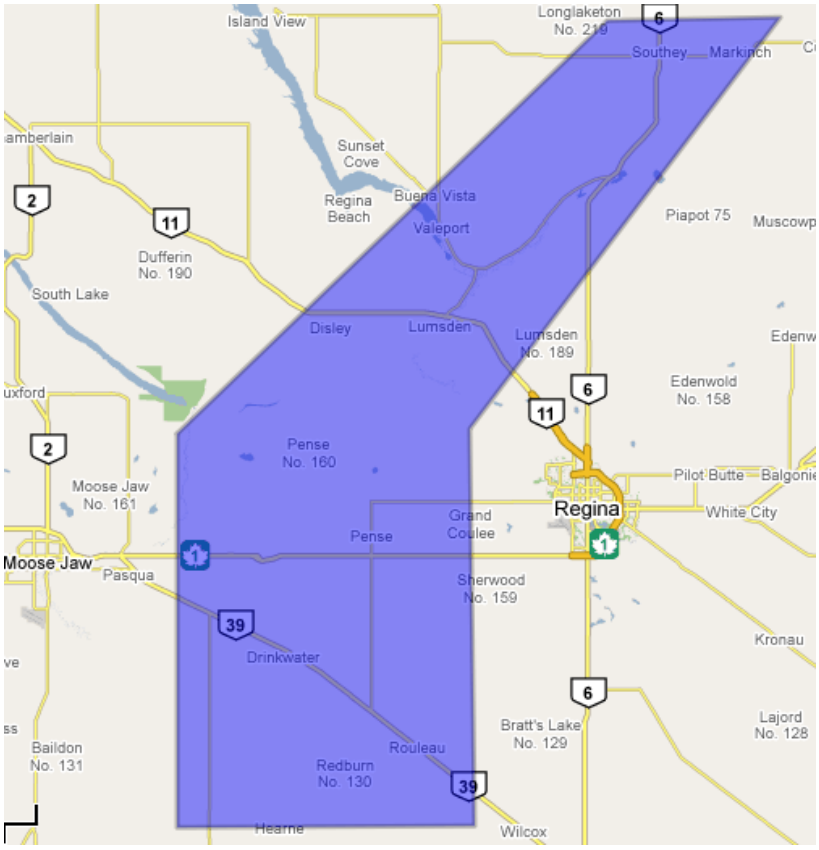

Figure 1-2. Approximate boundaries of Northern Study area

The RM of Pense is located directly north of the RM of Redburn and contains more variety in its terrain and farming practices. The southern half of the RM is nearly identical to that of Redburn consisting near exclusively of grain, oil seeds and pulse crop production. As one travels north into the RM, the terrain becomes more varied closer to the Qu'Appelle valley. This results in a higher degree of varied terrain and a larger presence of vegetation. As such this area had more mixed farming operations, the use of some irrigation and a larger livestock component.

Besides agriculture, there are numerous other economic activities in this RM. A major employer in the area is the Mosaic Potash mine located near Belle Plaine, north of the Trans Canada Highway. Directly adjacent to this large mine is the Canadian Salt company, Saskerco Products and the Terra Grain Fuels ethanol production facility which was under construction. Many employees of these companies live in the RM's main service community of Pense. Much like Rouleau, the close proximity of Pense to Regina has resulted in the departure of many services. Other communities in the RM include the village of Belle Plaine and the Hamlets of Keystone and Stony Beach.

Due to the participatory nature of the research being undertaken and limited number of active producers in the RM's, some further research was conducted outside of the two northern study area RM's. Several interviews ended up taking place in the RM's of Cupar #218 and Abernethy #186. Both located to the north east of Pense and Redburn. The farms in this location were similar but of a much smaller size making interview referrals much simpler. Terrain and farming practices were comparable and effect of being located near Regina could still be seen.

Southern Study Area

The southern study was centered around the RM's of Benson #35 and Estevan #5. Research began in these areas in February of 2007. Located approximately 170 kilometers south east of Regina, the geographic conditions of this area are quite different then those in the North. My initial sense of this area of Saskatchewan was that it is more much similar to that of western Manitoba. The terrain in this study area, as shown in figure 1-3, is much more varied with more vegetation, wetlands and topographic relief then that of the northern study area. This variation tends to increase slightly as you move further east towards the Manitoba border. This wider variety in vegetation makes the area much more conducive to smaller, mixed farming operations.

Figure 1-3. Typical Southern study area terrain

From the geographic and agricultural activity perspectives, there was not a large variation between the RM of Benson and that of the RM of Estevan, however a major difference could be seen in income levels between the two municipalities. The RM of Estevan is located in one of the most energy rich areas of the province. In fact the city of Estevan, is known as the "Energy City" with an approximate population of ten thousand inhabitants. In reality a large portion of the RM is an open pit coal mine used for Saskatchewan power generation. In addition to the large development of coal, oil and gas is also very prevalent in the region with pumps visible throughout the area.

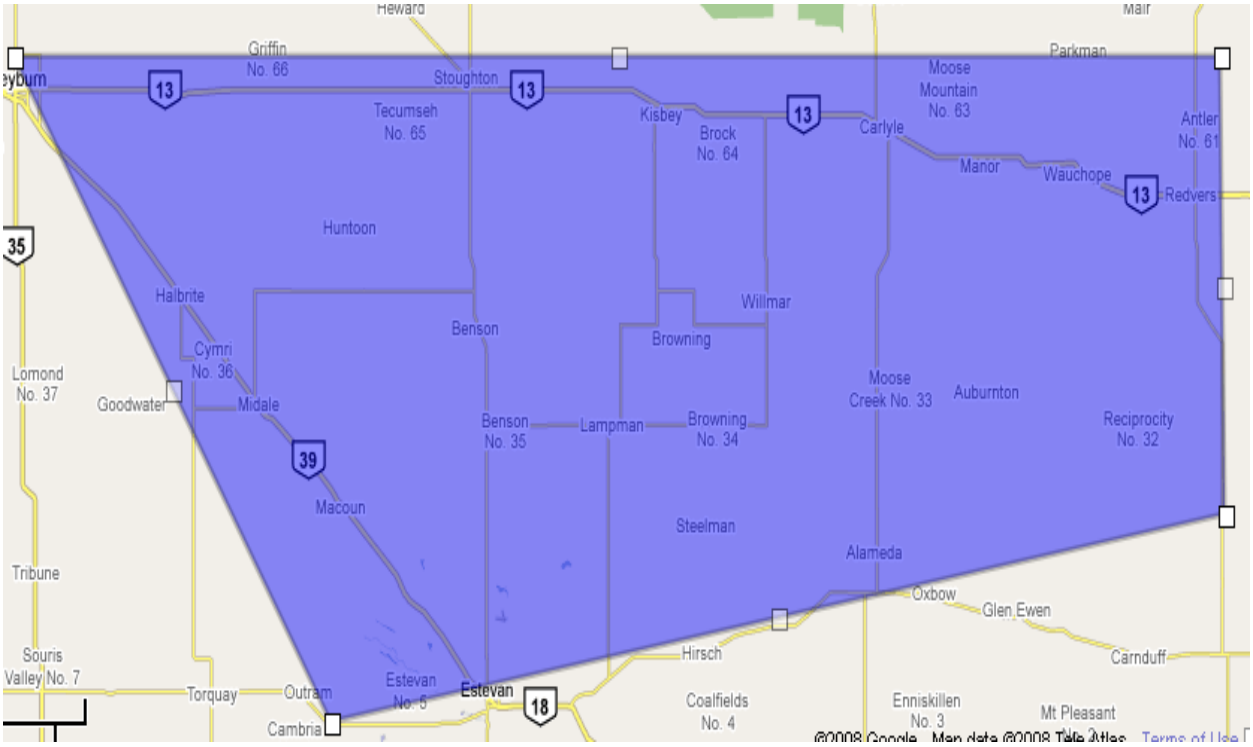

Figure 1-4. Southern Study Area

The RM of Benson, located directly to the north of Estevan, is much more agriculturally based. Oil and gas pumps are seen in this area and do provide income to the residents, however with the city of Estevan to the south and the town of Stoughton to the north, the RM's population is quite small. As with the Northern study area, due to the participatory natural of the research interviews were conducted outside the RM boundaries (Figure 1-4). Other RM's which were involved included the RM of Moose Mountain #63, the RM of Antler #61 and the RM of Weyburn #67. Farm size and type did not vary significantly between these RMs.

1.4 Recruitment of Interviewees

Recruitment of participants was one of the most challenging aspects of the research undertaken. Coming to the research areas, I had no prior knowledge of any of the inhabitants or organizations present. Beginning the interview process without a local "in" required a continual evolution of recruitment techniques. I began my research in the northern study area close to Regina. In speaking with local residents I learnt that many farms in this area were extremely large. This meant that although the landscape may have been dotted with farm yards, the majority of the land was owned or rented by a single individual. In order to learn more about the area and to

hopefully get some potential interviews, I began by contacting the local RM of Redburn municipal council. Because I had just missed the monthly council meeting, I proceeded to send each council member (7 members in total, the reeve and 6 district representatives) a letter containing information about myself and the research project. I had hoped that this would help avoid any confusion to my presence in the area as well as start a line of communication with a least one farmer in each RM district. The letters I sent out stated my research topic and asked for any help that could be provided. Of the seven letters I sent out, I received one response from an innovative and politically active council member located near the town of Rouleau.

In addition to sending letters, I also posted information sheets at public gathering points such as the post office, bank, RM offices and community centres. The main purpose of doing this was not so much to recruit as to get myself known in the community so that when I or a council member approached producers regarding the survey I wasn't a complete stranger.

Because of the relatively low response rate with letters, I began speaking directly with RM councils. I would call the council office and ask to be placed on the monthly council meeting agenda. On the day of the council meetings I would come prepared with a brief 10 to 15 minutes presentation outlining who I am, where I was from, what I was researching and asking for assistance from the RM. I was universally well received. Most council members were life long residents of the area and veteran producers. Generally most thought the research idea was an excellent topic and were happy to see someone conducting face to face interviews. Most RM's agreed to speak with area producers and hand out information packages at rate payers meetings. Despite this positive response however resultant interviews were small.

The challenge in obtaining interview subjects forced me to think of other recruitment techniques. For this I turned to the Internet. The first source of technology I employed was the brand new social networking tool at the time, Facebook. Facebook is a online program which connects friends and their respective social groups. Using this program I started a facebook group informing my group of friends of my research, what some of my difficulties were and asked for their help recruiting any family or friends that could help me. I was surprised by the effectiveness of this tool. Soon the group had well over a hundred members most of which I did not personally know but had been referred to by friends. The interviews that resulted from these

referrals were excellent and each interview usually resulted in at least a few more introductions. I believe this recruitment method was more successful because I was introduced to the interview subjects as a friend. I was vowed for as a student needing help with thesis research.. This helped reduced any skepticism about my research motives, my age or who I was working for.

Another recruitment tool from the Internet which proved extremely effective was an message board. Oddly enough it was a Canadian Football League on line forum that aided me the most in recruitment. I have been a lifelong Winnipeg Blue Bomber fan. As such I have been following and discussing the team on line with other fans since the Internet became widely available. The main rivals of the Winnipeg Blue Bombers have historically been the Saskatchewan Rough Riders. The rivalry can be quite heated at times but is generally very friendly. Because of this fact, I have been active on a Saskatchewan Rough Riders fan site for years. Partly out of frustration and chance, knowing full well that many members were producers or had family in agriculture, I decided to post my research topic on this on line discussion forum and asked if anyone could be of assistance. Much to my surprise within 15 minutes of asking for help a producer from the northern study area answered my request. We agreed to meet in Regina on a game day. We quickly became friends over our mutual love of football. The interview I conducted when well and he agreed to let me visit his farm to experience and view first hand much of what he had been talking about. In doing so I was introduced to several of his neighbors and it quickly became the most successful recruitment technique of the entire project.

The final recruitment process I employed was door to door solicitation. This process proved to be very time consuming and highly ineffective. Using RM land owner maps I would visit each individual farm site. If someone was home I would introduce myself and try to set up a meeting time. If not one was home I would leave a notice of visit, stating who I am, my research topic and my contact information. I produced three notice of visit letters for each consecutive visit (after three visits and no contact I would assume they were not interest or not present). The main difficulty in this method was that although landowner maps would show a diverse amount of land owners, an extremely large proportion of these land owners rent their land to a relatively small amount of people farming it. As a result of this 10-20 farms could be visited before finding a person actively farming the land and in many cases that person could be away for a

extended period of time or in fact living in Regina making their contact information difficult to obtain

1.5 Challenges and Limitations

I discovered through the research process several difficulties and challenges inherent with agricultural and student research. One of the first difficulties I encountered was over saturation of interviews. After conducting my first group of interviews it became clear that Saskatchewan producers are solicited for interviews very frequently, in some cases it can be a weekly experience. Government, insurance companies and agribusiness all actively contact producers for information. Unfortunately the majority of these surveys are conducted over the phone, many from out sourced over seas services, and require yes/no and a,b,c,d, type responses. The lack of ability to express opinions, the detached feeling of the surveys and simply the frequency with which they are asked to complete them made recruitment for my research extremely difficult. Asking over survived people to sit down and speak with me for 30 minutes was a definite challenge. Adding to the difficulty was that I was from an out of Province University, my youth and the lack of perceived credentials (i.e. not a government official). Two common reasons to decline an interview were that they would like to speak to me but didn't think that their responses would result in any change or be heard by the right people so they could not afford the time or conversely the exact opposite, saying that they did not wish their responses to be view or used by the government or agribusiness. Because their information could be used by PFRA and IISD several potential interview subjects declined.

Another difficulty was the agricultural political climate at the time. The 2007 agricultural season had a fair share of controversy in Saskatchewan. The two main issues at the time were the Canadian Wheat Board Barley Plebiscite and the potential purchase of Agricore United by the Saskatchewan Wheat Pool. Of these two issues, the Canadian Wheat Board Plebiscite was particularly sensitive. In addition to having to compete with other surveys taking place over these issues, the Wheat Board topic would often come up in conversation with interviewees. Opinions on the issue varied significantly between area residents. Some producers were very open with their opinions whereas others were quite secretive. The division in opinions made it difficult at times to utilize the snowball method of obtaining new interview subjects. When asked, a high percentage of respondents would either provide some names but wish to remain

anonymous or they would refuse to refer friends and neighbours either to spare them the trouble or because they did not want there to be any potential for their opinions to be known.

1.6 CRISTAL

CRISTAL (**C**ommunity-based **Ri**sk **S**creening **T**ool-**A**daptation & **L**ivelihoods) is a computer-based program developed by the IISD, IUCN, SEI-B and Intercooperation that was modified and used to facilitate the research preformed. It is a tool that was developed to offer local communities, project planners and managers a way of doing interactive climate risk management for planned or ongoing projects (IISD et al. 2005). CRISTAL's objective is to answer four major questions;

1. How past climate hazards have impacted the research area
2. Which resources and strategies are used for coping with these climate impacts
3. How specific projects and policies affected the availability and access to resources essential to livelihoods and coping strategies ; and
4. How to adjust the projects/programs to enhance the availability and access to these resources(IISD et al. 2005)

For use in this research, CRISTAL began by collecting basic information (Figure 1-5). The names of the interviewees were collected as a number, location was recorded as either the northern or southern study area, the implementing agency was recorded as IISD/NRI and the brief description in the project box was used to record farm size, type, farming experience and whether any significant changes to the on-farm operations had occurred in the past 5 years.

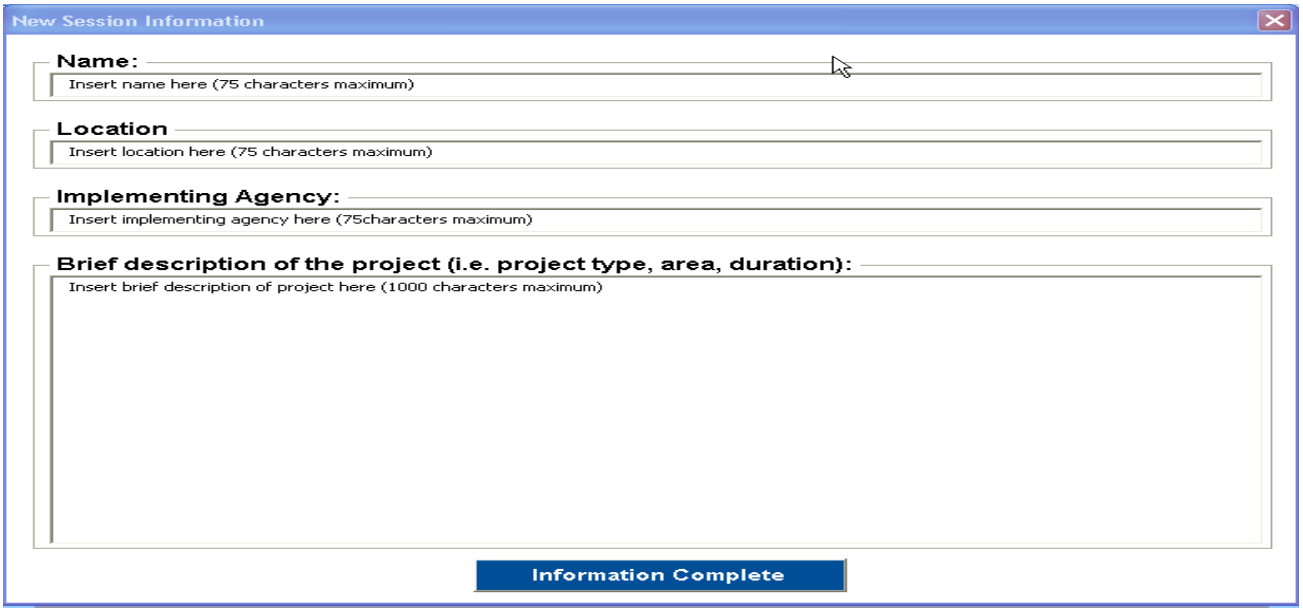

Figure 1-5. New Session Information stage of CRISTAL

Following the input of basic information, the climatic context of the interviewee was defined. This began by first entering where the project/interviewee was taking place or located (figure 1-6).

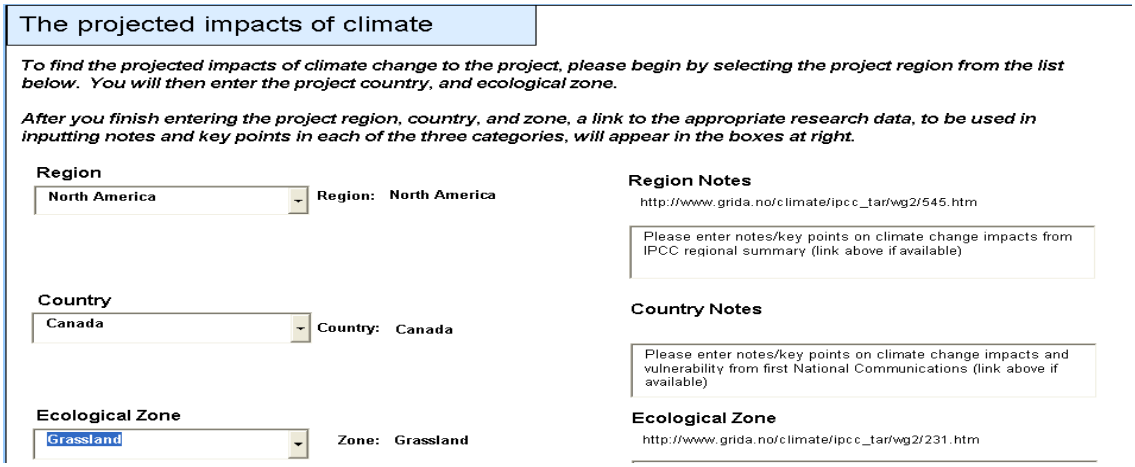

Figure 1-6. Defining the climatic context

From this point, more detailed and specific information was gathered regarding the climate context. A producer would begin by listing what weather events had impacted his operation, what were the subsequent impacts of these weather events and what coping strategies were used to minimize these impacts (Figure 1-7).

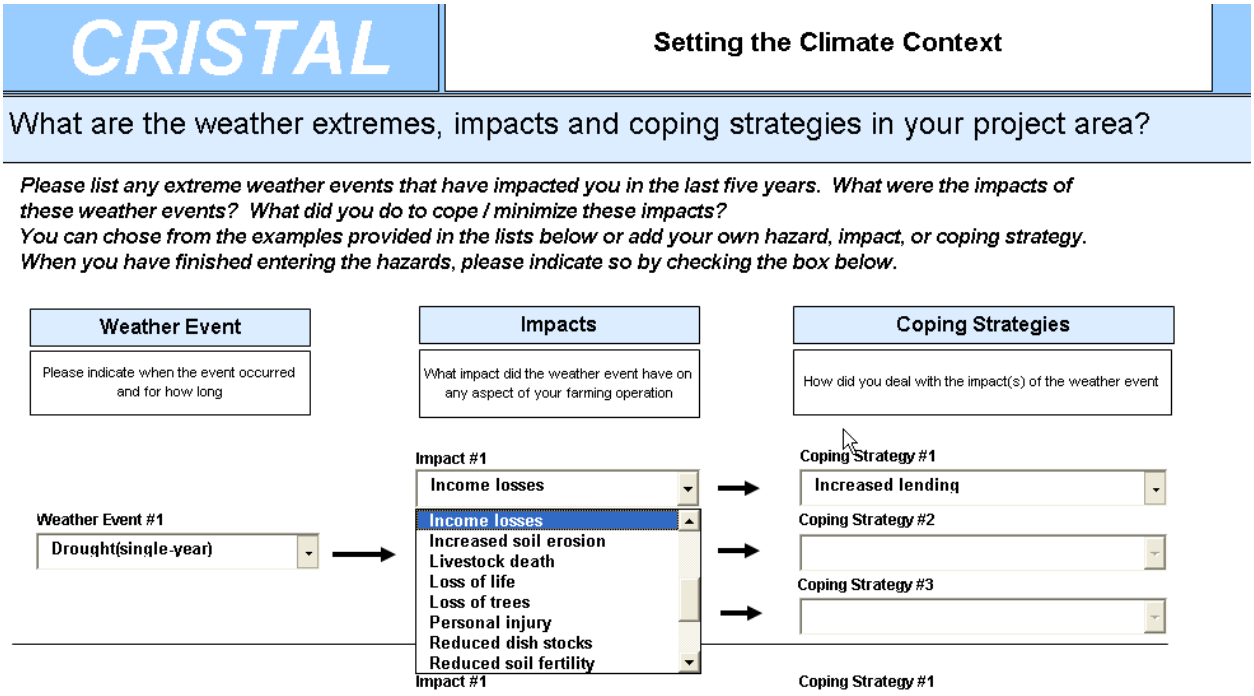

Figure 1-7. Recording weather events, their impacts and coping strategies used.

CRISTAL featured the option of typing a specific response or allowing the interviewee to select from a drop down list of responses. A limitation can be seen in figure 1-7 which shows that only 3 impacts and 3 coping strategies could be selected by the respondent.

At this point CRISTAL looked at the livelihood context of the interviewee. Figure 1-8 shows how this information was collected. Up to three important resources could be chosen from the categories of natural resources, infrastructure, financial resources, human resources and social/community resources. From this stage the impact of the previously mentioned weather

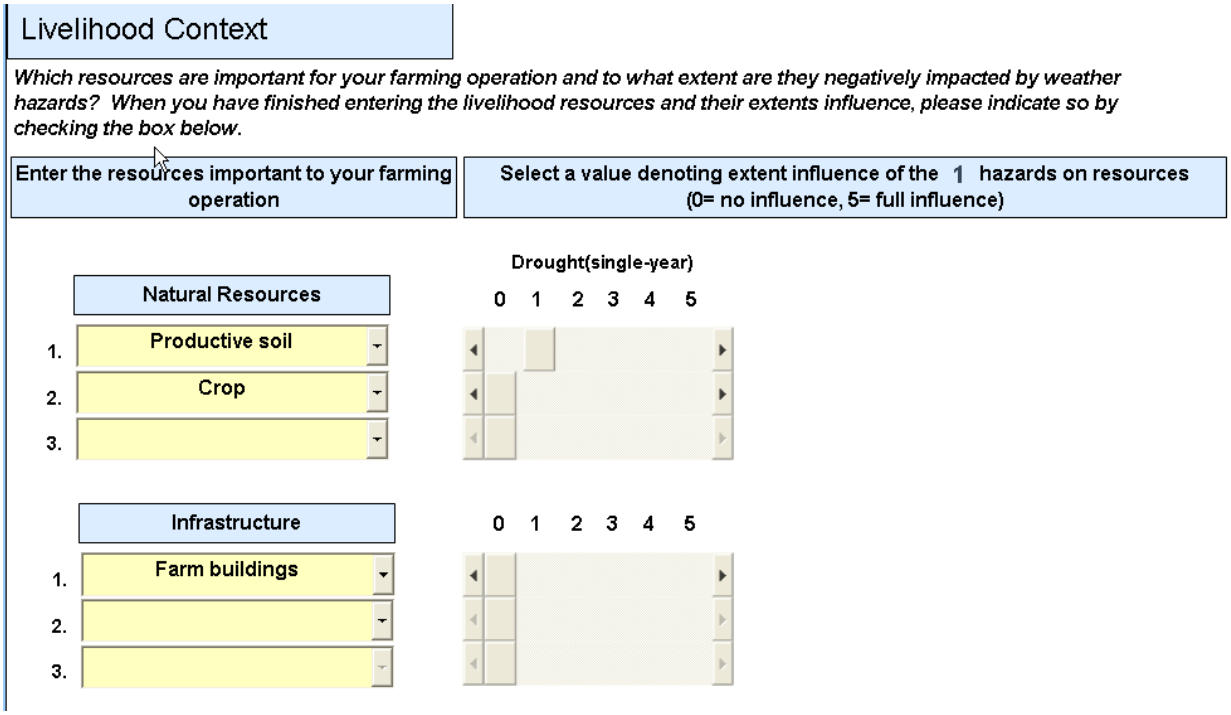

Figure 1-8. Determining the impact of the weather events on important livelihood resources

events were ranked from 0 (no negative influence) to 5 (large influence) on each of the previously chosen important resources.

After ranking the effect of the various weather events on important livelihood resources, the importance of these resources was then related to the coping strategies earlier mentioned for each weather event. Figure 1-9 shows how this was again accomplished using the 0-5 ranking system. For example, as shown in figure 1-9, during a single year drought, a producer used the coping strategy of increased lending to minimize the impact of income loss. A producer may not view any of his important natural resources as very important to receiving increased lending, whereas they may rank several important financial resources higher indicating their importance in this type of situation.

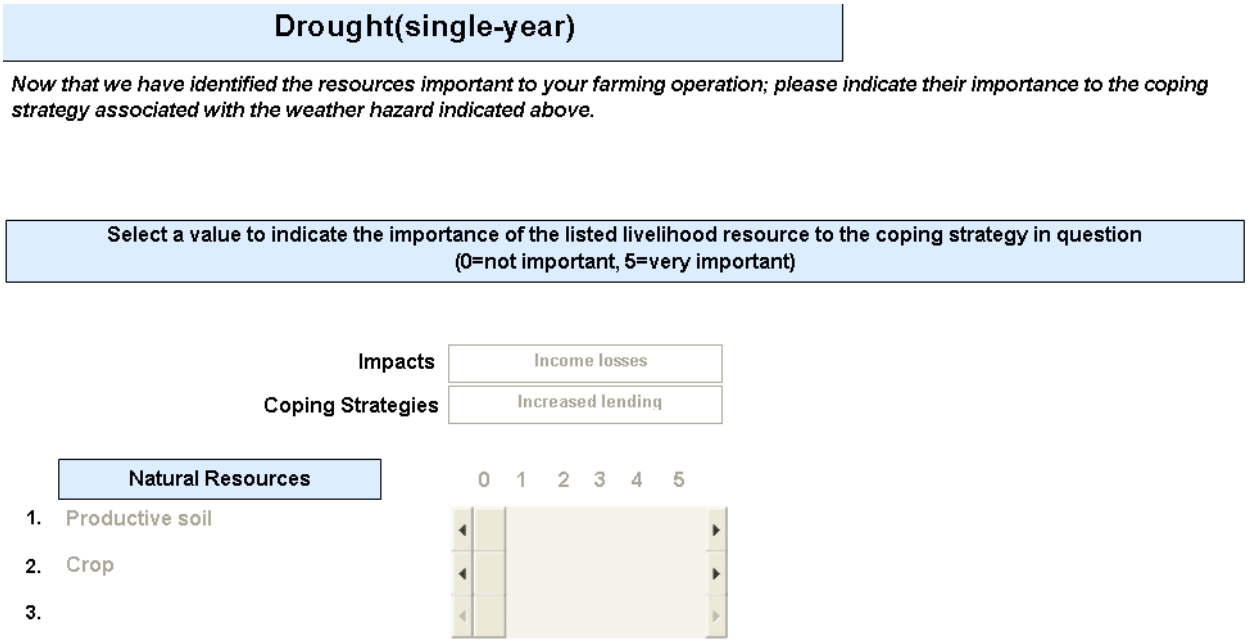

Figure 1-9 . Ranking the importance of resources to coping strategies.

CRISTAL then used the results from the rankings of the effects of weather events on resources important to coping and the rankings of the importance of these resources to coping strategies to determine the success or failure of programs. Figure 1-10 demonstrates how programs used by producers affect the resources flagged as being most negatively affected by the weather events (viewed as having an impact ranking of 4 or 5). The programmes are recorded as having a positive, neutral (no effect), negative or no applicable effect on the resources. Also included is the impact of the program on the resources most important to coping (impact rating of 4 or 5).

Screening Policies and Programs

You will now begin to assess the impacts of the different policies and programs on
(a) the livelihood resources that have been identified as being most negatively affected by the hazards and
(b) the livelihood resources that have been identified as being important to coping strategies.

Please enter the policy or program in the yellow spaces provided (at left) and indicate whether the impact of the activity is positive, negative, neutral, unknown or non-applicable (click on each for definitions) using an "X" in the appropriate box. Please select only one box for each resource.

Activities	Impact of activity on resources most negatively affected by hazards						Impact of activity on resources most important to coping					
Policy / Prgram 1	Resources	Pos	Neg	Neu	Unk	NA	Resources	Pos	Neg	Neu	Unk	NA
Crop insurance		X										
Policy / Prgram 2		Pos	Neg	Neu	Unk	NA		Pos	Neg	Neu	Unk	NA

Figure 1-10, the effect of programs on resources most negatively affected by weather events and resources most important to coping.

Figure 1-11 now shows the next step in which CRISTAL flags all programs and resources which received either a positive or negative rating and allows for an explanation of why this was positive or negative and how it could be improved.

CRISTAL — Adaptation Management Planning

Adaptation Management Planning

Agricultural policies / programs that were flagged as having a positive or negative effect on key livelihood resources have been identified.

Please enter why the policy or program had a positive or negative impact and any suggestions on how they could be improved.

Policy / Program	Flagged Resources by Weather Hazard	Impact of Policy/Program on Resource		Why positive/negative? Improvement suggestions
Activity 1		Positive	Negative	
Crop insurance	Productive soil	X		

Figure 1-11. Why programs flagged to have a positive or negative effect on resource and how they could be improved.

For the purposes of this research CRISTAL had to be modified from a program for project managers into a research tool. The changes however did not modify the organization of the program as seen in figure 1-12.

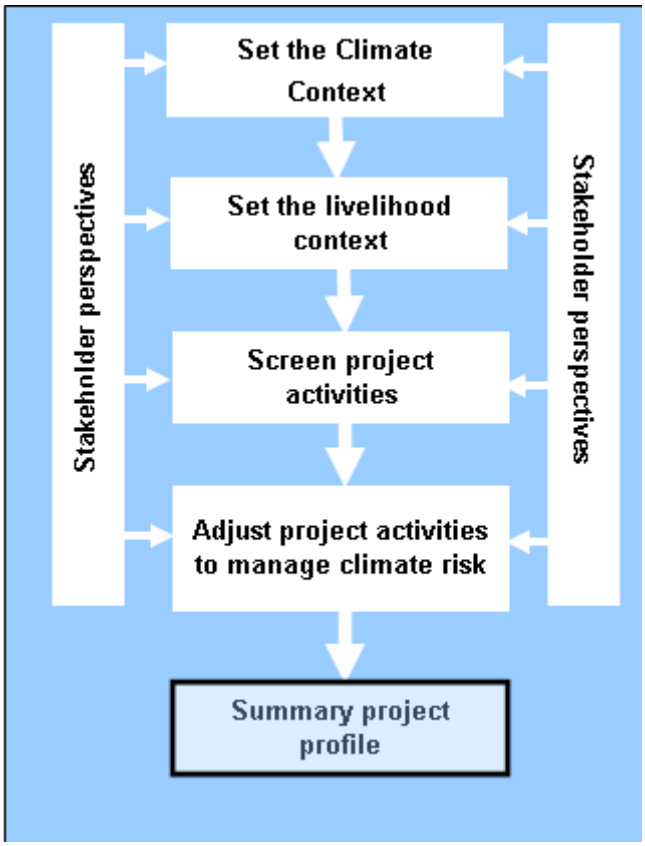

Figure 1-12. Organization of CRISTAL

A detailed list of changes made to the program can be found in Appendix E as well as the definition of terms used by the program in Appendix F.

Chapter 2: LITERATURE REVIEW

2.1 Resilience, Adaptation and Vulnerability in Agroecosystems

Resilience is a term and concept first developed by ecologists to describe the characteristics of ecosystems that maintain themselves during a disturbance produced by various forces. This notion has since been used in the realm of social science to describe social resilience as "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change" (Adger 2000). Although ecological and social resilience are often separately defined, they are inextricably linked by human dependency on ecosystem services (Berkes et al. 2003). As a result of this link, Walker et al. (2004) consider social-ecological resilience holistically as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedback." This recognizes that while social institutions are subject to external pressure and shocks from both political and economic change; their ability to absorb these disturbances depends both on social capital and the characteristics of the resource system (Adger 2000).

Walker et al. (2004) identify four critical aspects of resilience. They include:

- Latitude- the maximum amount the system can be changed before losing its ability to recover
- Resistance- the ease or difficulty of changing the system
- Precariousness- the current trajectory of the system, and how close it currently is to a limit or "threshold" which, if breached, makes recovery difficult or impossible
- Panarchy- how the above three attributes are influenced by the states and dynamics of the (sub)systems at scales above and below the scale of interest

The degree to which each of these four aspects are present determines the overall resilience of the system.

Closely connected to the notion of resilience is that of adaptability. Essentially adaptability is the capacity of the actors in a system to influence resilience (Walker et al 2004). In a social ecological system, adaptability is greatly influenced by the natural setting of the system but more

directly it is a function of the social component. It is the actions of individuals or groups which either intentionally or unintentionally influence resilience. Walker et al. (2004) note that "it is the collective capacity to manage resilience intentionally which determines whether the system can successfully avoid crossing into an undesirable system regime, or succeed in crossing back into a desirable one." Walker et al. (2004), in corresponding with their four critical aspects of resilience, point out that actors can move thresholds away from or closer to the current state of the system by:

- Altering the threshold- actors can move thresholds away from or closer to the current state of the system
- Altering resistance- making the threshold more difficult or easier to reach
- Altering precariousness- moving the current state of the system away from or closer to the threshold
- Altering panarchy- managing cross-scale interactions to avoid or generate loss of resilience at the largest and most socially catastrophic scales

Vulnerability is often referred to as a loose antonym of resilience (Adger 2000), or rather, "the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard, either a perturbation or stress/stressor " (Turner et al. 2003). It presents itself in two ways: through exposure to a shock or stress and in the resilience of the system experiencing the disturbance (Turner et al. 2003). While vulnerability may be considered an antonym of resilience, Berkes (2006) demonstrates that resilience thinking relates to vulnerability in three key ways:

- provision of an integrated, holistic approach for assessment of shocks and stresses
- placing emphasis on learning from shocks or stresses, and incorporating the lessons through feedback mechanisms; and
- adopting methods to deal with future uncertainty associated with unknowable shocks and stresses, thereby increasing resilience

2.2 Adaptation to climate change and variability

Most agricultural activities are inherently sensitive to weather variability and this may result in the agricultural industry being extremely vulnerable to climate change. Adaptation to climate change is not only essential to maintain agricultural production and for agricultural economies

and communities to remain in existance; but also to reduce vulnerability for future generations (Government of Canada 2004). The vulnerability of the Prairie agroecosystem to climate change and weather variability is greatly influenced by its adaptive capacity and it is because of this reason that recent climate change research has been increasingly directed towards the issue of adaptation (Bradshaw et al. 2004).

Adaptations to climate change and weather variability are extremely varied. Bradshaw et al. (2004) and Smit and Skinner (2002) identify several attributes which can be used to characterize adaptation measures. They include:

- Intent and Purposefulness- differentiates between adaptations that are undertaken spontaneously, or autonomously as regular on-farm management
- Timing and Purposefulness- differentiates between responses that are anticipatory, concurrent or responsive
- Scale and Responsibility- distinguishes the scale at which adaptations occur and the agent responsible for the development and employment
- Form- the process, form and scale used by the producer for adaptation

These adaptation measures may occur at varying scales. For example, adaptation may occur at the organizational level through technological advances such as crop development, machinery improvements and weather forecasting (Smithers and Blay-Palmer 2001). Adaptation also occurs at the farm level through tactical and strategic adaptations. Tactical adaptation would include practices such as changing planting times, input uses and harvesting to accommodate weather variability. Strategic farm-level adaptation would take the form of alteration of soil management practices, selection of crop varieties, purchasing crop insurance, or diversifying their farming operation (Bradshaw et al. 2004).

Smit and Skinner (2002) group agricultural adaptation options into four non-mutually exclusive categories. The first is technological developments. Technological research and development is one of the most frequently advocated strategies for adaptation to climate change (Smithers and Blay-Palmer 2001, Bryant et al. 2000). While this statement is true, Smithers and Blay-Palmer (2001) indicate that although this is the perception, research and development have received little explicit consideration in the context of climatic constraints on food production and complete faith in technological developments for climate change adaptations would be unwise.

The second category as identified by Smit and Skinner (2002) is government programs and insurance. These programs have the power to greatly influence farm-level production and management strategies as well as technological and research developments (Smit et al. 2000). Government income stabilization and disaster relief have the potential to stabilize farming incomes during times of weather variability associated with climate change (Smit and Skinner 2002) however programs such as crop insurance have been found by Smithers (1998) to decrease producers adaptive measures such as diversification and off-farm income.

Farm production practices are the third category. This involves changes in the actual operation of the farm. As mentioned above, this may be highly influenced by government programs. This category ultimately describes farm-level decisions with respect to farm production such as land use, irrigation and operational timings (Smit and Skinner 2002).

The final category is farm financial management. This again is highly influenced by government agricultural support. It is a farm-level response using farm income strategies to reduce the risk of climate-related income loss (Smit and Skinner 2002).

Few researchers have addressed adaptation in analyzing the decision making process at the farm-level. What has been identified by an interim report produced by the Canadian Senate (2003) is that:

- Adaptation in agriculture is driven more by the vulnerabilities associated with extremes
- Adapting in a reactive way could be costly
- Adaptation strategies are specific to locations and settings
- Adaptation to climate change is one component of risk management strategies for producers

2.3 Prairie agroecosystem regional studies

The Prairie agroecosystem is located in the physiographic region known as the Western Interior Basin and is well known for its combination of rich soils and favourable agro-climatic conditions

(IISD 1997). This combination has resulted in a significant amount of Canada's agricultural production coming from this region. The Prairie agroecosystem is however very vulnerable to drought. The region historically has seen devastating periods of drought in the 1930's and 1988 (IISD 1997). Climate change is predicted to bring increased periods of drought along with a greater degree of weather variability. Shindler and Donahue (2006) predict that "near future climate warming, via its effects on glaciers, snow-packs, and evaporation, will combine with cyclic drought and rapidly increasing human activity in the Western Prairie Provinces to cause a crisis in water quantity and quality with far-reaching implications." This prediction of an impending water crisis is supported by Agriculture and Agri-food Canada's 2005 synthesis report on the 2001-2002 droughts. Their analysis revealed three findings. The first was that major droughts were relatively rare in the 20th century and that more severe, decade-long droughts have historically occurred on a more frequent basis and may possibly do so in the future. Second, the increase in demand for good quality water will increase water system stress in drought periods and finally, most global climate models are predicting increased temperature and evaporation with less precipitation in the Prairie agroecosystem (Agriculture and Agri-Food Canada 2005). The 2001-2002 drought analysis also showed some adaptation trends. Preventative adaptation measures such as farm management practices to reduce wind erosion were found to be a success. Reactive adaptation measures were found to be less effective and more costly. The resulting conclusion was that earlier recognition may have enhanced the Prairie agroecosystem's adaptation capacities (Agriculture and Agri-Food Canada 2005).

Land managers, watershed managers, and policy makers have seldom, if ever considered the cumulative effects of climate change, drought and human activity as well (Schindler and Donahue 2006). Venema (2005) supported this claim in his review of ag-water policies in Prairie Canada. He finds that:

- Very few watershed plans have actually been completed within the Prairie provinces; even fewer have been implemented
- No formal learning mechanism exist to coordinate watershed-planning techniques among the provinces, nor does any coordination mechanism exist for interprovincial watershed planning

In addition Venema (2005) indicates there is no consensus and no clear direction on:

- The role/type of decision support tools and the degree to which the watershed planning process will be transparent and participatory
- How technical capacity requirement for local watershed planning will be met
- The use of economic instruments to finance watershed planning and management

These concerns of drought in the prairies were also brought forth by Wall et al. (2004). They do however note that some agricultural opportunities may also come forth. "Extended droughts and increases in temperature appear to be the conditions causing the most concern while longer growing seasons offer potential increases in yield and diversity of crops grown". In adapting to climate change manifested through weather variability Wall et al. (2004) go further to suggest some specific Canadian based suggestions. First they recognize that producers adapt to climate change in conjunction with other business risk management strategies, therefore a "whole-farm" approach should be used for understanding farm-level adaptation. Keeping this in mind, Wall et al. (2004) suggest that agricultural adaptation policy would be more effective if it is integrated into existing programs. They also note that there is currently a knowledge gap in climate change adaptation research. To date most climate change research has taken a top-down approach, focusing on greenhouse gas emission reduction instead of acknowledging the need for understanding adaptation to altering conditions. This top-down approach is removed from agriculture in that the producer's lived experiences are not considered. Using knowledge from producers with the vulnerability approach finds what is known among the agricultural community; it incorporates producer based experience and knowledge and builds on existing capacity (Wall et al. 2004). Examples of this type of research is available. Wall and Smit (2005), in a review of agriculture climate change research, found that producers (in general, not specifically the Prairies) respond in some innovative ways to climate change (Table 1). Their finding further demonstrated that "adaptations to climate change are not just discrete technical measures, but are modifications to farm practices with respect to multiple (climatic and non-climatic) stimuli and conditions" (Wall & Smit 2005).

In light of the specific research preformed in regards to agriculture and climate change. Wall et al. (2004) identify a large gap in adaptation research. As this areas of research is viewed by

many to be one of the most effective in practically dealing with weather variability attributed by climate change, they make several recommendations to address this gap. They include:

- Enhancing the knowledge of producers experiences with climate and weather risks and how these affect adaptation choices
- Incorporating knowledge of farm production practices and management so that linkages to existing (and future) programs and policies can be identified and acted on
- Ensuring that climate scenarios and related models include agro-climatic conditions identified as relevant by the agri-food sector
- Encouraging climate change related research projects to incorporate whole farm perspectives

TABLE 1. Summary of how producers use sustainable agriculture practices to manage climate

and weather risks (Wall & Smit, 2005)

Diversify Crops
• More perennial crops (eg., forges) are grown, thus improving drought tolerance by enhancing soil quality and moisture retention.
• Where possible, some producers are re-introducing native grasses for pasturing. These grasses are drought resistant when rotational grazing is practiced on them.
• Many Prairie producers are moving away from solid wheat production and growing a wide variety of new crops (e.g., pulses) that are more drought resistant.
• A diversity of crop types and varieties are grown in rotation and in different areas of farm properties. This spreads the risk of losing an entire year's production since conditions can vary across fairly small areas and different crops vary in how they respond to those conditions.
• When possible, some producers also stagger their seeding and therefore, harvesting dates by choosing a variety of crops that require a range of growing conditions so that crops are at a different stages (and therefore more or less vulnerable) if and when climate/weather conditions start having a negative impact.
Diversify Enterprises Within One Farming Operation
• Many producers are including more livestock in their operations to make use of increased forage production and to add value on the farm.
Land Resource Management
• Conservation tillage practices were cited by all producers as having several positive outcomes for reducing risks from drought. These include: reducing soil erosion; enhancing moisture retention; and minimizing soil impaction.
• Conservation tillage is also credited with limiting damage from run off and wash outs during flooding.
• Some producers are enhancing established shelterbelts and/or adding new ones. This can reduce negative impacts from drought by maintaining water tables, increasing biomass in soil, and ensuring surface moisture is kept on the land. Shelterbelts also provide protection from heat and wind for livestock, and can increase the heat units in adjacent fields.
• Some producers cut stubble at different heights to trap snow on field surfaces thereby enhancing spring moisture levels in the soil.
Water Resource Management
• The increase in drought conditions is leading to more interest in irrigation. Some producers are adopting newer, more efficient systems and timing for applications to avoid waste.
• Sloughs and ponds are managed to ensure water is captured and protected as much as possible.
Livestock Management
• Some producers who were affected by drought arranged to move some cattle out for winter feeding.
• In some cases, intensive grazing leads to doubling the number of cattle on same acreage, increasing economic returns.

2.4 Best Practices of Leading Farmers

The best practices of leading farmers was an initiative undertaken by the Saskatchewan Agrivision Corporation with the hypothesis that solutions to the problems that farmers already face can be found amongst the actions of successful or leading farmers (Best practices of Leading farmers 2004). 153 leading farmers were interviewed in Manitoba, Saskatchewan, Alberta and British Columbia. The results found commonalities between respondents. They include:

- They are all family-based operations which tend to have full time staff
- Most are corporate farms with the family members as shareholders
- Many are larger in size often including high-value operations
- Most still produce some traditional grains and livestock but also market directly to consumers

The best practice group found that collectively as a region, Western Canada has had a history of reacting defensively to change. The results of this reaction is heavy use of government aid programs, loss of rural population from frustration and disappointment and a stagnate rural economy. Conversely the producers who are responsive to change have found success and new opportunities in agriculture by understanding what the market needs and having the willingness to change their operation to meet demands (Best practices of Leading farmers 2004).

Chapter 3- RESULTS

3.1 Weather Events

Both the northern and southern study areas were affected by several extreme weather events in the past ten years (Table 2). Interviewees were asked to list the weather events in recent history which came to mind and then rank the negative effect it had on their farming operation. Rankings were on a zero to five scale. Zero having no effect to five having a major effect. Only weather events with a ranking of four or five are included in the results.

Table 2. Frequency of weather events identified by respondents as having a major effect on their farming operation. (Northern Study Ares n=23 Southern Study Area n=15)

Weather Events	
Northern Study Area	Percentage of Respondents
Early Frost	87%
Drought	74%
Flood/Excessive Moisture 1999-2004	61%
Hailstorm	57%
Extreme heat 2007	39%
Wet Harvest	13%
Windstorms	17%
Early Snow 2004	9%
Southern Study Area	Percentage of Respondents
Early Frost	74%
Flood/Excessive Moisture 1999-2004	47%
Hailstorm	33%
High Humidity	33%
Extreme heat 2007	27%
Late spring snowfall	20%
Wet Harvest	13%
Drought	13%
Windstorms	7%

3.2 Weather Events in Northern Study Area

The northern study area was affected by several weather stresses over the past five years. The most significant being early frost, drought, flooding/excessive moisture and hailstorms. These four events affected over 50 per cent of respondents and have reoccurred in the area on varying levels over the 5 year time period. The possibility of early frost has always been a major concern

in the area. An early frost has the potential to severely downgrade or completely decimate a year's production, reducing opportunity for profitability and increasing difficulties in harvesting and grain marketing. In the northern study area, early frost was the most significant weather event identified by respondents with 87% identifying it as affecting their farming operation. 2004 was identified as a particularly bad year for frost by most respondents. Although frost is a commonly reoccurring weather event, the frost in 2004 struck very early at harvest time and affected nearly everyone in the region. The affects of this event varied but for some in the area it resulted in total losses.

Drought is a continuous concern in the northern study area with 74% of respondents viewing it as having affected their operation. Fortunately the area surrounding Regina has a soil type known as 'Regina Heavy Clay'. The high clay content in the soil does permit good moisture retention for single year drought occurrences but does remain vulnerable to multi year droughts. Opposing the concern of drought is local flooding. Respondents varied dependent on location and soil type. This weather event presented itself more as a farm specific event highly dependent on the topography. Flooding and excessive moisture mainly occurred as spring flooding events or persistent moisture in low lying field areas. At the regional scale, spring road washouts were a concern exacerbated by the flat terrain and high clay content of the soil. While flooding has always been a concern, more concern exists today for the possibility of flash flooding. Several interviewed producers addressed this concern citing an observation of less steady gentle rains in the area with the higher frequency of thunderstorms and heavy rains releasing several inches at once.

Related to the higher frequency of storms in the region is the 57 per cent of respondents who identified their farms as being affected by hail. Because of the highly localized nature of hail, damages in the area varied and occurred yearly. 2005 was identified by several respondents as being a particularity poor year because of hail in which crop damages/losses ranged up to 50% in some of the affected areas.

3.3 Weather Events in Southern Study Area

The southern study area had a smaller degree of weather stress events when compared to the north. According to several producers in the area "the past five years have actually been fairly good weather wise" (Estevan Area Producer, April 2007), however many producers were still adversely affected. As it was in the north, early frost was the number one weather event indicated in the southern study area with 73 per cent of interviewees indicating it as affecting their operation. Contrary to the north however, the southern research area ranked flooding and excess moisture as the second most frequent weather event. This can somewhat be tied to 33% of respondents in the area reporting higher levels of summer humidity. This region does have much more water present than in the north. The availability of water in the southern study area dramatically reduced the effects of drought when compared to the northern study area. It should be noted however that with farms being more mixed in this region, the effects of a single weather event can be perceived as being less drastic. For example while a hailstorm might drastically reduce the harvest and income of a strictly cereal and pulse crop operation, a more diversified operation with a secondary revenue source such as livestock may not perceive a similar event as being as extreme.

3.4 Weather Impacts

The northern and southern study areas experienced somewhat similar impacts associated with the weather events (Table 3). The weather impacts shown in the results are once again seen as having a significant effect on the producer's operation (4-5 ranking in CRISTAL). Crop damage/loss was the number one impact in both the northern and southern study areas. This response was popular because it covered all levels of effects and ranged from total crop loss to minor damages. More specific responses and secondary effects to the crop damage/loss ranked lower and many are only associated with specific weather events.

Lower yields are another commonality between the northern and southern study areas and can be associated to weather events which struck during crucial growth periods reducing grain quality and bushels per acre. Frost and unusual temperatures (high or low) was a major causational factor in reducing yields. It is the combination of all impacts that result in income loss for both

areas. Percentage of respondents who cited income loss was surprisingly low considering the losses some producers have taken however it should be remembered that the questions focused on the weather events and impacts rather then financial questions.

Table 3. Reported significant weather impacts (4-5 ranking in CRISTAL). Northern study area n=23 southern study area n=15.

Weather Impacts	
Northern Study Area	Percentage of Respondents
Crop damage/loss	87%
Lower yields	39%
Reduced seeding area	39%
Equipment damage	22%
Income loss	17%
Harvest difficulties	17%
Increased Pest activity	17%
Delayed Seeding	17%
Farm Building Damage	13%
Slow crop growth	9%
Added field operations	9%
Reduced Crop residue	4%
Southern Study Area	Percentage of Respondents
Crop damage/loss	67%
Lower yields	33%
Income loss	33%
Disease	33%
Rapid Crop Growth	27%
Harvest difficulties	20%
Added field operations	13%
Reduced seeding area	13%

The differences between the north and south study weather events are reflected in the resulting impacts. The higher incidences of drought in the north are reflected in several of the specific impacts. Increased pest activity, slow crop growth and reduced crop residue are all results of the presence of drought in the area. Contrary in the south, flooding and high humidity is shown in increased disease, rapid crop growth and reduced seeding area. Other common impacts such as harvest difficulties and added field operations encompass a wide range weather events requiring an increased work load on the land or difficulties in accessing it. A major difference in impacts between the two study areas is in the area of income. While both indicated loss of income as a

major impact, it is much less prevalent in the northern study area. One reason for this difference may be attributed to farm size which is larger on average in the northern study area. For example, common localized events such as hail can severely reduce a particular field's yield. While this does have an effect on a 15,000 acres farm in the northern study area, the effect of hail is much more drastic on a 3,000 acre farm in the south.

Responses to weather events

3.5 Coping Strategies in Northern and Southern Study Areas

The responses or coping strategies displayed by producers in both the northern and southern study areas were wide and ranging. Responses varied from having to take the loss, to changes in farming operations and product sales (Table 4). Many of the responses were dependent on the type of farm. For example, the use of row covers in the northern study had a low response of 1. In this particular case, the producer who used row covers to protect against heat and wind was a small scale vegetable producer. This option, while very effective, is obviously not a viable choice for the majority of the respondent who farm grains, oil seeds, pulse crops and livestock on a much larger scale.

Both regions had several common responses or coping strategies. These included, taking the loss, the use of Saskatchewan crop insurance, zero or minimum tillage farming practices, and hail insurance. These four results are common in nearly 100% of all interviewees however they were not always self identified as a coping strategy or response to a weather event. In fact the use of zero tillage is so common place in Saskatchewan now that it is no longer seen as an innovation but rather as the standard farming practice. It has been so successful that several interviewees mentioned that perhaps the effects of recent droughts may have been much more severe prior to the low of zero tillage farming techniques.

Table 4. Reported coping strategies to weather events in the northern (n=23) and southern (n=15) study areas.

Northern Study Area	Percentage of Respondents
Take the Loss	78%
Sk Crop Insurance	65%
Zero/Min Till	43%
Hail Insurance	35%
Multiple field locations	17%
NISA payment	13%
Early Harvest	13%
Delayed Harvest	13%
Seed short season crop	13%
Multiple year grain storage	13%
Use crop as feed	13%
Ethanol	9%
Small land drainage	4%
Maintaining Fertility Program	4%
Increased Lending	4%
Marketing change	4%
Late seeding	4%
Specialty Crops	4%
Seed to hay	4%
New Equipment purchase	4%
Modify Equipment	4%
Irrigation	4%
Row Covers	4%
Increased spraying	4%
Southern Study Area	Percentage of Respondents
Sk Crop Insurance	87%
Zero/Min Till	53%
Use crop as feed	53%
Take the Loss	40%
Hail Insurance	27%
On farm Management	27%
Increased spraying	27%
Holistic Ranching	20%
Marketing change	20%
Early Harvest	13%
Late seeding	13%
Ethanol	13%
Seed to hay	13%
Leave crop on field to retain snow	13%
Increased Lending	7%
Delayed Harvest	7%
Multiple field locations	7%

One of the most common responses was “taking the loss”. This response referred to not having the ability to take a specific action in the case of a particular weather event. The popularity of this response stems from several reasons, the first being that the majority of farming operation decisions are made well before the growing season starts. This implies that when a major weather event strikes, the producers has no choice but to accept the loss as it is already to late to make any possible changes to farming practices. An example would include a major hail storm. The producer, other then purchasing hail insurance, has no ability to predict the arrival of a storm and very few options after it occurred. There are no major changes to the farming operation that can occur to help prevent future losses from the same occurrence. In most cases the only option is to recover what is available, take the loss and use any purchased insurance to minimize the effects of the hail.

It is the use of insurance to help with the common response of “taking the loss” which results in both Saskatchewan crop insurance and municipal and private hail insurance ranking high amongst responses. While not used every year, the vast majority of Saskatchewan farmers purchase at minimum Saskatchewan crop insurance. The price and level of coverage varies greatly from fifty to one hundred percentage coverage but in the case of a “take the loss” situation, it becomes invaluable to the producer.

Beyond the common responses of taking the loss and insurance programs, the remaining coping strategies identified by respondents represent to a large part innovation and specialities to certain operations. The most common innovation identified as being a coping strategy in both study areas was the wide spread use and acceptance of zero or minimum tillage farming practices. This method of farming was introduced widely in the area approximately 15 years ago and has since become the most common farming method. Interviewees who cited it as a response to weather events praised it for its use for the ability to retain moisture and prevent widespread erosion. Many respondents citied the use of zero tillage farming as a major factor in being able to survive weather events and being largely responsible for favourable growing conditions for the past five years.

Other innovations include the use of multiple field locations. The use of this coping strategy was more common on larger farms in the northern study. It is the practice of using multiple field

locations to limit the affect of regional weather events. For example, spreading out field locations, whether intentional or simply a necessity due to land ownership and field rental locations, spreads out a farming operation's resources and limits losses associated with localized weather events. This could include frost, hail, flooding etc. Having a greater diversity of land locations and conditions often prevents total losses for producers. Related to multiple field locations is also the practice of maintaining a diversified farming operation. This is the practice of growing multiple crops and/or with the combination of livestock or other financial opportunities. Growing a wider range of crops provides an inherent resilience to the producer. Different crops can be more or less susceptible to weather events such as frost and gives a wider range for seeding/harvest timing. The practice of diversifying farming operations is now common place on Western Canadian farms due to improved farming management practices, new markets for a wider variety of crops and crop rotation practices. Its success can be seen in the results where the more diversified southern research area has a lower reported frequency of simply "taking the loss". A diversified farm operation has more opportunity for responses to weather events than a more monoculture operation.

Various other responses are farm management practices and options available to the producer at the time. Examples include delaying harvest, having an early harvest, planting a short season crop etc. Several other farming operation changes respond to the weather events by using marketing opportunities. Very often this includes cutting losses for a given year by selling damaged grain as livestock feed or after a series of poor years, seeding farm land to hay specifically for sale on the feed market or use in a mixed farming operation. More recently, a common trend in Saskatchewan has been the switch by many producers to devote a certain percentage of their land for ethanol production. This move is heavily supported by both the federal and provincial governments. There currently exists several ethanol production plants in or close too both study areas. The production of utility grain for ethanol requires less work from the producer with a lower quality grain which can tolerate a wide climatic variation and ensures a local opportunity for grain sales. While not directly related to the weather, the move towards ethanol has been politically motivated as a response to climate change by both the federal and provincial governments. The financial help it provides to producers gives them a greater opportunity to absorb shocks and stresses associated with increased weather variability and the financial power to implement change and innovation.

3.6 Resources Important to Coping Strategies

Behind the coping strategies used by producers in both the northern and southern study areas are the resources which give them the ability to cope with weather events and to make adaptations to future weather events. Table 5 illustrates the farming operation resources that have been self identified by producers as being very important to their adaptation and coping strategies (4-5 ranking in CRISTAL)

Table 5. Resources identified as very important to weather event coping strategies in the northern (n=23) and southern (n=15) study areas.

Northern Study Area	Percentage of Respondents
Crop	89%
Savings	61%
Insurance	50%
Agriculture Implements	39%
Liquid Assets	28%
Transfers from the State	17%
Farm Buildings	17%
Soil	17%
Livestock	11%
Water	11%
Grain storage	11%
Credit systems	6%
Hired Help	6%
Local Greenhouse	6%
Farm hands	6%
Farmers Market	6%
Local Restaurants	6%
Southern Study Area	Percentage of Respondents
Crop	88%
Savings	63%
Liquid Assets	50%
Agriculture Implements	50%
Livestock	38%
Farm hands	38%
Soil	38%
Employment in town	25%
Insurance	13%
Transfers from the State	13%
Family Help	13%

The results from the northern and southern area show that both areas rely heavily on natural (management of physical conditions), financial (savings, government programs, insurance, credit and off-farm employment) and infrastructure resources (farm buildings, implement technology and social/community structure) to cope. The number one response in both areas is understandably the actual production of a crop. The annual production and sale of a crop or livestock is the keystone to all subsequent resources such as farm savings, liquid assets and farm implements. It is these subsequent resources on which farm operations rely upon in situations where harvest results are poor due to weather events. This demonstrates the importance of financial security to having the ability to adapt and cope through increased weather variability associated with climate change.

Another resource common to both research areas an one which ranked high previously as a coping strategy is insurance and transfers from the state (government support). Interestingly, compared to their importance as a response to weather events, they ranked relatively low in importance as a resource to coping strategies. This reflects the sentiments of many producers stating that "insurance and government support are important but farming operations are not planned around these resources" (multiple producer respondents, spring/summer 2007).

The differences between the northern and southern study areas are fairly small with the difference in importance associated mainly with insurance and greater off farm employment opportunity. Less importance placed on insurance in the southern study area may be a factor of the diversity naturally incorporated in farms of the southern study area.

3.7 Resources Most Negatively Affected by Weather Events

Resources which can be grouped into the categories of natural, financial and infrastructure resources, were identified by Saskatchewan producers in this study as being most important for having the ability to cope and adapt to the affects of weather events. Table 6 demonstrates the resources which are most negatively affected by weather event in both the northern and southern areas[2].

[2] Only results receiving a 4 or 5 (criteria for being considered significant in CRYSTAL) were represented.

Table 6. Resources most negatively affected by weather events in the northern (n=23) and southern (n=15) study areas

Resources most negatively affected by weather	
Northern Study Area	Percentage of Respondents
Crop	83%
Insurance	39%
Savings	33%
Liquid assets	17%
Water	17%
Roads	11%
Water	11%
Grain storage	11%
Agriculture Implements	9%
Farm Buildings	6%
Credit systems	6%
Farm hands	6%
Transfers from the State	6%
Southern Study Area	Percentage of Respondents
Crop	88%
Savings	75%
Liquid assets	38%
Insurance	25%
Credit systems	13%
Water	13%
Transfers from the State	13%
Soil	13%
Farm Buildings	7%

Results show that resources most negatively affected by weather events and resources most important to coping with weather impacts mirror each other closely. This shows the vulnerability that currently exists in both the north and southern study areas. The negative affects of weather events on crop, financial and infrastructure resources demonstrate vulnerability especially to weather events that occur in multiple years. It is during these events that financial strain can prevent adaptation and lead to heavy use of insurance and government subsidies.

Chapter Four: DISCUSSION

4.1 Effectiveness of Government Programs on Important Farm Resources

A commonality between northern and southern study areas is the use of government programs. Virtually all interviewees took part in a least one government program with only one exception who did not use any programs at all. The list of programs used is wide ranging, with the four most common being Saskatchewan Crop Insurance, CAIS, NISA and the Environmental Farm Plan. These programs were cited as being used in over 50% of the interviews. The other programs mentioned were much more limited in their use or perceived importance to coping with weather variability. Examples include the wheat board cash advance, GRIP, Educational bursaries and the PFRA shelterbelt / dugout program. The four most common programs do have an effect on resources important to coping and the resources most negatively affected by weather events (Table7).

Generally Crop insurance was seen as a positive program by the majority of users. It is virtually recognized that purchasing crop insurance is a necessity of farming because it covers farmers in situations where little else can be done. An unpopular move has been the removal of the hail insurance aspect from general crop insurance. If a producer wants hail insurance for their operation it must now be purchased separately from the RM or a private insurance broker. Coverage rates, expenses and claims are other common complaints. The opinion of many producers is that coverage payments increase much too rapidly from 50% to 60% and so on, making it not worth the investment to purchase more then basic coverage. In order to improve the program, producers would like to get rewarded for responsible farming practices. Producers using the latest technology and farming techniques see themselves as doing everything possible to avoid having to make an insurance claim. These producers would like to see their good farming practices rewarded in insurance rate reductions.

CAIS is an extremely unpopular program currently in use. The majority of producers do not understand how the program functions or have not received any form of payment. Because of the time and complexity of the paper work involved with this program, it is mostly completed by professional accountants. Producers are unsure if they are eligible for a payment from CAIS and if so do not know when payments will be made. “I did receive a payment from CAIS during the

BSE crisis, it wasn't much but it helped, two years later I was informed that they wanted the payment back. I of course had already spent the money; it was all a major inconvenience" (Southern Area Producer, August 2007).

The Environmental Farm Plan is a fairly popular program in both areas. The program requires producers to complete a workbook identifying areas of improvement that can be made to the farm operation which would benefit both the management of the farm and the environment. After self addressing areas of concern, the producer can apply for cost sharing to help make the improvements. This program requires the producer to make significant investments but it offers the opportunity for these costs to be shared by the government. The educational component of this program combined with financial aid has made it popular. Producers see it as helping to improve their operation while benefiting the environmental health of the region as well.

Table 7- Four most common government programs and their effect on resources important to coping and most negatively effected by weather events in the north and south study areas (n=36). (x) indicates the most common response.

Polices / Programs	Impact of program /policy on resources most negatively affected by weather events					Impact of program /policy on resources most important to coping				
Crop Insurance	**Resources**	**Positive**	**Split result**	**Negative**	**N/A**	**Resources**	**Positive**	**Split result**	**Negative**	**N/A**
	Crop	x				Crop	x			
	Savings			x		Insurance	x			
	Insurance				x	Savings		x		
	Agriculture Implements	x				Liquid assets		x		
	Liquid Assets		x			Water				x
	Transfers from the State	x				Roads				x
	Farm Buildings	x				Grain storage		x		
	Soil	x				Agriculture Implements	x			
	Livestock		x			Farm Buildings	x			
	Water				x	Credit systems			x	
	Grain storage		x			Farm hands				x
	Credit systems			x		Transfers from the State	x			
	Hired Help				x	Soil	x			
	Local Greenhouse				x					
	Farm hands	x								
	Farmers Market				x					
	Local Restaurants				x					
	Employment in town				x					
	Family Help		x							

Polices / Programs	Impact of program /policy on resources most negatively affected by weather events					Impact of program /policy on resources most important to coping				
CAIS	**Resources**	**Positive**	**Split result**	**Negative**	**N/A**	**Resources**	**Positive**	**Split result**	**Negative**	**N/A**
	Crop		x			Crop		x		
	Savings			x		Insurance			x	
	Insurance			x		Savings			x	
	Agriculture Implements		x			Liquid assets			x	
	Liquid Assets			x		Water				x
	Transfers from the State			x		Roads				x
	Farm Buildings		x			Grain storage				x
	Soil		x			Agriculture Implements		x		
	Livestock			x		Farm Buildings		x		
	Water				x	Credit systems			x	
	Grain storage				x	Farm hands				x
	Credit systems			x		Transfers from the State			x	
	Hired Help			x		Soil				x
	Local Greenhouse				x					
	Farm hands				x					
	Farmers Market				x					
	Local Restaurants				x					
	Employment in town				x					
	Family Help				x					

Polices / Programs	Impact of program /policy on resources most negatively affected by weather events					Impact of program /policy on resources most important to coping				
Environmental Farm Plan	**Resources**	**Positive**	**Split result**	**Negative**	**N/A**	**Resources**	**Positive**	**Split result**	**Negative**	**N/A**
	Crop	x				Crop	x			
	Savings	x				Insurance		x		
	Insurance		x			Savings	x			
	Agriculture Implements	x				Liquid assets	x			
	Liquid Assets	x				Water	x			
	Transfers from the State	x				Roads				x
	Farm Buildings		x			Grain storage				x
	Soil	x				Agriculture Implements	x			
	Livestock	x				Farm Buildings				x
	Water	x				Credit systems	x			
	Grain storage				x	Farm hands				x
	Credit systems		x			Transfers from the State	x			
	Hired Help				x	Soil	x			
	Local Greenhouse				x					
	Farm hands				x					
	Farmers Market				x					
	Local Restaurants				x					
	Employment in town				x					
	Family Help				x					

Polices / Programs	Impact of program /policy on resources most negatively affected by weather events					Impact of program /policy on resources most important to coping				
NISA	**Resources**	**Positive**	**Split result**	**Negative**	**N/A**	**Resources**	**Positive**	**Split result**	**Negative**	**N/A**
	Crop	x				Crop	x			
	Savings	x				Insurance		x		
	Insurance		x			Savings	x			
	Agriculture Implements	x				Liquid assets	x			
	Liquid Assets	x				Water				x
	Transfers from the State	x				Roads				x
	Farm Buildings				x	Grain storage				x
	Soil		x			Agriculture Implements	x			
	Livestock		x			Farm Buildings		x		
	Water				x	Credit systems	x			
	Grain storage		x			Farm hands				x
	Credit systems	x				Transfers from the State	x			
	Hired Help				x	Soil	x			
	Local Greenhouse				x					
	Farm hands				x					
	Farmers Market				x					
	Local Restaurants				x					
	Employment in town				x					
	Family Help				x					

NISA is the final common program and has been discontinued. The final payments from this program were being made in 2007 while I was conducting interviews. This program was the predecessor to CAIS. It allowed producers to enter money into a savings account which would be matched by the government. The simplicity of the program is what made it popular. Producers knew what they had available and could plan accordingly. Unfortunately the program was cancelled largely due to the older generation of producer's unwillingness to use the money when near retirement. Despite it being cancelled it still remains a popular program in Saskatchewan. While most producers acknowledge that CAIS will be around for a while, a NISA-like component would like to be seen in CAIS to reduce confusion and allow for better planning.

Adaptations and innovations of resilient producers

The vast majority of producers who participated in this survey could largely be combined into two groups, those who's farming practices follow the status quo or regional average techniques, and those who differentiate from status quo and use new technology and innovation. These innovative producers are often referred to as leading farmers (Scholz 2007) and tend to enjoy greater security financially and also demonstrate a higher resilience to weather variability. Examples of innovations are extremely wide ranging, and the scale to which they are used is highly variable. This chapter will discuss six categories of innovations which closely relate with the findings of the best practice group (2007), showing a relationship between innovation and success despite high weather variability.

4.2 Specialty Crops

The movement to speciality crops is a departure away from the commodities market. Commodities are sold in a competitive market where those who can produce the most and sell it for the least will benefit. Under this system, producers have largely experienced low prices for their crop. Low crop prices in turn leave producers financial vulnerable during periods of poor weather. The production of a high value speciality crop can help a producer increase their stability by being able to operation in outside markets. This can often involve local sales or

direct marketing. The concept of growing a specialty crop is to produce a product which is in high demand but currently has a small supply. Most often specialty crops are grown as an addition to a typical farming operation however some farms do exist that deal specifically with speciality crops. Speciality crops were found to be grown in both the northern and southern study areas. Two crops of particular interest, cherries and fireweed/rumex, were found in the northern study area.

The interviewee who exclusively produced cherries represents an example of a farming operation which focused exclusively on a speciality crop. The interviewee began farming with his father in 1993. Together they ran an 1120 acre pulse, oil seed and grain farming operation. A death in the family, new machinery expenses and the combination of a bad frost in 2004 and a 60% loss to hail the following year prompted the interviewee to cease farming operations and begin renting all but 4 acres of his land. The 4 acres was set aside for the production of dwarf sour cherries. Currently the cherry trees are too young for production however the goal is to process the cherries in the on site production facility for sale in the nearby Regina farmer's market, summer road side fruit stands and custom orders. The dollar per acre potential is around ten thousand dollars per acre with low maintenance and input costs. Once fully established the cherry operation will help to supplement the income of family members working in town and allow the interviewee to remain at home with the family.

The cherry production is seen by the interviewee as a regional speciality which can take advantage of the nearby farmer's markets, proximity to the Trans Canada highway and the popular nearby tourist destinations. Support for the production of this speciality crop came from the Canada-Saskatchewan Farming stewardship program (environment farm plan) and aids in the funding for the fruit trees, increased shelter belts, drip irrigation system and wildlife fencing.

The production and basic processing of fireweed and rumex in the northern study area is an example of a speciality crop being used to supplement more traditional farming practices. The interviewee in this example, a northern study area producer, farms approximately 10,000 acres of peas, feed wheat, canola, oats, 32 cattle and 5 acres of fireweed and rumex. The cultured production of fireweed and rumex is not common in Saskatchewan. Fireweed and rumex are

both common weeds growing wild in Saskatchewan and the Prairies. Rumex tends to grow in areas where water is plentiful and fireweed is common in areas of disturbance. Harvesting of these weeds in a wild situation is open to the public, however this interviewee has obtained an exclusive contract to plant, grow and process for the region.

The intentional growth and harvest of common weeds seems like an unusual agricultural activity. The products they produce however are quite valuable. Fireweed is sold to the pharmaceutical company Johnson and Johnson that use it for the production of skin care products ranging from baby wipes to salves for burn victims. Rumex is in demand in Asian markets where it is used as a key ingredient in skin lighteners.

In total, both weeds are planted on a 5 acre plot. During the growth period, other weeds are removed to ensure maximum growth. Just prior to the commencement of the usual harvest, the weeds are hand picked by two hired farm hands. The harvested weeds are in turn placed in a farm building over air driers and are routinely turned to prevent mould and fungal growth. Once the weeds are dry they are placed into a machine which grinds the dried plants into a fine powder. This powder is in turn sold in Saskatoon for 8 dollars a kilogram. In total 5 acres of this weed production has the equivalent value to the producer as 9 quarter sections of wheat .

In both examples of specialized crops production, the crops demonstrate a high tolerance to weather variability. Trees and weeds both naturally have a high tolerance to shocks and stresses from the weather but also the small scale on which they are grown allows the producer to take action to prevent damage during a weather event. With this low risk crop the producer's farm has an overall greater tolerance to weather events and impacts.

4.3 Direct Marketing

Western Canada has traditionally sold agricultural produce in bulk. This is highly facilitated through the Canadian Wheat Board and is the choice method for the sale of commodities. More and more Saskatchewan producers however have begun seeing opportunity in taking control of the sale of their product. The result of this is the movement towards direct marketing. Simply put, direct marketing is the action of the producer selling directly to the consumer/purchaser.

The direct sale of an agricultural product to a consumer/purchaser almost exclusively requires it to be a specialized product which one producer or a small group of producers could provide. For example, while a single producer's grain or oil seed crop could be very difficult to direct market to a consumer/purchaser, a speciality crop or rare crop could realistically be sold. Examples would include organically produced products, locally grown produce (farmer's market) or a regional speciality. Direct marketing can also be used in cost recovery situations. A common example in both the northern and southern research areas is the selling of downgraded grain for livestock feed.

Whether used as a tool to sell high value products or in an example of cost recovery after a weather event, direct marketing gives the producer an advantage in removing the cost of a middle man. When the producer is selling directly to the consumer, the producer has the ability to set the price and avoid potentially expensive handling and transportation costs. Direct marketing does require a significant amount of work and innovation on the part of the producer. Done properly however, the producer can build a significant amount of financial security and help develop resilience into their farming operation. An example of this can be seen with a livestock producer in the Southern research area .who had been a traditional grain farmer and decided to switch to a livestock operation 10 years ago. He made the switch by seeding 800 acres from grain to grass and purchasing 250 cattle, 5 sows and 400 chickens all with the goal of becoming a holistic rancher.

Simply put, a holistic rancher is a modern rancher who mimics "old style" ranching by allowing cattle to graze for their nutrition and keeping them in movement. The major difficulty in converting to this method is building up the grass to a point at which this can take place. This requires the build up of litter. Litter maintains the soil's temperature allowing for micro-organisms to survive. For example, the soil on a grass field with litter will remain around 18 degrees Celsius on a hot summer day whereas the soil on a typically grain farm can reach temperatures of around 45 Celsius, killing organisms at or near the surface. With the increase in litter, grass height can be developed. Grass height above the ground indicates root length below the surface. A healthy root system and thick tall grass not only provides a good source of food for the cattle but it also retains soil and captures rain and snow. In fact when the grass conditions

are properly built up the healthy condition of the grass and soil virtually eliminate weather stress (Southern Area Producer, Aug 2007). The height and thickness of the grass allow cattle to graze outdoors until January. At this time hay is used until cattle can return to grazing on the 5th of April. The height of the grass allows them to eat the portion above the snow during the winter and also permits new growth from being eaten during the spring. The significant time allowed for outdoor grazing in this farming method reduces antibiotic use due to the elimination of close confines and a more natural calving schedule which takes place in May and June. The elimination of antibiotics and pesticides (Ivomec) given to the cattle also supports the soil's health. The lack of antibiotics and pesticides in the cattle's waste allows for dung beetles to survive. With active dung beetles, a ton of manure gets worked into the soil daily. This naturally aerates the soil and fertilizes the grass. Within 2 to 3 weeks cow droppings are eliminated from the field fully worked into the soil.

Maintaining the health of the grass does require a significant amount of work. Land is only grazed twice a year and cattle only remain on a single area for 48 to 60 hours to prevent overgrazing. The type of vegetation present must also be closely monitored. 30% of the vegetation must be legumes for the purposes of nitrogen fixation. This eliminates the requirement to fertilize and helps to minimize input costs. The result of this is cattle which can be called holistic, although not organic, as they do graze on other farmer's stubble and antibiotic will be used in rare but extreme cases to prevent disease outbreaks. The breeds of cattle that can be used are limited as well. Traditionally many cattle have been bred for show as opposed to outdoor survival. Colder bred breeds such as Herford and Angus therefore do better in this farming system. Herd culls do have to take place at times to eliminate poor survivors.

After about 10 years of building up the grass and cattle herd, this southern area producer can now direct market his cattle. He can now produce a semi load of holistic cattle for slaughter giving him the power to set the price for his speciality product and the power to choose to whom he sells (buyers for the cattle found on the internet). The reduction in input cost such as fuel, pesticides and antibiotics mean that his profit margin is higher and the health of his grass and soil eliminate the effects of short term weather events. This form of production also has numerous benefits for the region. Local area flooding is reduced as the thick grass prevents runoff, the soil

sequesters carbon, methane production from cattle is reduced and neighbouring farms can receive small payments to allow the cattle to graze stubble. Conversion to this method of farming is supported by; (a) Ducks Unlimited which help pay for the switch to grass, (b) local communities who are now offering holistic management courses and (c) watershed authorities who will help cover 1/3 of the cost for cross fencing. This innovative farming method allows the producer to have a greater chance of achieving financial stability by being in control of the sale of his product and it is achieved in a manner that works in unison with the environment, including weather events, and the cattle's natural feeding style instead of opposing in an unatural fashioin

After farming for 34 years, this southern area producer does see the weather as changing. It is more erratic then it used to be and the south east winds which used to bring rain no longer exist. Growing seasons are getting longer with a longer fall and earlier spring. This farming method is an adaption this producer is having to make so he can maintain controlled production on his farm.

> "A farmer cannot control outside forces such as the weather and politics. Worrying about them solves nothing. What a farmer can do is affect what he controls such as the method in which he farms. Increasing strength over what you control reduces the affect the outside forces have on your farm"(Figure 4-1 Southern Area Producer 2007)

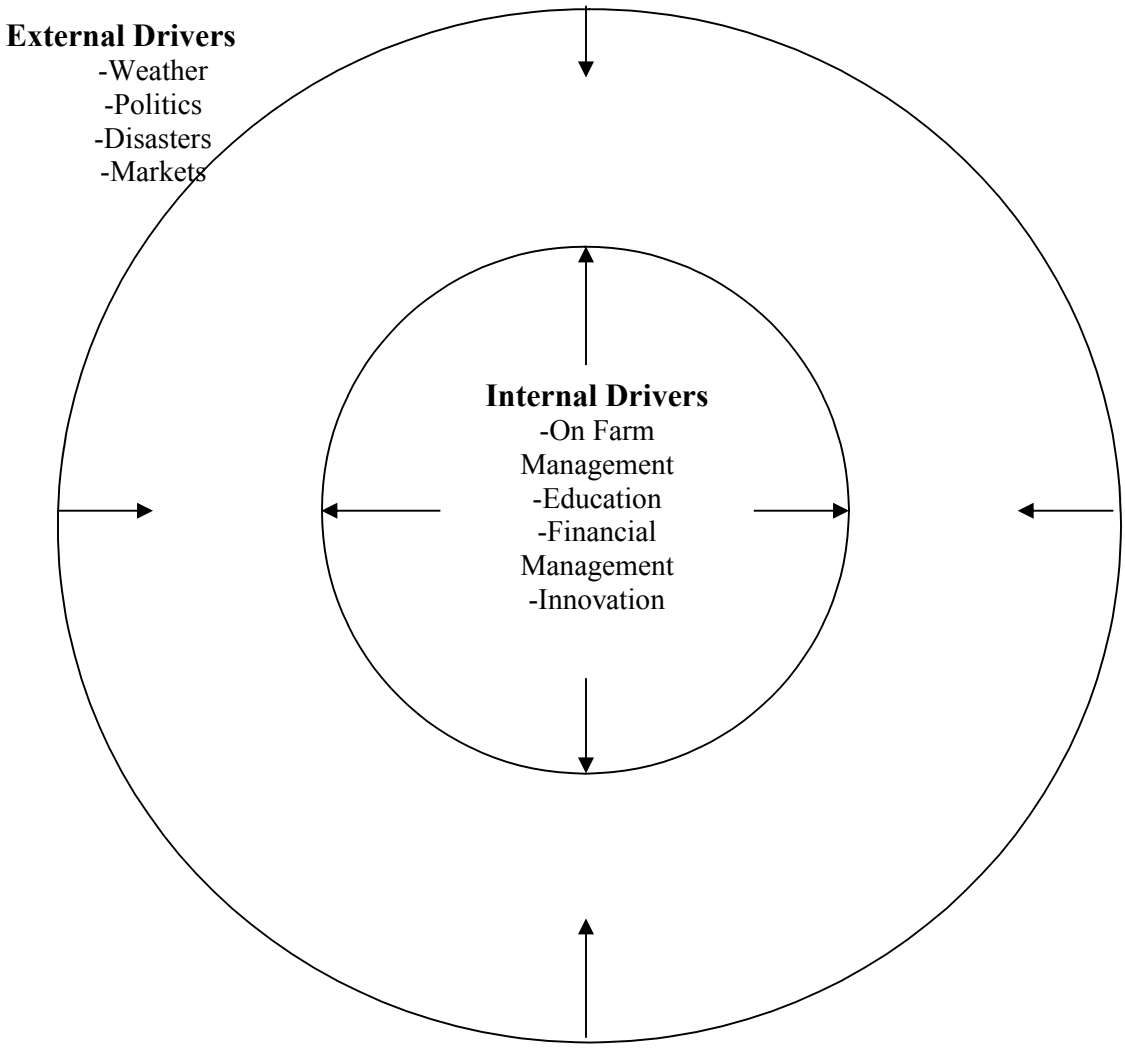

Figure 4-1- Demonstration of how controllable on farm choices minimize uncontrollable external stresses (Southern Research Area producer 2007)

4.4 Interdependence

The idea of the independent farmer is very strong in both study areas. Each producer owning their own land and equipment is common for the vast majority of interviewees. There are however a few examples of interdependent producers. Interdependence is a new example of old traditional farming practices being used in the present. It can be referred to as the pooling of human and equipment resources in an effort to save on rising input costs. Like threshing machines of the past, machines owned by separate individuals not associated with any particular farm, which used to travel from farm to farm harvesting the crops, interdependent producers may not own all the equipment or all the land used for the farming operation. It is a form of "back to the future thinking, or thinking back forward" (Southern Area Producer, April 2007), where producers can reduce costs by pooling resources which can in turn help build resilience to weather events.

A good example of interdependence existed in the southern study area. A southern study area producer makes a living off of 500 acres of land with no off farm income. This is a very small parcel of land when compared to most Saskatchewan farming operations but it works in this situation because of interdependence. The producer pools his labour and equipment with his father and brother. Instead of each family member owning individual farm machinery, the costs are shared amongst each family member's farm. Instead of three sets of farm equipment working three small farms, there is one set working three farms. This reduces costs for each farming operation by a third. The result is less impact to each farm due to a weather events as there is less impact on each farm's financial resources.

This form of interdependence works in this situation because labour and shared operating expenses for equipment, which can range up to three hundred thousand dollars, can be counted upon. As a result, expenses are drastically reduced on a per farm basis, allowing a 500 acres grain farm the opportunity to make a profit.

Another example of interdependence can be found in the northern study area. The rising cost of equipment and inputs has dramatically increased. This has made operating and purchasing new equipment very expensive. A practice now used to minimize some of these costs is custom

farming. This type of farming occurs where an area farmer who owns equipment and has time will help a neighbour's farming operation for a fee. This allows a producer's farming operation to remain in operation when he/she does not have the time and/or money to purchase new equipment, allowing a producer with the proper equipment an opportunity to recover some operating costs.

Interdependence is not limited to equipment and labour. It can also be used to reduce purchasing expenses by pooling the purchasing power of several operations or also when selling to reduce transportation costs. Essentially any situation where an advantage can be achieved through resource pooling could be considered interdependence.

4.5 Education and Expert Advice

Education and the use of expert advice is a common trend among all participants who displayed innovation in their farming techniques. This may include attainting a university or college, outside work experience, on farm education or attending local workshops and expert lectures. The value of education can be seen in basic production but also in adaptation and management during weather events, farm management/planning and human resource management. The advantages of this were seen in the Northern study with 3 neighbour participants. All three attended the University of Saskatchewan's agriculture program at the same time. The commonalities between all three farming operations were clear. Each had detailed farm management plans and good record keeping, all three were run in as business like fashion and stood out as successful farms in the region. Each to varying degrees used direct marketing, speciality crops and interdependence to their advantage and finally all three closely monitored weather conditions and had backup plans for extreme weather events.

Because all three had received significant agricultural training in the past, they were open to innovation and using new technology. All three had been hit with extreme weather events in recent years and survived through on farm management.

4.6 Next Generation Management

While the vast majority of farms have gotten bigger and moved to a more corporate method of operation, maintaining and involving the future generation of producers is essential. Without a network of family run farms in Saskatchewan, rural decline will continue. As rural populations have decreased in the past, small towns have disappeared or lost significant services. Elevator closures, last of postal service, medical offices, school service and basic service stores all add expenses to producers and decrease the likelihood of the subsequent generation from continuing the operation. A decrease in the number of ratepayers within an RM also decreases the ability of the municipality to respond to effects from extreme weather events such as spring road washouts. Interviewees in the northern study area commented on spring washouts of roads preventing their children from being able to make it into town to attend school. With children having to remain at home and other family members working off farm, producer cannot work a full day on the farming operation.

From the research conducted in the northern and southern studies, it is clear that the average age of producers is rising. The majority of participants had been farming for over 20 years with 0 having less then 10 years experience as a producer. Most interviewees in conversation made it clear that their children were either attending school or working in the city. In speaking with two second generation children who have taken employment in the city, they don't perceive there being a future in farming. "If I thought I could return to the farm tomorrow and make a decent living I would be there. I love the farm but my dad and I have talked and know the opportunities are in town." (Son of a northern study area interviewee 2007). "I still help out on the farm during the busy times of the year, it really makes me miss living out there but I have a much more stable job in town and my kids have a nearby school. "(Son of northern study area interviewee 2007).

From speaking with the second generation, it is clear that the desire to remain in agriculture is strong but they have been encouraged by their parents to seek a more stable lifestyle in the city. Next generation management is a way to get the second generation involved in the operation at an early age to help maintain future generations of producers. Next generation management begins with the first generation. Accurate record keeping and a well documented farm plan must be developed. The current operation should be evaluated and future opinions considered. Future

options would include movement to new high value crops, new farm technology and farming methods and consideration for reaction to future weather patterns. "I believe 100% that climate change is real and occurring. It won't be the end of farming but we have to adapt and change. We have to begin looking at more drought tolerant crops and crops that can be harvested in less then ideal conditions" (Northern Study Area Producer 2007).

With a detailed plan in place, the entire family can be involved with farm operation decisions. By involving the second generation in decision, the potential for opportunity and valuable experience can be gained. This valuable on farm experience combined with off farm education, will give the second generation a higher probability of remaining on farm as highly skilled farm operators with the ability to adapt to changing farm conditions including weather events and impacts. The possibility of a more stable financial living from the farm may entice those who enjoy farm life, but needed a better financial living, to stay on the farm. A farming family in the the southern research area provides an example of a farm using next generation management. They run a 2000 acre mixed farming operation with 1300 acres seeded with grain and 120 cow/calves. During our interview it was clear that their son was fully involved in the farming operation. In the past ten years the farm has changed to direct seeding, eliminated the on site hog operation and has begun changing focus to grains and oilseeds. By having him involved in the operation he can see the good and bad aspects of farming. He has seen how the hog market has changed and how direct seeding has kept yields high during hot and dry summers where rains have ended in early June. In the future he will have the experience and knowledge to make a confident decision on whether to remain on the farm or to seek other opportunities.

4.7 Zero Till

The conversion to zero till farming practices has been virtually universal in Saskatchewan. Zero till is a method of farming in which tillage is completely eliminated. Seeds are directely injected into the soil using air pressure and the previous year's crop residue remains on the soil. The result is a farming practice that is successful in maintaining soil moisture, reducing soil erosion and reducing field time and fuel expenses. This is achieved by the maintenance of root systems and organic matter in the soil. By maintaining organic structure on the field, surface runoff and snow drifting is reduced, keeping more natural moisture in the soil (Image 5). The fuel savings

are manifested by the producer having to make less passes on the field. Less field time also has the added benefit of affording the producer more time to concentrate on other aspects of the operation or to expand the area farmed. "Zero Till has been the most significant change that I've seen in my time farming. Since I've changed I've been very happy with it. My production went up and my time in the field went down" (Southern study area producer, August 2007).

A consequence of zero till is higher chemical use when compared to farming methods using a higher level of tillage. Tillage is a chemical free method to destroy root networks of weeds. By eliminating tillage, weeds must be now removed chemically. Although zero till farming does have numerous advantages, the consequence of higher chemical use cannot be completely ignored. "We used to have swallows everywhere around here. There used to be nests all over the place. You rarely see them anymore though. I think it's because we used way more chemicals then we once did. They are used to kill weeds and the insects the swallows eat" (Southern area producer, July 2007).

Figure 4-2. Organic matter left on soil from zero till

Conversion to zero tillage in Saskatchewan began largely 15 years ago. Change was brought about by industry and promoted through word of mouth. Neighbours saw

how yields of producers who had made the switch had improved and began attending local information seminars and started purchasing the equipment necessary for the switch. Today zero till is much more refined then it is was in the beginning and remains very popular. All grain producers involved in this survey used zero till or minimum till farming practices to at least some degree.

The ability of zero till to maintain soil moisture and reduce soil erosion has brought a higher degree of stability to Saskatchewan grain farmers. "The weather has definitely been more variable in the past 10 years but with zero till we've always managed to pull off a fairly decent crop" (Southern research area participant, April 2007). "Zero till helps me to capture snow in the winter and maintain soil moisture in the summer. In a hot dry summer it's your saved moisture that keeps your crop growing (Northern research area participant, June 2007).

4.8 CRISTAL as a research tool

My impressions of CRISTAL as a research tool have been relatively neutral. It is quite obvious that CRISTAL was designed as an analysis tool and while the sequence and type of questions it allowed me to ask did have merit, the practically of its use and difficulty in combining interview results significantly detracted from its potential as a research tool.

CRISTAL did prove to have several positive uses while conducting research. While conducting interviews using CRISTAL, it allowed me to sit side by side with interviewees giving them an unobstructed view of the computer screen and the visual interface. This allowed the interviewee to read the questions being asked as well as allowing them see the answers being typed. This helped build trust as the interviewee could see how their information was being entered and they could instantly verify its accuracy. CRISTAL also ensured that the sequence of the questions asked went in a logical order from identifying weather events, impacts and coping strategies to more complex questions such as identifying the resources most affected by the weather events in question and the resources most important to coping. This question sequence got the interviewee in the proper frame of mind to deliver information and underlying factors which may not have come out using more traditional interview methods. Interviewees also liked the drop down

boxes which helped clarify the questions being asked as well as encouraging more thought to their answers. Conversely, drop boxes did encourage interviewees to give the same or similar answers and limited the number of responses they could give.

CRISTAL did show limitations as a research tool at the organizational level. Because of the increased complexity of farm organizations, interview questions were not easily answered with CRISTAL. For example, from an organizational stand point, extreme weather events could be viewed as a positive event for many organizations because they could develop a higher interest in their services from the farming community as well as more funding from the government. CRISTAL would miss this information however because the weather events, although bad, would not be recorded as having any negative effect on livelihood resources from an organization stand point. This fact also reigns true for organizations who's funding and actions are not dependent on the weather (For example, weather has little to no influence on Ducks Unlimited Canada's agricultural programs, because the majority of their funding comes from the United States government. US foreign policy came up as the key factor in this particular organization's decision making.)

Because of time and distance constraints, sometimes the only way the interviews could logistically be completed was by phone. The design and visual nature of CRISTAL made it nearly impossible to complete over the phone in the standard order. General questions had to be asked and conversation directed in order to answer the questions contained in the program however without the interviewee being able to visually see the computer screen, information was very difficult to obtain

Another difficulty with CRISTAL was amending the program itself. While I could make minor changes to make it an interview tool, I could not makes changes so they would appear on the final reports produced by the program. This was partially solved by creating an excel version of CRISTAL designed for my research. The Excel version was not only created as a backup but also as a means to be able to combine information as data cannot be merged on CRISTAL.

Overall CRISTAL could be seen as a prototype for new program. The interview design and the questions asked combined with the open visual nature of the program were positive aspects. It is in time and logistics that many of the advantages of CRISTAL are lost. After I had become well verse in the sequence of questions used in CRISTAL I began conducting interviews with a paper and pen. This allowed me to shorten the interview time and open up interview location options. I found the premise of the program to be successful with the possibility of future applications; however in an agricultural situation, the speed and mobility of a paper and pen are superior.

4.9Additional Findings

Throughout the course of my research I had the opportunity to speak to several farm groups and organizations. Although their information could not be entered into CRISTAL, they did bring up several important points which complimented the on farm interviews. A commonality amongst several of the agricultural professionals interviewed was their observation of shorter winters and an increased frequency of extreme weather events. These weather related stresses are recognized by agricultural professionals as "one of the most difficult stresses because the producer has no control over it. Despite good planning, in a matter of days, yearly plans can change and a source of income can disappear " (Saskatchewan Wheat Pool, 2007).

Organizations in Saskatchewan do work closely with producers to help increase agricultural resilience. Ducks Unlimited Canada is popular amongst producers for offering payments to maintain wetlands and retain permanent cover for waterfowl. Although their primary goal is maintaining duck habitat and populations for hunting purposes, their payment program for producers to maintain wetlands is helping to reverse drainage practices of the past. The maintenance and enhanced design of natural wetlands does provide drainage and storage during wet years, reducing field flooding and provides a water source during drought. The maintenance of permanent cover around wetland areas also helps keep cattle out of sources of agricultural water. Ducks Unlimited's presence is limited in the northern study area because of the lack of natural wetlands, they are however more active in the southern research area.

The Saskatchewan Watershed Authority is also highly involved with producer's water issues offering services such as financial assistance with livestock fencing and solar water pumps. While both of these organizations aid producers both acknowledge that their decisions and ability to implement programs are mostly dependent on political and economic issues. Ducks Unlimited's decisions are mainly influenced by American funding and politics as opposed to regional climatic events. The Saskatchewan Watershed Authority, being a component of the provincial government, has more of an ability to act on weather events and impacts however they to acknowledged limitations imposed by funding. While they have introduced and implemented several popular programs, they simply lack the man power and funding to ensure they are being properly used at the farm level. "Our solar water pump program is intended to ensure that cattle can get access to water away from wetlands and the producer wouldn't have to install wiring. While it is popular we simply don't have the staff to ensure they are being properly installed on the farm. I know that a lot of pumps are getting dusty in the barn" (Saskatchewan Watershed Employee, 2007).

The Saskatchewan Agrivision Corporation is highly involved with changing business and agricultural practices. Through their research work in the best practices of leading farmers (2007), they have found that despite climate change and weather events, innovative producers can continue to exist and make a profit. Regionally, the Saskatchewan Agrivision Corporation is working on changing the transportation methods of grain and pulse crops. They see bulk grain and pulse crop transportation as an "Achilles heal" of Saskatchewan agriculture. They are currently working with producers to develop a network of overseas shipping containers to allow for the ability to deliver on demand to meet just in time delivery demands. This is an effort to eliminate delays, price undercutting and degradation of pulse crops. (Sk. Agrivision representative, 2007).

Saskatchewan Agrivision is also working directly with producers to get them involved in the value chain. This includes having more control of marketing their

product and the development of processing plants (canola oil, ethanol) within the province. According to Agrivision one of the most difficult challenges is changing agricultural traditions. Saskatchewan Agrivision has observed that the top 10% of producers in the province are involved in a commercial enterprise or a producers alliance of some nature. This most often involves a movement away from land ownership to land renting. The sale of land and subsequent rental of it allows producers to invest more in enterprises and reduces year to year dependency on crops.

Agrivision was the only interview to speak towards the resilience of Saskatchewan agriculture in general. They commented that Saskatchewan is the only agricultural area in Canada that does not have a 50% livestock 50% grain spilt. Currently Saskatchewan operates at a 24% livestock 76% grain spilt. "This puts all of Saskatchewans agricultural eggs in one basket when it comes to the weather" (Al Scholtz, 2007). Of the potential 66 million acres of agricultural land in Saskatchewan, 40 million is currently cultivated with a remaining 26 million that could be used to diversify Saskatchewan Agriculture with more livestock production. "There is so much potential in Saskatchewan Agriculture, the problem is there is very little leadership and producers look towards the government. Leadership from producers in changing the culture of agriculture is what is needed to move forward" (Sk. Agrivision representative, 2007).

Chapter 5: CONCULSIONS

Farming is an incredible challenging occupation requiring constant change and adaptation to a multitude of physical, economic and social events. Climate change and the weather variability associated with it presents an increased challenge. From the research conducted in this project, it is clear that the majority of producers see climate change as real and happening. The general opinion of producers is however that it is not the end of farming in Saskatchewan, rather another challenge to deal with. In dealing with the increase in weather variability, very few changes have been made in response to the weather. It was found that the majority of changes were based on financial rather then climatic or weather events. The changes however, regardless of why they were made did show evidence of resilience.

Producers in this study acknowledged that the majority of farming operation decision are made before the ground thaws. Therefore, little can be done to change mid season in response to extreme weather events. Instead of relying on government programs though, many innovative farmers are beginning to change their farming operation to maximize their natural, human and financial potential. It is these producers who maximize their production during good growing years, who achieve the financial stability required to keep their farm in a continual state of adaptation and who can survive single and multiple poor years to remain in operation. The practices and methods of these producers allowed them to excel through the weather events of the past 5 to 10 years and it is this type of producer with who demonstrated the most evidence of resilience.

Resilience in this research was found to be associated with innovative famers. These producers shared the common factor that they were all willing to try new forms of agriculture that varied from the typical status quo. Although weather was not their sole reason for changing their farming operation, change forced them to think in a longer financial time period then year to year as found more with traditional farmers. Removing all or a portion of their farming operation from main stream farming practices also forced these producers to take more control over the marketing and sale of their product. Whether a conscience decision or not, it was found that innovative producers integrated increase options, a flexibility to switch and a reduced

dependence on government programs, all factors needed to increase resilience to climate change and extreme weather events.

Innovative farmers are resilient for three main reasons. Although their decisions were financially based, they were made with long term goals in mind as opposed to year to year. This generally allowed the producer to increase resilience by:

- Increasing options – High value niche crops, multiple field locations, use of new technology and farming techniques all increased options to producers during weather events allowing them to focus on other options when weather events took place.
- Flexibility to switch- Producers who had a willingness to try new crops, technologies and change their mind set showed a willingness to not remain status quo. These producers demonstrated a higher level of current success and potential for future success as they are willing to adapt to new situations.
- No dependence on government programs- Innovative producers made independent decisions based on their farm, independent of traditional government support. Not factoring government support allowed producers to increase their farm options as well as improve their flexibility to switch.

The producer who switched his operation completely from grain to holistic livestock exemplifies producers seeing and filling market niches, while reducing the environmental impact of their operation and the effects of extreme weather and maintaining or increasing their profitability. In general it is innovative producers who take control and manipulate the factors they can affect that have reduced their stress from outside, uncontrollable factors like climate change and extreme weather events.

It appears that current agricultural programs fall short in promoting innovation. Crop Insurance and CAIS do the opposite in rewarding status quo farming practices. When a producer takes a risk employing new farming techniques he may be removed from the safety of government programs. Changes need to be made which promote and aid producers willing to change and increase their options on the farm.

Leadership amongst producers is also needed. Local producers need to reduce their dependency on the government by pooling their knowledge and resources together. Leadership from the government cannot be relied on for innovation and change. Programs are dependent on funding and political influence and may not be appropriate for regional variations. Leadership from industry is also plagued by similar problems. Through the promotion of producer driven innovation and the willingness to change, producers will maintain their operations through climate change and weather events. Traditional agriculture will always remain a part of the Saskatchewan agricultural scene but innovation and the increasing in options to farming operations is what will allow producers to survive and flourish.

REFERENCES

Agriculture and Agri-Food Canada. 2005. *Lessons learned from the Canadian drought years 2001 and 2002: Synthesis report.* (Publication No. 11602-46E03).

Adger, W.N. 2000. Social and ecological resilience: are they related? *Progress in Human Geography* 24(3): 347-364.

Berkes, F. 2006. Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural Hazards* (in press).

Berkes, F., Colding, J. & Folke, C. eds. 2003. *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* Cambridge: Cambridge University Press.

Berkes, F. & Jolly, D. 2001. Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. *Conservation Ecology* 5(2): 18. [online] URL: http://www.consecol.org/vol5/iss2/art18

Best Practice Group. 2007. Best Practice of Leading Farmers. [online] URL:http://www.leadingfarmers.com

Bradshaw, B., Dolan, H. & Smit, B. 2004. Farm-level adaptation to climatic variability and change: crop diversification in the Canadian Prairies. *Climate Change* 67: 119-141.

Bryant, C.R., Smit, B., Brklacich, M., Johnston, T.R., Smithers, J., Chiotti, Q. & Singh, B. 2000. Adaptation in Canadian Agriculture to Climatic Variability and Change. *Climate Change* 45: 181-201.

Canadian Senate. 2003. Interim Report- Climate change: we are at risk. Standing Senate Committee on Agriculture and Forestry, June 2003. [online] URL: http://www.parl.gc.ca/37/2/parlbus/commbus/senate/com-e/agri-e/rep-e/repintjun03-e.htm

Chamber, R. 1994. The origins and practice of participatory rural appraisal. *World Development* 22(7): 953-969.

Cornwall, A, & Jewkes, R. 1995. What is participatory research? *Social Science Medicine* 41(12): 1667-1676.

Government of Canada. 2004. *Climate change impacts and adaptation: a Canadian perspective.* (Publication No. M174-2/2004E). [online] URL: http://adaptation.nrcan.gc.ca/app/filerepository/F80B56D9915F465784EBC57907478C14.pdf

Hammil, A., Faye, A. & Quddus, A. 2006. Assessing and enhancing project impacts on local adaptive capacity- experiences from Mali and Bangladesh.

International Institute for Sustainable Development and the Environmental Adaptation Research Group. 1997. Draft report- Agriculture and climate change: A Prairie perspective. Institute for Environmental Studies, University of Toronto.

International Institute for Sustainable Development., The World Conservation Union, Stockholm Environment Institute. & Intercooperation. 2005. CRISTAL user's manual, October 2005.

Ira, G.C. 1998. Introductory paper- Participatory Methods in Community-based Coastal Resource Management, Volume 1, Introductory Papers (IIRR).

Robledo, C. 2006. Climate change, vulnerability and adaptation- report on Tanzania testing.

Schindler, D.W. & Donahue, W.F. 2006. An impending water crisis in Canada's western prairie provinces. *Proceedings of the National Academy of Sciences*.

Smit, B., Burton, I., Klein, R.J.T and Wandel, J. 2000 How is climate change relevant to farmers? in D. Scott, B. Jones, J. Audrey, R. Gibson, P. Key, L. Mortsch and K. Warriner (eds.), *Climate Change Communication: Proceedings of an international conference*, Kitchner-Waterloo, Environment Canada, pp. F3.18-F3.25.

Smit, B. & Skinner, M.W. 2002. Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Strategies for Global Change* 7: 85-114.

Smit, J.B., Klein, R.J.T. & Huq, S. eds. 2003. *Climate Change, Adaptive Capacity and Development*. London: Imperial College Press.

Smithers, C. 1998. *Crop insurance and farm management,* M.A. thesis, Department of Geography, Guelph, Ontario, University of Guelph.

Smithers, J. & Blay-Palmer, A. 2001. Technology innovation as a strategy for climate adaptation in agriculture. *Applied Geography* 21: 175-197.

Statistics Canada. 2001. *2001 Census of Agriculture*. [online] URL: http://www40.statcan.ca/l01/cst01/agrc22a.htm.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, L.C., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C. Pulsipher, A. & Schiller, A. 2003. A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences of the United States of America* 100: 8074-8079.

Venema, H.D. 2005. From Cumulative Threats to Integrated Responses: A Review of Ag-Water Policy Issues in Prairie Canada. Prepared for the OECD Workshop on Agriculture and Water: November 14-18, 2005, Adelaide and Barmera, South Australia

Venema, H.D. 2005. Position paper- Biophysical and socio-economic stressors on the Canadian Prairies: The joint impacts of climate change and agricultural sector liberalization. International Institute for Sustainable Development, Winnipeg.

Venema, H. D. 2003. Project Proposal- Adaptation as Resilience Building: A policy study of climate change vulnerability and adaptation on the Canadian prairies. International Institute for Sustainable Development, Winnipeg.

Walker, B., Holling, C.S., Carpenter, S.R. & Kinzig, A. 2004. Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society* 9(2):5. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art5

Wall, E. & Smit, B. 2005. Climate change adaptation in light of sustainable agriculture. *Journal of Sustainable Agriculture* 27: 113-123.

Wall, E., Smit, B. & Wandel, J. 2004. Position paper- Canadian Agri-food Sector Adaptation to Risks and Opportunities from Climate Change.

APPENDIX A:

USER'S MANUAL

CRISTAL

A decision support tool for assessing and enhancing project impacts on local adaptive capacity to climate variability and climate change

Version 1.0

October 2005

2 Introduction

In its Third Assessment Report (TAR), the Intergovernmental Panel on Climate Change (IPCC) concluded that the globally averaged surface temperatures increased 0.6 ± .2°C in the 20th century. This trend is expected to persist, with a 1.4 to 5.8˚C warming predicted for the current century. Warming will vary by region and be accompanied by significant changes in local precipitation, sea level rise and changes in the frequency and intensity of some extreme events. These changes will impact natural and human systems independently or in combination with other determinants to alter the productivity, diversity and functions of many ecosystems and livelihoods around the world. Yet these impacts will not be distributed or felt uniformly, as those "with the least resources have the least capacity to adapt and are the most vulnerable."[3]

The poor are already vulnerable to climate risks. Settlement on marginal or unstable lands such as steep slopes or floodplains heightens their exposure to the impacts of climate hazards. Heavy dependence on ecosystem services can place their welfare -- and possibly even their survival -- at the mercy of environmental conditions. As the availability and quality of natural resources decline due to natural and human-induced pressures, so does the viability and security of their livelihoods. With limited capacities and resources at their disposal to respond to stresses such as droughts and floods, their ability to meet basic needs and move out of poverty is constrained. Climate change therefore threatens to exacerbate existing vulnerabilities and further entrench development disparities. With regional changes and impacts already being observed, the need for adaptive response measures is urgent and must start with minimizing current vulnerabilities.

2.1 Reducing vulnerability through sustainable livelihoods

Reducing current vulnerabilities requires an understanding of how local livelihoods are conducted and sustained, as the assets and capabilities that comprise peoples' livelihoods often shape vulnerability and the ability to reduce it. Moreover, by understanding the dynamics of poor people's livelihoods, we can begin to understand how they will be affected by climate change impacts, how they might respond with the resources they have, and how these conditions can be reflected and built upon for successful adaptation strategies.

Given the reliance of the poor on environmental services for their livelihoods, a central element of this adaptation approach should be natural resource / ecosystem management and restoration activities such as watershed rehabilitation, agroecology, and forest landscape restoration. By protecting and enhancing the natural services that support livelihoods, vulnerable communities can maintain local safety nets and expand the range of options for coping with disruptive shocks and trends.

For example, re-establishing mangroves along the cyclone-battered coasts of Vietnam, not only restores degraded ecosystems and increases physical protection against storms, but also boosts aquaculture production, which generates much-needed income for local communities. This combination of a secured natural resource base, reduced exposure to

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[3] IPCC. 2001. Climate Change 2001: Impacts, Adaptation and Vulnerability. Technical Summary. Geneva: IPCC.

natural hazards and diversified livelihood activities has increased resilience to future threats, including climate change. In fact, this livelihoods approach to adaptation has the advantage of meeting immediate development needs while contributing to longer-term capacity development that will create a basis for reducing future vulnerabilities.

2.2 Assessing and enhancing the adaptive capacity of livelihoods with CRISTAL

Securing local livelihoods through environmental/natural resource management is not a new concept or goal, as evidenced by decades of conservation and development activities. Similarly, many of these projects recognize climate variability as one of the many – and in some cases, most important – risks faced by local communities, particularly those with natural resource-dependent livelihoods. Yet most of these projects are rarely designed with a look to the longer-term implications of climate change, and especially how they might affect local adaptive capacity. Projects may serve to improve adaptive capacity or constrain it. But without a tool to assess the role and impact of a project vis-à-vis climate adaptation, it is often difficult for project planners and managers to see these impacts *a priori* and to design activities that actually foster adaptation; often unwittingly, planners and managers introduce activities that are neutral where they could have a positive effect, or even maladaptive.

In response to this identified need, IISD, IUCN, SEI-B and Intercooperation have developed a tool called CRISTAL (**C**ommunity-based **R**isk **S**creening **T**ool - **A**daptation & **L**ivelihoods) that is intended to offer local communities and project planners and managers a way of doing interactive climate risk management for planned or ongoing projects. While this tool is still in the development phase, it currently offers an architecture for:

- Honing in on aspects of a particular project that are directly related to current coping and adaptive capacity at the community scale;
- Evaluating the specific effect of project activities this capacity, and
- Determining changes that could be made to improve the projects' effect.

Overall, the purpose of the tool is to provide a basis for improving community- and project-based decision-making so that adaptation opportunities can be maximized, and maladaptation minimized. It is expected to be relevant in project design as well as project evaluation. An overview of the tool is provided in Box 1.

More broadly, this tool has been developed to serve as a component of a larger set of climate change adaptation tools, all of which are aimed at facilitating the adaptation process at all levels – i.e. community, country, region, sector, etc. It is hoped that these tools, along with the lessons learned from their design and implementation, will feed into a centralized, easily accessible 'adaptation knowledge bank,' enabling individuals and communities to derive guidance and share experiences on operationalizing climate change adaptation.

2.3 Installing and Opening CRISTAL

The tool is contained in a zipped file that accompanies this User's Manual. When installing the tool, simply open Winzip and extract to the c:\ drive. A shortcut is provided that can be dragged to the Microsoft START button for Windows98 and later versions of

Microsoft Windows. It is important that the tool be installed on the c:\drive as in this current version, it will not operate in any other drive.
To open and begin using CRISTAL, simply click on the shortcut (or double-click on CRISTAL.XLS in the c:\CRISTAL directory). The screen shown in Figure 1-1 appears which is the "START" page of the tool (CRISTAL has a setup that is similar in look to a web page). This initial page has introductory information regarding livelihoods and climate change, what the tool is intended to do, and its organizational structure.

Box 1: Overview of CRISTAL

Purpose:

Enable users to identify the impact of projects on local adaptive capacity (planned, ongoing, completed); support users in adjusting projects (planned, ongoing) to improve adaptive capacity; serve as component of larger toolkit

Approach:

CRISTAL applies the following approach

- Draws on environmental impact assessment model;
- Uses sustainable livelihoods framework to enable users to hone in on elements of coping and adaptive capacity at the community level;
- Aims for logical, user-friendly process in spreadsheet format
- Focuses initially on screening natural resource management (NRM) or ecosystem management and restoration (EM&R) projects

Structure:

The focus of the tool is on the following 4 framing questions:

- What is climate context of project?
- What is livelihood context of project?
- How do project activities relate to key livelihood resources?
- How can project activities be adjusted?

Intended results:

The use of CRISTAL should lead to enhanced local adaptive capacity through a better understanding of the following:

- How current climate hazards and future climate change impact a project area, particularly local livelihoods;
- How people cope, looking specifically at the resources people need for coping with climate impacts
- How a specific project affects the availability and access to resources that are essential to local livelihoods and coping strategies -- Is it enhancing, undermining or not having any impact on availability / access?
- What can be changed in the project so that activities that enhance availability/access are strengthened and expanded, and those that undermine availability/access are adjusted?

The menu on the left is used to navigate between four different "pages" in the tool. Clicking on the 'TUTORIAL" option sends the user to the page on Figure 1-2. The tutorial is based on a project undertaken in Sudan which for achieving carbon sequestration benefits, and which did not have climate change adaptation as a goal. The tutorial walks the user through each of the four steps in the tool using illustrative information.

Figure 1-1: Home page for CRISTAL

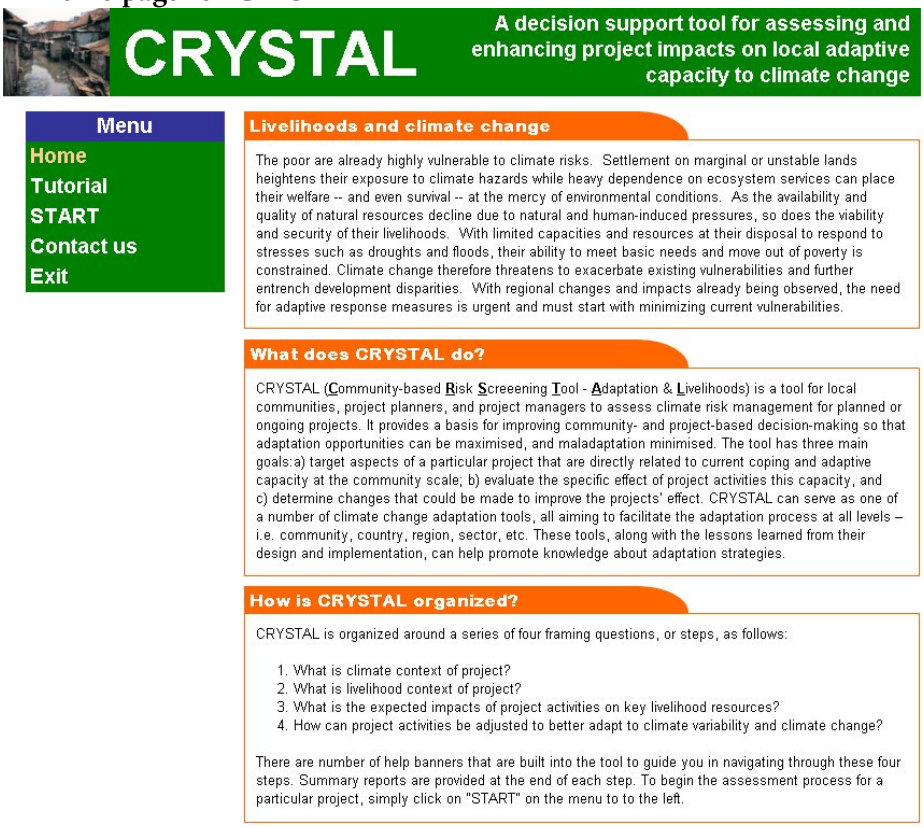
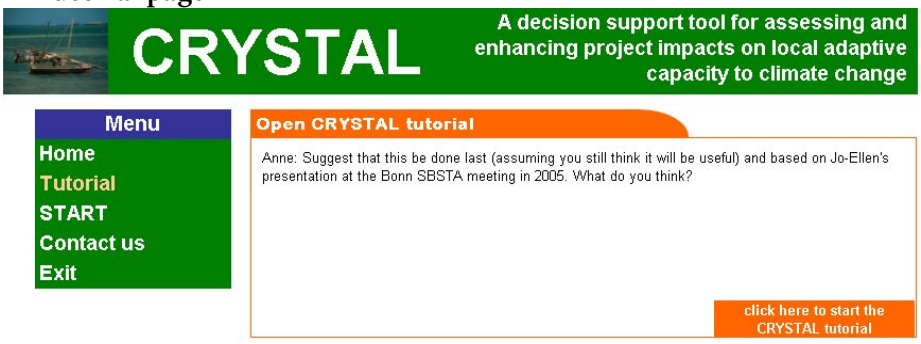
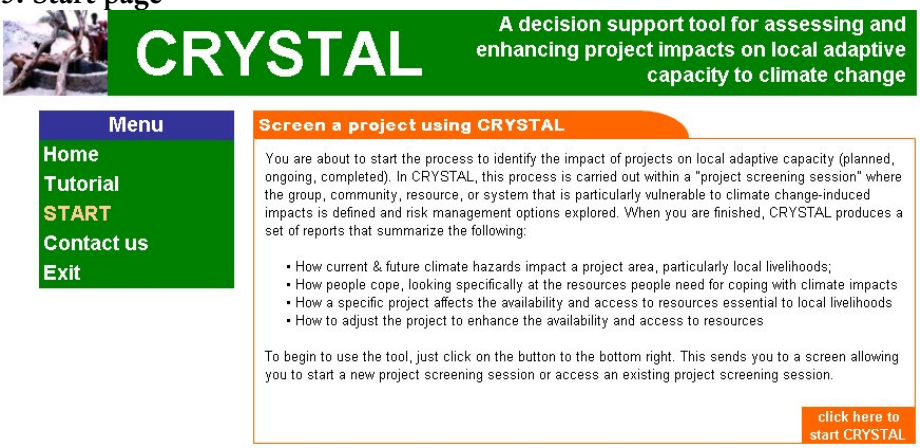


Figure 1-2: Tutorial page



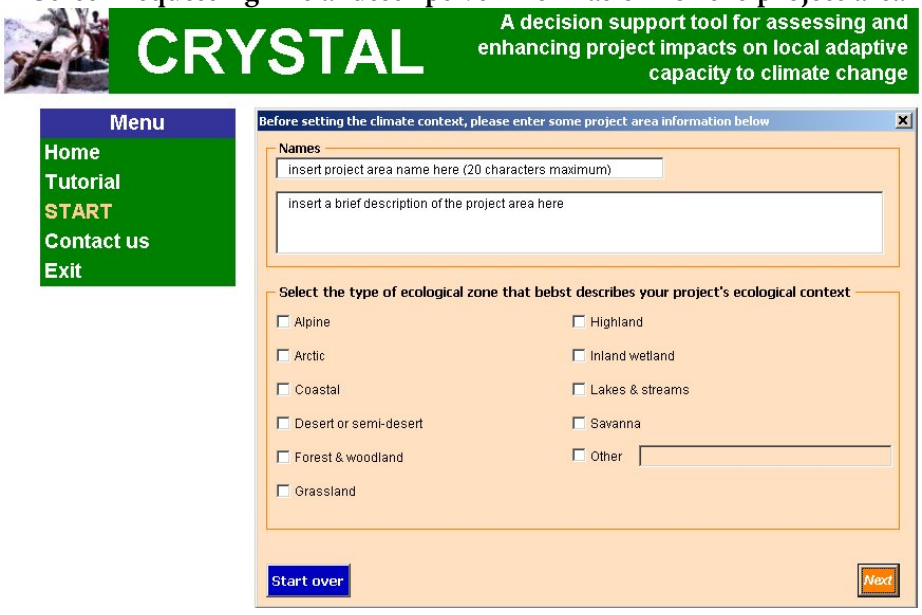
Clicking on the 'START" option sends the user to the page on Figure 1-3. This page is where the tool is launched. Some introductory information is provided on this page to orient the user to the major processes in the tool. To launch the tool form this page, one needs to click on the orange button to the lower right.

Figure 1-3: Start page



A dialog box then appears that offers the user two options – a new session or an existing session. A new CRISTAL session is a blank set of screens that the user can fill in as described in the sections that follow. An existing session is one that has been stored with user-defined information which can be opened and reviewed or updated as needed. If the new session option is selected, the screen shown in Figure 1-4 appears which prompts the user for some basic information regarding the project area.

Figure 1-4: Screen requesting initial descriptive information for the project area



Clicking on the 'CONTACT US" page sends the user to the page on Figure 1-5. This page provides contact information in the event that technical support is needed. To exit the tool, simply click on the 'EXIT" button on the menu.

Figure 1-5: Contact us screen

APPENDIX B:

Synopsis of Interview Questions

1. *Please briefly describe your operation including both type and size*
2. *How long have you been farming in this area?*
3. *Have you changed your farming operation in the last five years?*
4. *List any weather extremes which have impacted you in the last five years*

Questions 5-8 to be designed for use with CRISTAL

6. *Please describe how (insert event) impacted your operation*
7. *How did you respond to (insert event)?*
8. *What aided you in your response?*
9. *What impeded you in your response?*

APPENDIX C: Recruitment letter

Hello Mr./Mrs. _____

My name is Kent Pearce and I am a graduate student from the University of Manitoba working on my masters of natural resource management. The reason why I am contacting you is that I am currently doing climate change adaptation research in your rural municipality.

What I am interested in finding out is how farmers and individuals involved with agriculture have dealt with significant weather events in the recent past and what agricultural programs have helped or hindered them during this time. The purpose of this research is to help improve and develop better agricultural climate change policies and programs for the future.

This project is funded by the International Institute for Sustainable Development (IISD), a policy advisor to both provincial and federal governments. Please be assured that participation in this study is completely voluntary and responses are kept confidential.

Your participation in the study as a member of the RM council would be greatly appreciated. The interview takes approximately one hour and can be conducted at whatever time and location that is convenient for you. If you cannot, or do not wish to take part in the survey, any recommendations of other individuals or organizations within your RM that you believe would be interested would be most welcome.

I have included a copy of the interview consent form to give you more information on the project. A brief overview of the project can be viewed at the IISD's website http://www.iisd.org/climate/canada/prairies.asp

If you would like to participate or have any questions, concerns, or comments, please feel free to contact me at any time.

Thank you,

Kent Pearce

Regina contact number- 306-569-0499
Cell phone- 204-990-7581
E-mail- pearce_k@yahoo.com

APPENDIX D: Recruitment Poster

RM of Pense Residents

I am a University of Manitoba graduate student currently conducting surveys in your area as part of a prairie wide study regarding **farm management in reaction to extreme weather events in the past 5 years and your opinion of government programs during this time.**

Each survey take approximately 30 minutes to complete and can be conducted in person or by phone at a time and location that is convenient to you.

I understand that your time is very valuable and therefore would like to offer:

- **Half a day of free labour**
- **Any reasonable compensation for your time**

All information and identities are kept strictly confidential and you can change your responses or withdraw from the survey at anytime. I am interested in your opinion regarding agriculture policy and local weather. No personal or financial records are requested or required.

If you have any questions or if you would like to schedule an interview please contact me by phone at **306-569-0499** or by e-mail at **pearce_k@yahoo.com.**

Thank you for your help,

Kent Pearce
Masters of Natural Resource Management Candidate

Appendix E: Changes made to CRISTAL

In order to use CRISTAL as a research tool in this project I had to make changes to the program. The majority of the changes were minor, designed mainly to help the interview process work better. Based on the page numbers associated with the program, here are the page by page changes that were made.

Page 1- New Session information

- No Changes made, the "Brief description of project" section is used to answer the following questions: 1. Please briefly describe your operation including both type and size, 2. How long have you been farming in this area and 3. Have you changed your farming operation in the last five years.

Page 2- The Projected Impacts of Climate

- No changes made. Every interview has the same region, country and ecological zone.

Page 3- Setting the Climate Context

- Wording change- Highlighted blue title box now reads *What are the weather extremes, impacts and coping strategies in the project area.*
- Wording change- Question below blue title box now reads *Please list any extreme weather events that have impacted you in the last five years. What were the impacts of these weather events? What did you do to cope / minimize these impacts? You can choose from the examples provided in the lists below or add your own hazard, impact, or coping strategy. When you have finished entering the hazards, please indicate so by checking the box below.*

- Wording change- Blue column headers now read *Weather Event, Impacts, Coping Strategies*. Wording changes were also transferred to drop box titles.
- New text boxes were placed beside the coping strategies column to be able to type additional details provided from the interviewee. This was done in an effort not to lose valuable information describing the extent of weather related impacts as well as factors in coping strategy decisions. These text boxes have since been removed. By the nature of the interviews being performed, typing in the new text boxes proved to be awkward and a time delay. Another factor in the decision to remove the boxes was that I could not figure out how to get the narratives to be included in the final reports produced by CRISTAL. The function of the text boxes is now performed simply with a notebook and pen. The narratives are handwriting and later typed in an Excel version of CRISTAL created to provide a secondary digital backup of the information being collected.

Page 4- Livelihood Context

- Wording Change- Question below light blue Livelihood context title box now reads *Which resources are important for your farming operation and to what extent are they negatively impacted by weather hazards? When you have finished entering the livelihood resources and their extents, please indicate so by checking the box below.*
- Wording change- First blue text box column title now reads *Enter the resources important to your farming operation.*
- A new column was created beside the *Select a value denoting extent influence of the 'x' hazards on resources*. The column was again a series of text boxes

to be used as a space to included narratives to explain why particular numerical values denoting the influence of the weather event on the resource were assigned. For example, beside the value of 4 a farmer gave regarding the influence of a flood on his road infrastructure it would read "The spring flood of 2004 completely washed out sections of my road and others in the rural municipality (RM). I therefore could not get to town for several days. My kids could not get to school and I couldn't move machinery to my other quarter sections." This column however had to be removed. Space was left to allow for several weather impacts to be included; however after 4 events the text boxes would overlap the 0-5 value slides. This problem solved by using a notebook and pen to write the narratives and later type them in the excel version of CRISTAL.

Page 5- Indicating the Importance of the Selected Livelihood Resources to each Coping Strategy

- Wording change- Below the blue title box indicating the weather hazard the question now reads *Now that we have identified the resources important to your farming operation; please indicate their importance to the coping strategy associated with the weather hazard indicated above.*
- A new column was created beside the *Select a value denoting extent influence of the 'x' hazards on resources* to record any additional information. This column was removed for the same reasons as the previous page.

Page 6- Screening Polices and Programs

- Wording change- Beneath the blue title box the question now reads *You will now begin to assess the impacts of the different policies and programs on*

  (a) the livelihood resources that have been identified as being most negatively affected by the hazards and

  (b) the livelihood resources that have been identified as being important to coping strategies.

  Please enter the policy or program in the yellow spaces provided (at left) and indicate whether the impact of the activity is positive, negative, neutral, unknown or non-applicable (click on each for definitions) using an "X" in the appropriate box. Please select only one box for each resource.
- Wording change- First column now appears as *Policy/ Programs*. This column is used for the farmers to identify which policies or programs they self identify as being a participant and or are affected by.

Page 7- Adaptation Management Planning

- Wording change- Below blue title box reading "Adaptation Management Planning" the question has been changed to *Agricultural policies / programs that were flagged as having a positive or negative effect on key livelihood resources have been identified.*

  Please enter why the policy or program had a positive or negative impact and any suggestions on how they could be improved.
- Wording change- Column titles now read *Policy/Program, Flagged Resources by Weather Hazard, Impact of Policy/Program on Resource and Why positive/negative? Improvement suggestions*.

- A text box was added to answer two final questions: 1. How do you regard weather related stresses compared to other farm stresses? 2. Do you regard climate change as something real and currently happening, if so when did you form this opinion? This text box was again removed simply do to disruption of the interview flow. As with the other text boxes, it was replaced by using a notebook and pen and later being transcribe to the excel back up.

Appendix F- CRISTAL terms

Added Field Operations- Increased work load and time spent in the field
Agriculture Implements- Farm machinery i.e. Tractors, Combines, Sprayer etc.
Credit Systems- Ability to get loans, lines of credit etc.
Crop Damage/loss- Damage or complete loss of a crop resulting in reduced income
Crop- The quality and yield of the producer's actual crop
Employment in Town- Having off farm income
Equipment Damage- Direct or indirect damage to farm machinery from weather events
Ethanol- Movement away from food to biofuel production
Extreme Heat - Extended period of above average temperatures in the interview period
Family Help- Unpaid help from family members
Farm Building Damage- Damage to farm buildings most commonly associated with hail
Farm Buildings- Storage and household buildings
Farmers Market- Selling speciality produce at the local Farmer's market
Flood/Excessive Moisture- Standing water or higher then average precipitation
Hailstorm- Precipitation consisting of balls or lumps of ice.
Harvest Difficulties- Difficulty in harvesting the year's production due to weather events
High Humidity- noticeable increase in average summer humidity levels
Hired Help- Paid employees
Income Loss- recorded below average income
Increased Lending- Increasing loans and lines of credit to remain in operation
Increased Pest Activity- noticeable increase in insect pest activity (Grasshoppers)
Increased Spraying- Increased use of chemical products as a result of weather events
Leave Crop on field to Retain Snow- Leaving the crop on the field over winter to retain snow and harvesting in the spring
Liquid Assets- Assets which can be sold or turned into cash, closely linked with grain storage.
Livestock- Sheep, cattle, pigs etc.
Local Greenhouse- Help from local greenhouse to help start speciality crops
Local Restaurants- Ability to sell produce directly to local buyers
Modify Equipment- adjustment to existing equipment as a result of weather events
Multiple Field Locations- A positive response to having fields in several locations
New Equipment Purchases- new equipment as a result or to better deal with weather events
Rapid Crop Growth- Faster then average crop growth
Reduced Crop Residue- Less organic matter left on the field
Reduced Seeding Area- reduction in seeded acres due to weather events
Row Covers- Shade cover used in small speciality crop operations
Savings- Quantity of funds available to remain in operation
Seed to Hay- Permanently seeded consistently wet areas of land to hay
Slow Crop Growth- Delayed crop maturity due to cool weather
Small Land Drainage- drainage projects to deal with most commonly spring run off
Soil- Productive soil
Take the Loss- Barring financial consequences of weather event
Transfers from the State- Government programs and aid
Used Crop as Feed- The sale or on farm use of a downgraded crop for livestock feed
Water- Precipitation and access to a water supply
Wet Harvest- Wet field conditions which made harvesting difficult
Windstorms- Periods of high winds which caused crop / equipment damage
Zero / Min Till- Switching to, or noting the positive affects of zero till farming practices