REPORT ON PARTICIPATORY MAPPING SESSIONS.

Community recommendations to policy-makers to facilitate the adaptation of farming communities to potential impacts of future climate change on water. Municipalities of Taber (AB), Saskatchewan Landing (SK), Riverside (SK), Fertile Valley (SK), and Rudy (SK), South Saskatchewan River Basin.

Taber, Alberta (December 3rd, 2007)
Cabri-Stewart Valley, Saskatchewan (December 7th, 2007)
Outlook (April 21st, 2008)

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Executive Summary

This document reports on the results of three participatory mapping sessions conducted in Taber, Alberta, Cabri-Stewart Valley, Saskatchewan, in December of 2007, and Outlook, Saskatchewan in April of 2008. The sessions attempted to link the everyday life experiences of community members concerning climate related events and water, and information regarding the science of climate change, in order to develop a set of community recommendations to policy-makers. Those recommendations are intended to contribute to policy development to ameliorate the impacts of future climate change on water resources in the SSRB. These sessions form part of a doctoral dissertation research under the Institutional Adaptation on Climate Change Project (IACC). IACC is a research project supported by the Social Sciences and Humanities Research Council (2004-2008).

A participatory mapping session is a methodological approach that combines sequences of mapping presentations and small group discussions. It uses maps to facilitate and stimulate discussion among participants. Within the context of this study the focus of the discussion centred on rural community vulnerability and adaptive capacity to climate change and water. The sessions drew upon knowledge (*i.e.*, main patterns and trends) derived from an analysis of IACC community vulnerability assessment reports (*i.e.*, ethnographic work results), and the perspectives of rural community members on their vulnerability to climate change. In addition, series of maps were used to provide a visual representation of future climate change scenarios constructed by IACC scientists.

The participatory mapping sessions were also intended to enrich the capacity of participants to adapt to future impacts of climate change by helping them to foresee future alternatives/options to reach such a goal, and provide them with the means to develop a set of conscious recommendations to policy-makers in terms of climate change and water issues. Five important components of the participatory mapping session facilitated the latter: (a) participants took *ownership* of the session; (b) mapping presentations were *meaningful* to participants; (c) maps *validated* community and participants perspectives; (d) maps facilitated the visualisation of *patterns and trends* enriching participants' perspectives, providing context, and promoting discussion; and (e) the combined mapping-discussion sequences were not only *informative* but also facilitate a *progressive learning process*.

The participatory mapping sessions in this study targeted primarily the farming communities in the towns of Taber and surrounding area (within the boundaries of the Taber Municipal District, Alberta), Cabri and surrounding area (within the boundaries of the Riverside Rural Municipality, Saskatchewan), Stewart Valley and surrounding area (within the boundaries of the Saskatchewan Landing Rural Municipality, Saskatchewan), and Outlook and surrounding area (within the boundaries of the Fertile Valley and Rudy Rural Municipalities, Saskatchewan).

Participants in the Taber, Cabri-Stewart Valley, and Outlook sessions identified a number of stressors/exposures that either mirrored and/or complemented those identified in the community vulnerability assessment reports pursued earlier by IACC researchers. In

particular, the juxtaposition of multiple stressors was highlighted through the sessions. Taber, Cabri-Stewart Valley, and Outlook face two main external stressors/exposures: (a) the international market; and (b) global climate (*e.g.,* drought). Those external stressors interplay with particular regional and local conditions, generating a number of derived issues resulting from that interaction.

While the compound effect of the above global stressors impose serious challenges to the livelihoods of the farming communities of Taber, Cabri-Stewart Valley, and Outlook, governmental institutions, particularly those at the federal and provincial levels, were identified by participants as constraining the ability of these communities to adapt to climate stress and water issues. This third external stressor or force, *i.e.* governmental arrangements, was seen by the participatory mapping session participants as not responsive to community needs, and labeled by them as 'entrenching bureaucracy' characterized by governmental failure to listen and mistrust.

Intended to ameliorate the impacts of future climate change on water in the SSRB, participants in the three sessions (*i.e.* Taber, Cabri-Stewart Valley and Outlook) identified the following general recommendations:

- Long-term planning on climate change, water, and all initiatives.
- Improve communication between different levels of government (*i.e.* federal, provincial, and local).
- Increase funding for agricultural research and technology.
- Fund and promote conservation programs (including water and climate change).
- Fund communities and people to allow change (*i.e.* adaptation).

In addition, participants in at least two of the three communities (i.e. Taber, and/or Cabri-Stewart Valley, and/or Outlook) identified recommendations specifically directed towards each level of government as follows:

Federal level

- Long-term planning initiative.
- Support world wide climate change efforts.
- Increase existing utilization/construction of water storage capacity and associated irrigation operations.
- Fund research and technology, including agricultural research and technology and climate change institutes.

Provincial level

- Cut on crop insurance premiums and/or develop useful crop insurance (*e.g.* market neutral crop insurance; re-incorporation of hail into crop insurance).
- Listen to and get involved with the local government.

Participants at the Taber session also provided a number of additional recommendations:

Federal Level

- Clear climate change leadership.
- Political power to set policies of best management practices for conservation purposes.
- Political power to enforce existing legislation.
- Increase stakeholder groups input in the decision making process.
- Long-term funding for planning and research institutions with climate change mandate.
- Better watershed management.
- Oil industry best management practices regulations.
- Provide provincial and local governments the authority to develop change.
- Resolve outstanding water issues.
- Measure water resources nationally.

Provincial Level

- Invest in water conservation research.
- Develop water management strategy.
- Resolve standing issues in inter-provincial agreements of water crossing boundaries.
- Fund long-term solutions and balance economic level with environment.
- Need to work with federal government to lesser impact of climate change.

Municipal Level

- More water conservation policies.
- Education in water conservation and use.

Participants at the Cabri-Stewart Valley session provided the following additional recommendations:

Federal Level

- Increase utilization of existing water storage infrastructure (Gardiner Dam).

Provincial Level

- Intensify irrigation operation and increase utilization of Gardiner Dam.

Participants at the Outlook session provided the following additional recommendations:

Federal Level

- Education for both urban and rural population regarding the importance of agricultural activities and food production, and climate change.
- Support agricultural/climate pilot projects.
- Target and streamline immigration towards rural communities.

- Fund rural infrastructure.

Provincial Level

- Encourage and fund vegetable production.
- Cooperate with federal government to develop agricultural projects.

Local Level

- More decision-taking to ensure local relevance.
- Encourage better living standards.

The participatory mapping session approach developed in this study provided an effective mean of facilitating community input, while at the same time building capacity in those participating in the session. Participants engaged in a reflective and learning process that enriched their own perspectives in terms of climate and water stress, and also provided them with the opportunity for making informed and conscious recommendations to policy-makers.

The evaluations of the participatory mapping sessions indicated that participants found the methodological approach used in this study valuable and useful. Participants expressed their satisfaction with the overall mapping-discussion sessions, considered them informative and well done, and recognized them as venues for discussion. The evaluations also revealed that this type of combined approach, based on contextual mapping and discussion groups, helped participants to better understand the potential impacts of future climate change on water in their communities.

Remarks and comments made by participants in the evaluations of the sessions, revealed that maps and images enhanced participants understanding of vulnerability to climate change, by providing context to participants' relevant issues, such as drought, water and storage, and population patterns. In addition, participants suggested that maps and images allowed them to identify and recognize spatial and temporal trends and patterns in terms of exposures, adaptation strategies and climate change issues. These provided participants with a better understanding of the context, trends, and patterns in order to pursue a meaningful discussion in terms of community climate change issues and government roles.

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1. Introduction

This document reports on the findings of three participatory mapping sessions pursued in Taber and Cabri-Stewart Valley in December of 2007, and Outlook in April of 2008. The sessions constitute an important component of a Ph.D. research under the Institutional Adaptation on Climate Change Project (IACC). IACC is a research project supported by the Social Sciences and Humanities Research Council (2004-2008). The IACC project attempts to address the capacity of institutions in dry-land regions to adapt to the impacts of climate change, focusing on water (Diaz *et al.*, 2004). This is a comparative study of two basins: the South Saskatchewan River Basin (SSRB) in western Canada and the Elqui River Basin (ERB) of north-central Chile. The project seeks to understand the adaptive capacity of rural communities and rural households and the roles played by governance institutions in the development of those capacities (Diaz *et al.*, 2005). For further information on the IACC project refer to www.parc.ca/mcri.

The participatory mapping sessions targeted primarily the farming communities of Taber, Cabri-Stewart Valley, and Outlook, although not exclusively. The focus on farmers is mainly due to the fact that rural communities in the SSRB tend to rely primarily on agricultural activities such as crop production and livestock production on rangeland and pasture (Canadian Council on Ecological Areas, 2005), both highly dependent on the availability of water resources (freshwater and rain-fed water). Hence, this report refers mainly to the farming community living in the towns of Taber and surrounding area (within the boundaries of the Taber Municipal District, Alberta), Cabri and surrounding area (within the boundaries of the Riverside Rural Municipality, Saskatchewan), Stewart Valley and surrounding area (within the boundaries of the Saskatchewan Landing Rural Municipality, Saskatchewan), and Outlook and surrounding area (within the boundaries of Rudy and Fertile Valley Rural Municipalities, Saskatchewan).

Each participatory mapping session combines a sequence of mapping presentations and small group discussions. Maps were used to provide a visual representation of peoples' environments (*i.e.*, maps as visual language), when possible, as an alternative by which complex phenomena, such as climate change issues, can be interpreted (Weiner *et al.*, 2001; Schlossberg and Shufford, 2005). The use of maps aimed at facilitating and stimulating dialogue among rural community members, in terms of rural community vulnerability and adaptive capacity to climate change. The sessions attempted to provide the means for integrating in community members' minds the everyday life experiences (*i.e.*, community members' vulnerabilities and adaptive capacities previously identified through ethnographic work) and the science (*i.e.*, future climate change scenarios developed by IACC researchers). The goal is to facilitate the integration of knowledge of the vulnerability and adaptive capacity of the rural communities, in order to develop a set of community recommendations to policy-makers to contribute to policy development to ameliorate the impacts of future climate change on water resources in the SSRB.

2. Main Goal and Objectives

The main goal of the participatory mapping session is to facilitate the integration of knowledge of the vulnerability and adaptive capacity of rural communities, in order to contribute to policy development to ameliorate the impacts of climate change on water resources in the South Saskatchewan River Basin.

2.1 Objectives

1. To facilitate knowledge transfer between community members and researchers.
2. By combining the use of map data and small discussion groups, to stimulate discussion and allow community members to assess the future potential impacts of climate change on water, within the context of previously identified community vulnerabilities to climate change and water (*i.e.*, how do they see themselves adapting?).
3. To develop a set of community recommendations to policy-makers.

3. The conceptual background behind the participatory mapping session

The content and construction of the participatory mapping session was based on four main components: (a) focus on institutions as enhancing or hindering the adaptive capacity of rural communities; (b) community perspectives on their vulnerability to climate change and related patterns and trends; (c) scientists' climate change scenarios as a complementary understanding of the community perspectives on vulnerability to climate change; and (d) participatory mapping as the means to facilitate the integration of knowledge of (b) and (c). Following is a brief explanation of each component.

3.1 Institutions as enhancing or hindering the adaptive capacity of communities

Within the context of climate change adaptation, the IACC project focuses on institutions, and recognizes *formal* as well as *informal* institutions. Government organizations are a good example of formal institutions, while communities and households are representative of informal institution. Institutions are important because they are 'the rules, organizations, and social norms that facilitate coordination of human action' (The World Bank, 2002: 38), as well as the 'means that hold society together by creating and maintaining an ordered system of social behaviors and relationships' (Diaz and Rojas, 2006: 1). Hence, institutions can potentially contribute to, or hinder the adaptive capacity of rural communities to cope with climate change impacts.

Formal institutions, *i.e.* government institutions and policies, have been identified as key actors regarding societal adaptation to climate change (Handmer *et al.*, 1999). In this sense, adaptation to climate change, *i.e.* institutional change, 'involves the development and implementation of comprehensive support mechanisms that improve the capacity of

different sectors to adapt to climate change.' (Diaz *et al.*, 2005: 4). Effective official policies, strategies and programs need to be tailored and respond to local needs in order to address local vulnerabilities, particularly because adaptation occurs at the community level (Klein and Smith, 2003; Smit and Pilifosova, 2003). Therefore, under the forecasted impacts of climate change on water resources, the sustainability of rural communities in prairie dry-lands depends in part on the capacity of government institutions to address the current and future vulnerabilities of those communities.

3.2 The concept of vulnerability to climate change, community perspectives, patterns and trends

In order to understand the adaptive capacity of rural communities and households to the future impacts of climate change on water, the IACC project studies the issue of adaptation and adaptive capacity based on the concept of vulnerability. Although there are a number of definitions of the concept of vulnerability in the climate change literature, the IACC project understands vulnerability based on the idea of the 'wounded soldier' or prior damage. Once wounded, the current capacity of the soldier, to respond to, or to cope with further attack has already been hindered by his existing wounded condition. Such an understanding of vulnerability incorporates the notion of *pre-existing constraints* on the capacity of individuals and social groups to respond to a wide variety of socio-economic, political and biophysical factors or stressors (Kelly and Adger, 2000).

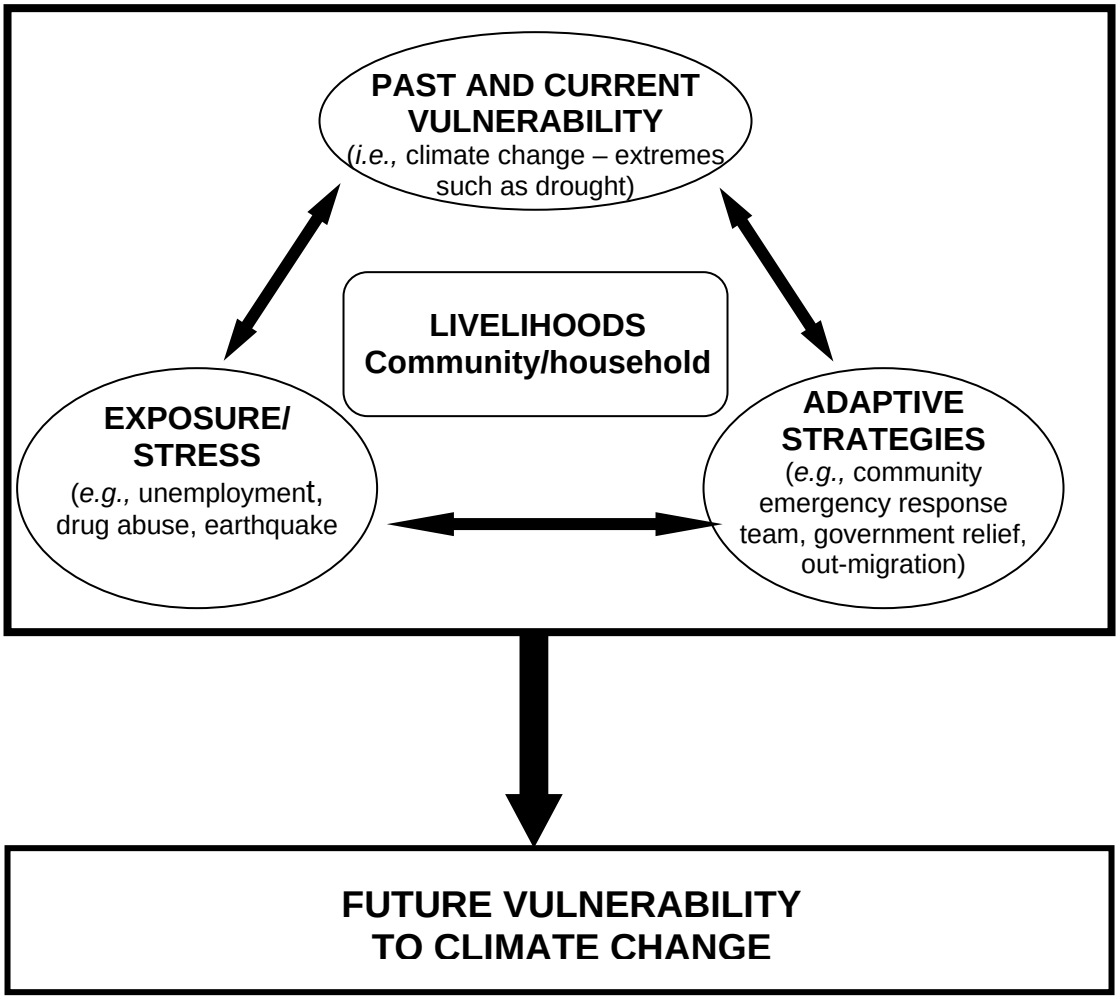
The above understanding of vulnerability is built upon the notion of susceptibility to be harmed (Smit and Pilifosova, 2003), and is defined as 'the degree to which a system [*e.g.*, community, household, family, and ecosystem] is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes' (Matlock, 2007:4). Hence, in terms of vulnerability to climate change, the adaptive capacity of a rural community to cope with the *future* impacts of climate change is based on its past and *current* vulnerability.

The vulnerability of a rural community to climate change is a function of its exposure and its adaptive capacity (Smit and Wandel, 2006). Figure 1 provides a simplified diagram of the vulnerability concept used in this report. The exposure component of vulnerability is reflected by the dynamic interaction and juxtaposition of multiple and diverse stressors/forces acting upon and within a rural community, such as unemployment levels, drug abuse levels, and earthquake events. These are local (*e.g.*, community kinship) and global (*e.g.*, international market) forces, some include intermediate forces, that do not act in isolation. For the contrary, these forces are tidily interconnected, and they interact generating processes that produce differential vulnerability patterns (Downing and Ludeke, 2002; Smit and Skinner, 2002).

The adaptive capacity component of vulnerability 'is understood as a community's ability to adapt to biophysical and social exposures and the environments that these exposures create' (Matlock, 2007:3). However, the ability of a rural community to adapt to exposures, is quite dependant on the availability and/or accessibility to

capitals/assets/resources (*e.g.*, natural resources, kinship and social networks, education and skills, existing industry, institutional arrangements), and the way in which the community relates and uses those capitals. In general, two rural communities exposed to the same climatic event, drought for example, might present different degrees of vulnerability, depending on each community's adaptive capacity, hence having a direct impact on the livelihoods of those living in the communities.

Figure 1. Simplified diagram of the concept of vulnerability.



There are a number of methods to identify and collect exposure and adaptive capacity information for a particular rural community in terms of vulnerability to climate change. The IACC project pursued ethnographic work to accomplish the latter. Researchers, research assistants and graduate students spent time living in the communities and pursuing observations and semi-structured interviews with community members. Semi-structured interviews were coded and analysed, allowing for the generation of information, and the identification of main themes and patterns in terms of exposures and adaptation strategies to climate change and water. This type of approach is based on

grounded theory, where theory emerges from the data itself, while data has been systematically obtained in an iterative and reflexive mode (Steinberg and Steinberg, 2006). The value of the ethnographic work resides in that it provides the perspectives of community members in terms of exposures and adaptive strategies, instead of the expert-outsider understanding of the community vulnerability. The results of the five community vulnerability assessments (*i.e.*, Blood Tribe Reserve, Cabri-Stewart Valley, Taber, Hanna, and Outlook) pursued in the SSRB can be found at www.parc.ca/mcri in the IACC project webpage.

3.3 Climate change scenarios, the scientist perspective on the rural communities vulnerability to climate change

A complementary understanding of the concept of vulnerability, refers to vulnerability as the outcome of the impacts of future climate change (Smit and Pilifosova, 2003; Parson *et al.*, 2003). By developing and applying global climate models (GCMs) and climate change scenarios, scientists are able to explore potential climate change impacts, as well as humans and ecosystems vulnerabilities. These vulnerabilities however, are defined after climate change has occurred, hence it does not consider prior damage to the climate change impacts (Olmos, 2001).

By using climate change scenarios, scientists attempt to elucidate possible future climates under particular assumptions on the use of fossil fuel and other human activities (*e.g.*, population growth trend, economic structure, climate initiatives, etc.). Climate change scenarios present scientists with an array of equally possible future alternatives in terms of climatic parameters, such as temperature, precipitation and climate moisture index. The value of this approach to climate change adaptation resides in that it provides a plausible range (*e.g.*, temperature) within which humans, and other systems such as ecosystems, might have to adapt sometime in the future.

3.4 The integration of multiple perspectives of the rural community vulnerability to climate change

The co-existence of multiple perspectives or realities in the understanding of vulnerability has been previously acknowledged by Hilhorst's (2004), and particularly to climate change by Diaz *et al.* (2005) and Patiño and Gauthier (2006). For the purposes of the participatory mapping sessions developed in this study, two perspectives of the rural community vulnerability to climate change are considered: (a) the rural community members' perspectives on vulnerability to climate change derived from IACC community assessment reports resulted from ethnographic work; and, (b) IACC project scientist's perspectives on the rural communities' vulnerability to climate change in terms of climate change scenarios. Although these two perspectives represent complementary pieces of knowledge, they are mainly *meaningful* for those who created them.

Therefore, in terms of developing a set of community recommendations to policy-makers to ameliorate the impacts of climate change on water resources in the SSRB, the challenge resides in finding venues to allow for the integration of the above complementary perspectives on vulnerability to climate change in community members' minds. Such integration requires participatory approaches that allow participants to build upon their understanding of vulnerability through an iterative and reflective process, promoting knowledge exchange as well as a continuous learning or co-learning between all those involved (Boothroyd *et al.*, 2004; Montero, 2004).

The visual capabilities of mapping and geographic information systems (GIS) have the potential for enhancing participation, while fostering dialogue as well as conveying different perspectives (Patiño and Gauthier, *in press*). Public Participatory GIS or PPGIS is a well established and growing discipline that combines participatory democracy and technologically based spatial analysis (Weiner *et al.,* 2001; Schlossberg and Shufford, 2005). By spatially visualizing information that draws upon rural community members' understanding of vulnerability within an area, such as a watershed, GIS can potentially facilitate and stimulates a reflective discussion capable of promoting knowledge exchange as well as a progressive learning process.

To accomplish the above, the participatory mapping sessions constructed in this study are comprised of a sequence of mapping-discussion sections. The first mapping portion of the first mapping-discussion section constitutes a series of maps that represent or reflect the main patterns and trends derived from the examination of the results of IACC project community vulnerability assessment reports, hence meaningful for community members. A consecutive mapping-discussion portion builds upon the latter by providing a visual representation, in map format, of future climate change scenarios constructed by IACC scientists, meaningful to scientists.

The coupling of GIS (visualization) and ethnographic work has already been explored by Knigge and Cope (2006) and Mathews *et al.* (2005). However, this study draws upon knowledge (*i.e.*, main patterns and trends) resulted from the analysis of the community vulnerability assessment reports (*i.e.*, ethnographic work results), hence of the rural community members' perspective of their vulnerability to climate change. Maps are used as an alternative/complementary approach to tell community members the *story* of their perspectives on vulnerability to climate change through an interconnected series of maps. The latter provides context while allowing participants to visually depict meaningful exposures and adaptive strategies patterns, providing a place to the rural community in question within the SSRB.

In summary, a participatory mapping session for this study is comprised of a combination of a series of maps and discussion, where maps are used to support, stimulate and encourage discussion, in order to facilitate the integration of knowledge in participants' minds. The latter attempts to enrich the capacity of participants' to adapt to future impacts of climate change, by helping them to foresee future alternatives/options to reach such a goal, and provide them with the means to develop a set of conscious recommendations to policy-makers in terms of climate change and water issues.

4. Methodology

Participatory mapping sessions were pursued in the SSRB communities of Taber and Cabri-Stewart Valley, in December of 2007, and Outlook, in April of 2008. Twenty letters of invitation were sent to community members on each community. Initially, invitations were sent only to community members that had been previously interviewed by IACC researchers during ethnographic field work. This targeted selection was intended to build onto the vulnerabilities and adaptive strategies already identified by community members in the ethnographic work pursued by IACC researchers. However, due to the lack of responses the invitation was then opened to other community members. Eleven community members participated in the Taber session. Five to 7 community members participated (7 in the morning portion of the session and 5 for the entire session) in the Cabri – Stewart Valley session, and 6 in the Outlook session.

One government official was invited to attend each participatory mapping session as an observer. Government officials that attended the sessions were asked to provide feedback of their observations during the sessions, as well as to provide suggestions and concerns they might have regarding the sessions.

4.1 Content of the participatory mapping sessions

The material developed for the participatory mapping sessions was primarily derived from the results of three main research components of the IACC project. These are: (a) the community vulnerability assessment reports for Cabri – Stewart Valley (Matlock, 2007), Taber (Prado, 2007), and Outlook (Pittman, 2008); and (b) the climate change scenarios research component developed by IACC project Ph.D. candidate Suzan Lapp. First, the community vulnerability assessment reports developed by IACC researchers, graduate students and research assistants, were reviewed to carefully select the information to be mapped. These maps were intended to reflect the community members' vulnerabilities perspectives to climate change and water, and at the same time, to provide community members with an alternative visual perspective and tool that allowed them to see spatially and temporally their own identified vulnerabilities.

IACC scientists, graduate students and research assistants have been developing a range of climate change scenarios. They have also been examining the potential effects of climate change impacts on the above identified vulnerabilities, as well as interpreting the potential impact of those scenarios on water. This component of the IACC project provided the perspective of scientists to the issue of climate change and water in the SSRB. A number of maps reflecting potential future climate change scenarios on precipitation, temperature and climate moisture indexes where created at the SSRB level, depicting 1961-1990 climatic normals and 2050s scenarios.

The above two components of knowledge (*i.e.*, community vulnerability assessments and scientific climate change scenarios) were used to generate a number of maps that either have meaning for community members or for IACC scientists. Rather than portrait specific rates and values, maps were used to depict main spatial and temporal trends and patterns. Furthermore, participants were specifically asked to focus on visualizing trends and patterns. Maps and images, and small group discussions were combined in order to facilitate and stimulate dialogue, in an attempt to provide the means for integrating in peoples' minds the science and the everyday life experiences.

The information was mapped for all the SSRB at the municipal level. Most social, economic, and agricultural related information was obtained from Statistics Canada through the University of Regina Data Liberation Agreement: (1) 1996a and 2001a Agricultural Census; (2) 1996b, 2001b and 2006 Census, and; (3) 1996c and 2001c Census - 20% sample data. Saskatchewan oil and gas digital map data was downloaded from the Government of Saskatchewan (2007) webpage. Climate scenarios data was provided by Susan Lapp, Ph.D. candidate at the University of Regina, Saskatchewan, and research fellow of the IACC project.

Approximately 60 maps were presented in each participatory mapping session. Maps were created using ArcGIS 9.1 geographic information systems from Environmental Systems and Research Institute © (ESRI©). The software was facilitated by ESRI© through the 2005 ESRI Student Scholarship Award.

4.2 Structure of the participatory mapping session

Each session ran for approximately 5.5 hours (9:00 a.m. - 2:30 p.m.) and comprised three main mapping-discussion sections (see Appendix 1 for a sample of the participatory mapping session agenda). The dynamic of the participatory mapping sessions combined a sequence of mapping presentations and small group discussions in order to facilitate and stimulate dialogue, in an attempt to provide the means for integrating in peoples' minds the science and the everyday life experiences.

The first mapping-discussion section of the participatory mapping session started by asking participants to construct a scheme containing the main current community vulnerabilities, constraints and adaptive strategies, in terms of climate events and water issues. The purpose of this section was to allow participants to identify and discuss vulnerabilities that they considered relevant for the community in terms of climate events and water. The expected outcome of this section was a jointly reflected and constructed scheme of current community vulnerabilities.

This first section was the most extensive and included: (1) presentation of the objectives of the participatory mapping session; (2) brief introduction to the IACC project and an explanation of the concept of vulnerability as understood by IACC researchers, and an explanation on how to read a map (3) discussion and construction of the main climate and water related vulnerabilities, constraints and adaptive strategies scheme (see Appendices

2 and 3 for a template and example of a vulnerability scheme); (4) presentation of the results of the community assessment pursued during the ethnographic work; (5) re-examination of the vulnerability scheme constructed in step 3, if necessary, and; (6) participants' evaluation of the of results of the community assessment based on the ethnographic work and mapping component (Appendix 4 shows an evaluation form for the results of the community assessment).

The second section of the participatory mapping section related to climate change scenarios for the area, and the implications of the potential impacts of future climate change on current exposures/constraints and adaptive strategies. The purpose of this section was to allow participants to reflect on the potential implications of future climate change on their livelihoods and current adaptation strategies, as well as considered future alternatives. This section included: (1) introduction to the concepts of climate change and climate change scenarios; (2) presentation of a medium climate change scenario for the area in terms of temperature, precipitation and climate moisture index. Participants were encouraged to focus on trends rather than on particular number figures, and; (3) discussion of the implications of potential impacts of future climate change on current vulnerabilities and adaptive strategies (see Appendix 5 for a template of the implications of potential impacts of future climate change on current vulnerabilities).

Finally, the third section of the participatory mapping session focused on a discussion on the role of government institutions under potential impacts of future climate change on water (see Appendix 6 for a template of the discussion of the role of government institutions under potential impacts of future climate change on water). The purpose of this section was to allow participants to discuss the current role of government institutions, and reflect on how government could facilitate community members to adapt to the future impacts of climate change and water. The outcome of this section was a set of community recommendations to policy-makers in terms of climate change and water issues. In addition, an evaluation of the overall participatory mapping session was pursued. Appendix 7 shows an evaluation form of the participatory mapping session.

5. Results

The participatory mapping sessions pursued in the three rural communities generated three main sets of results. Each set of results relates directly to the three main mapping-discussion sections described above in the methodology: (1) the construction of the main current community vulnerabilities scheme; (2) climate change scenarios for the area and potential impacts, and: (3) the role of government institutions and community recommendations under potential impacts of future climate change on water.

Eleven community members attended the Taber participatory mapping session, and were divided into two small discussion groups of five and six participants respectively. The Cabri-Stewart Valley initially counted with seven community members during the morning portion of the session, while five participants attended the whole session. One small discussion group was created in the Cabri-Stewart Valley session. Six community

members attended the Outlook participatory mapping session conforming one discussion group.

5.1 Construction of the main current community vulnerabilities to climate events and water related issues scheme

This section of the participatory mapping session started with a presentation of the objectives of the participatory mapping session, and an overview and main objectives of the IACC project. Participants were introduced to the concept of vulnerability to climate change as understood by IACC researchers. An example of community vulnerability to climate change was reviewed with participants, as well as an explanation on how to read a map.

Participants were asked to gather around a table to discussion and construct a scheme of the main vulnerabilities to climate related events and water that their communities are currently facing. Each participant was given a paper copy of the community vulnerability climate scheme template depicted in Appendix 2. A researcher and/or research assistant sat with each small discussion group to assist in any questions and provide support and guidance to the reflective process of constructing a community vulnerability scheme. As describe in the methodological portion of this report, participants in Taber separated into two small discussion groups of five and six community members. Participants in Cabri-Stewart Valley and Outlook sessions gathered in one discussion group of 5-7 and 6 participants, respectively.

Once the discussion and construction of a scheme of the main vulnerabilities to climate related events and water was completed, research results of the community vulnerability assessment pursued during the summer of 2005 in Cabri – Stewart Valley, the summer of 2007 in Taber, and the fall 2007 and winter of 2008 in Outlook, were presented to participants. These results were presented in two formats: (a) as an explanation of the findings listed in a slide presentation; and (b) as a sequence of maps that told the same story (*i.e.*, main patterns and trends identified in the ethnographic work) spatially and temporally, providing a visual regional perspective (*i.e.*, watershed level - SSRB) in conjunction with a more local situation (*i.e.*, municipal level). Then, participants had the option to revise their previously developed scheme of the main vulnerabilities to climate related events and water, if desired. Finally, participants were asked to evaluate the degree to which they agree or disagree with the results of the community vulnerability assessment previously presented.

5.1.1 Taber main current community vulnerabilities to climate events and water related issues scheme

Participants identified and discussed main vulnerabilities to climatic events related to water issues, constraints and impacts as well as adaptation strategies, that they considered relevant for the community livelihood and every day lives. In terms of vulnerability to

climate and water related events, participants focused on the **lack of water availability (mainly on consecutive droughts)**, **intense rain events** and **watershed water quality**. Figures 2 and 3 show the community vulnerability scheme created as a result of the above discussion.

The most dramatic climatic and water related event identified by participants, in terms of lack of water availability, referred to consecutive droughts, particularly because consecutive droughts negatively impact both irrigated as well as dry-land crops. Participants felt that farmers are currently able to cope with two consecutive years of drought, but there is no capacity to cope with three years of consecutive drought. Drought has meant a reduction in both crop yield and quality, as well as an increase in the cost of irrigation for irrigation farmers. Related to the lack of water availability, the lack of storms in spring has meant a poor start in terms of spring planting. In the past, community members have dealt with the lack of water by applying water rationing policies (such as watering lawn schedules), and relying on weather based crop insurance, and government programs such as the Canada Agricultural Income Stability Program.

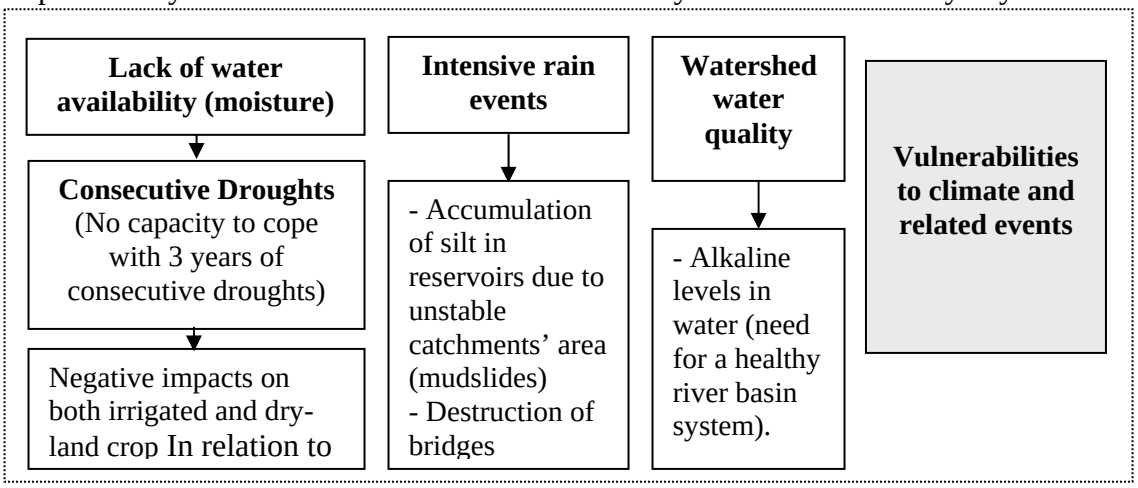
In relation to lack of water availability (moisture), participants stated that the water issue is in part a 'water storage' issue. The insufficient water storage is seen as a constraint to deal with the impacts of consecutive droughts. In terms of irrigation and reservoirs, participants noted the limitation of snow in the mountains, and commented on the reduced amount of snow precipitation currently occurring in relation to the past. Also, participants recognized the contribution of June rains to the storage of water for irrigation, and mentioned the failure of the Taber irrigation district to provide the necessary irrigation water in 2000 due to the lack of available water in the St. Mary dam. This failure is attributed in part to repair work needed to be pursued in the dam.

In addition to the water storage issue for irrigation, and while acknowledging a dramatic improvement on the efficiency in the supply and distribution of water, participants identified the need for maintaining and updating the whole irrigation infrastructure system, including updated channels and pump lines. Technology is recognized as playing a relevant role in terms of improving the efficiency of water use.

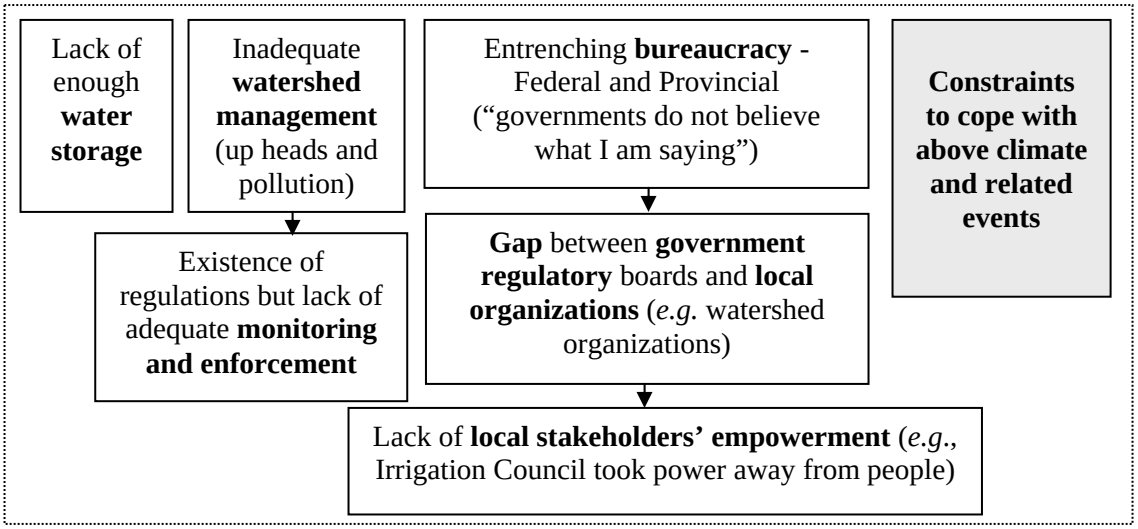
The improvement in the efficiency of conservation of moisture in the soil is mainly attributed to the implementation of agricultural techniques and practices (*e.g.*, no tillage and continuous cropping). However, participants saw the need for an additional paradigm shift in the minds of farmers, where soil tillage needs to be replaced by rotation crops to further conserve moisture in the soil. Related to this issue, ranching and community pastures are seen as contributing to moisture conservation, because cattle maintain litter on the soil.

Figure 2. Group 1: Current Vulnerabilities to climate Scheme BEFORE Ethnographic Current Vulnerabilities Presentation. Taber.

In terms of climate events and water, list the main climate and related events and their impacts that you consider relevant for the community livelihood and every day lives.



What constraints the community to deal with the impacts of the above climate and related events.



How have the community dealt with the impacts of the above climate and related events.

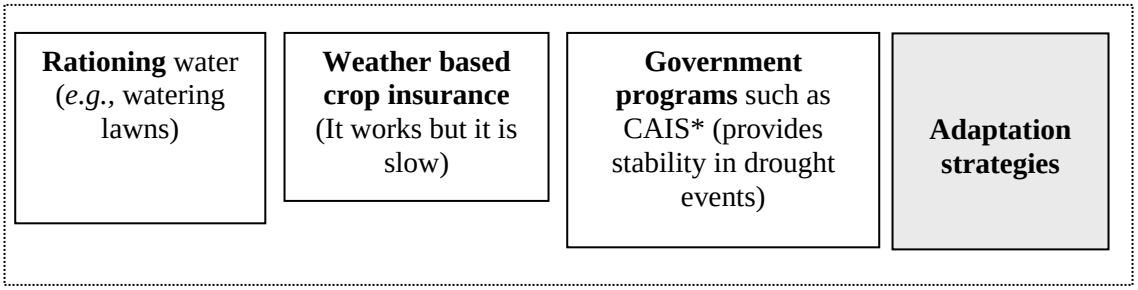
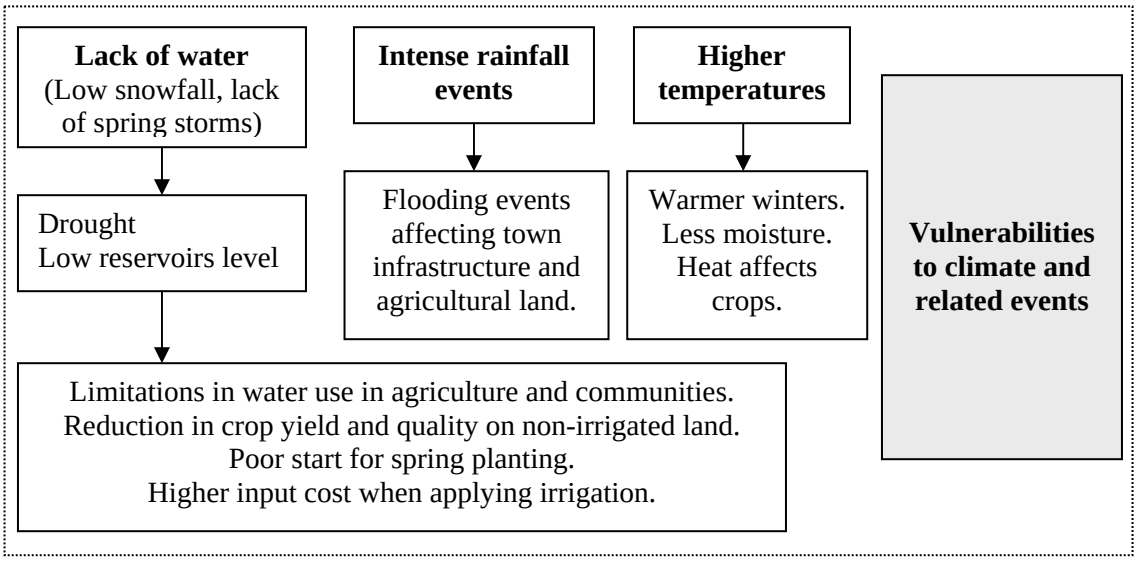
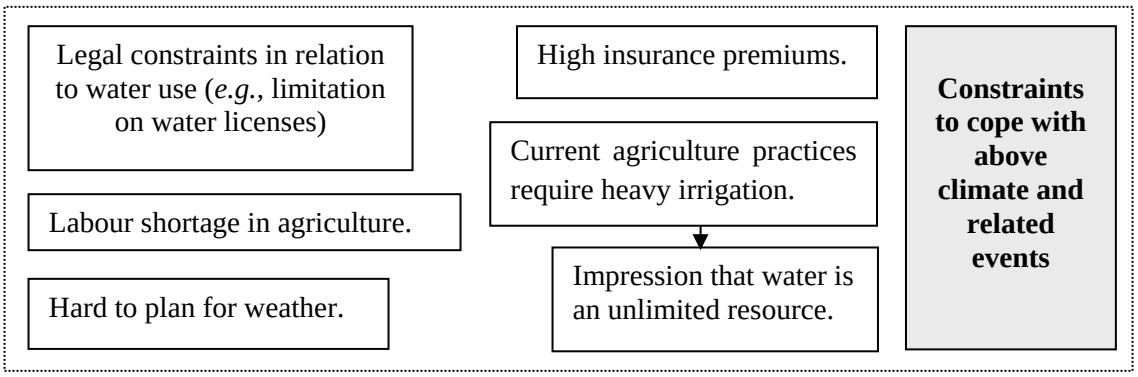


Figure 3. Group 2: Current Vulnerabilities to climate Scheme BEFORE Ethnographic Current Vulnerabilities Presentation. Taber.

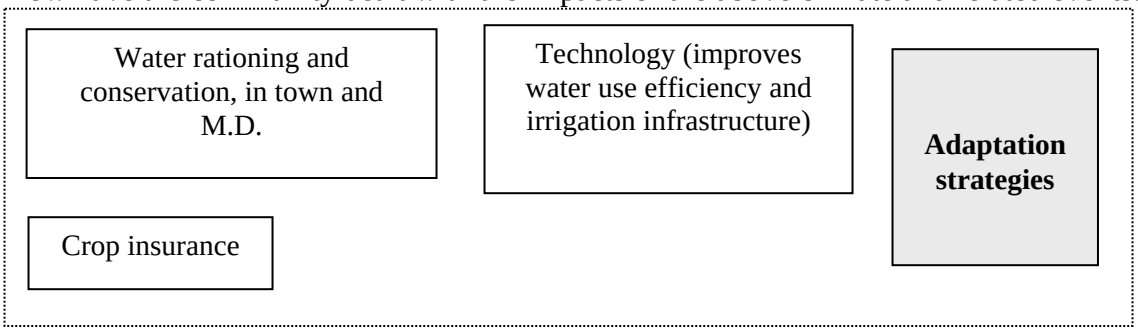
In terms of climate related events and water, list the main climate events and their impacts that you consider relevant for the community livelihood and every day lives.



What constraints the community to deal with the impacts of the above climate and related events.



How have the community dealt with the impacts of the above climate and related events.



In relation to water conservation in town (*i.e.*, Taber), participants expressed their concerns regarding an apparent general perception of water as an unlimited resource, and particularly at the household level. In other words, participants identified the lack of a culture of water conservation in town.

Participants identified four main users of water in the Taber and surrounding area: the agricultural sector, municipalities (towns and cities), industries (canneries) and oil and gas. While the discussion considered that all users must be responsible for the use of water, the agricultural sector was identified as the one that consumes the vast majority of the water made available by dams in the Oldman River basin. Over 90% of the water is used for agricultural irrigation purposes, and over 75 % of the water withdrawn for irrigation is not returned to the watercourses (Rush, 2003). Participants recognized that current agricultural practices in the Taber M.D. require intense irrigation, increasing the pressure on available water resources. Potatoes and sugar beets farmers, for example, are high users of water.

The second main climatic and water related event identified by participants refers to intense rain episodes. Participants see themselves as vulnerable to intense rains, because these events negatively impact reservoirs and add to the issue of 'water storage'. The accumulation of silt, plus the impact of mudslides due to unstable watershed catchments' areas, has the potential for further reducing the existing water storage capacity of reservoirs. Forestry and agriculture were mentioned as two of the activities that disturbed the stability of the watershed catchments' areas. In addition, intense rains bring the destruction of bridges, disruption of communication and transportation networks, flooding of basements and other infrastructure, as well as flooding of agricultural land in the Taber Municipal District.

The third main climatic and water related event recognized by participants corresponds to watershed water quality. The discussion centred on the issue of alkaline levels in the water and its potential increase. Other types of pollutants are not seen as eminent threats for the population or ecosystems. Participants realized that maintaining a healthy river basin system is vital to preserve adequate levels of alkaline in the water, as well as to reduce the accumulation of silt in reservoirs, discussed above. While watershed management and regulatory bodies are in place, participants felt that these are insufficient, and that there is a lack of adequate monitoring and enforcement.

In terms of institutional constraints, external institutions, *i.e.* Federal and Provincial governments, are described by participants as entrenching bureaucracies and as lacking a long-term environmental vision. This situation is understood as a communication gap between government regulatory boards and local organizations (*e.g.* watershed organizations). The feeling is that "… governments do not believe what I am saying", and there is a sense of frustration. In addition, while participants felt that the process of decision-making requires the involvement of all stakeholders, they recognized the lack the motivation/incentive to act in people (*i.e.*, lack of local stakeholders' empowerment, "… Irrigation Council took power away from people').

Other institutional constraints relate to legal restrictions in the use of available water. For example, water licenses are limited, and therefore they restrict the amount of water to be used by farmers and others. Participants also mentioned the restrictions on water use brought by the Milk River Water Agreement with the U.S. Finally, crop insurance premiums were referred as excessively high imposing a serious financial challenge to farmers.

High temperatures, and particularly warmer winters, were also identified by participants as having a negative impact on farming. Warmer temperatures in winter translate into less snow accumulation, hence less soil moisture for crops in spring. Finally, shortage of agricultural workers in the area was considered an important constraint, mainly due to the labour intensive nature of the vegetable crops.

5.1.2 Cabri-Stewart Valley main current community vulnerabilities to climate events and water related issues scheme

The discussion identified the main community vulnerabilities to climatic events related to water issues, constraints and impacts, as well as adaptation strategies, considered important by participants for the livelihoods and every day lives of the community. Participants attributed the **lack of water availability** (including moisture) as the main climatic related vulnerability that the community currently faces, followed by **excess of water**, and **tornados and wind**. Figure 4 shows the community vulnerability scheme created as a result of the discussion on main current community vulnerabilities to climate events and water related issues.

In terms of lack of water availability, **droughts** were identified as the main vulnerability for the livelihoods and every day life in agricultural communities. Participants are quite aware of the community dependency on soil moisture for agriculture. They also recognized and have experienced the negative impacts of drought events on towns and villages, as well as on farmers' and ranchers' incomes. In addition, drought is also acknowledged as an event that increases the possibility of soil erosion due to the lack of straw on the ground.

Agricultural conservation practices, such as zero tillage and continuous cropping, have been identified by participants as important adaptation measures in order to retain moisture in the soil and prevent soil erosion. Also, water storage, such as dugouts and dams, had also been acknowledged as strategies to cope with the lack of water. Although quite limited, there is some irrigation in the Stewart Valley area.

Participants identified economic restrictions as the main constraints to cope with the lack of water availability. The discussion focused on low income or lack of income, due to marker driven prices and/or drought events. Participants recognized the impact of these economic limitations as affecting the entire community system, such as schools and sport/recreational facilities.

Farmers and ranchers incomes are quite dependent on market driven prices. Although the price of the grain has improved lately, years of low income, due to low grain prices based on international subsidies, affected Canadian prairie farmers. Farmers have introduced specialty crops, such as pulse crops, in an attempt to cope with low grain prices. However, specialty crops are a challenge in terms of getting them to the market, and although irrigation is available, the pumping cost is too expensive and makes irrigation impossible in the area.

Economic constraint also relates to the lack of income as a result of drought events. The area is strongly based on a dry-land agricultural activity, where soil moisture and rain fed crops play a crucial role in the livelihoods of the communities of Cabri and Stewart Valley. The compound impact of high input costs, low grain marker prices, exacerbated by drought events, has dramatically altered the agricultural demographic and land patterns of the area. The traditional family farm is rapidly disappearing. While farm sizes are increasing, family farmers are struggling to survive until they have to sell the land and/or migrate. The latter has meant the depopulation of rural areas, and particularly a decrease in the number of children and young population.

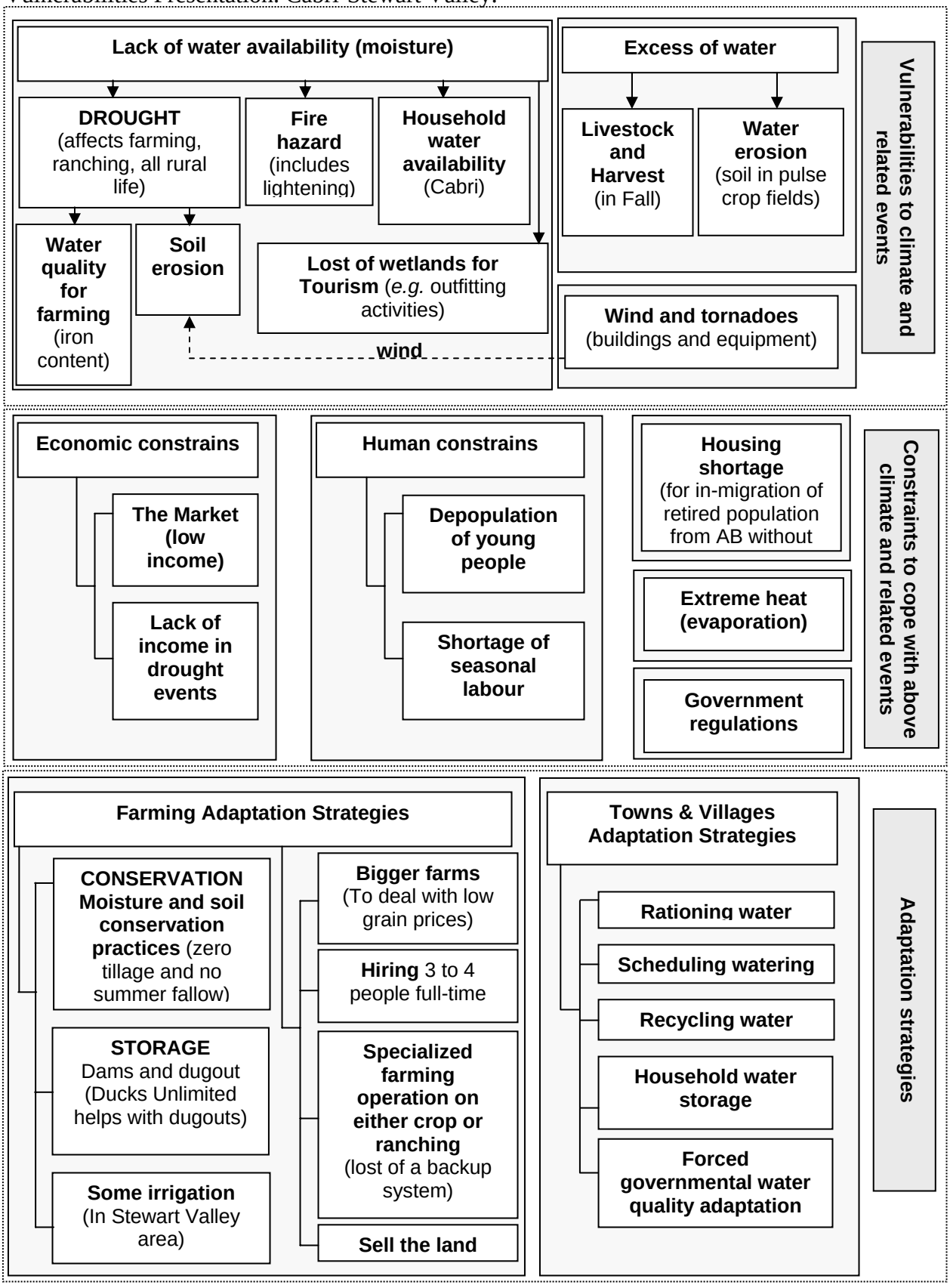
Adaptation strategies to cope with low income due to low grain price have resulted in larger farm sizes, which have in part translated in an increasing operation cost due to the need for hiring 3 to 4 full-time people. In addition, start input costs have prohibited the younger generation to start farming. In the past, land used to be given to the younger generation by their parents. Nowadays, parents need to sell the land to their children to survive.

Bigger farm sizes, and hence decreasing number of farms, have not only meant that the family farm is disappearing, but also that the mixed farming/livestock (*e.g.*, pork and cattle) operation practice is being abandoned. It seems that in order to survive, farmers/ranchers have shifted to a specialized farming operation of either crop or ranching, and giving up what once was a backup type of system (*i.e.*, if either ranching or farming failed in providing income, there other would allow for a minimum income).

In addition to, and in part as a result of, the above economic constraints, participants have identified two main human constraints, that is depopulation, and particularly of young people, and shortage of agricultural labour. Participants expressed their concerns regarding the lack of young population. A young population base is recognized as vital in order to support the required infrastructure (*e.g.*, schools, hospitals, roads, etc.) that sustains rural communities and their lifestyle. Young people leave the community in search for better job opportunities and/or further education.

On the other hand, the oil and gas industry has brought some activity to the area, providing a number of job opportunities for the young population, as well as somewhat helping the local economy. Participants see the oil and gas industry as a temporary activity and wonder how long it will last. In relation to shortage of agricultural labour, and in conjunction with the lack of population, the high salaries paid by the oil and gas industry makes impossible for farmers to compete for labourers.

Figure 4. Current Vulnerabilities to climate Scheme BEFORE Ethnographic Current Vulnerabilities Presentation. Cabri-Stewart Valley.



In terms of infrastructure constraints, participants identified a shortage of adequate housing. During the last few years participants have noticed that population from Alberta has moved into their communities, comprising mainly of retired population. Although participants value and welcome newcomers, they pointed out that this in-migration process occurs generally without bringing any children to the area.

Extreme heat has also been identified as a constraint to cope with the lack of water/moisture availability. Related to the lack of water availability, dry weather and lightening, participants identified an increase in fire hazard. Currently, there are two major fires every year. Participants noticed that certain adaptation strategies have had an impact on fire events. These adaptation strategies include: abandoned marginal lands; the use of agricultural equipment; the introduction of specialty crops; and, moisture and soil conservation cropping practices. The impact on fire hazard of these adaptation strategies do not act in isolation, on the contrary, they feed on each other increasing the frequency and intensity of fires.

Crop production on marginal lands has not been economically viable lately, and the land has been abandoned and converted back to grass. In addition, the introduction of specialty pulse crops in the area, and particularly peas, increases the hazard for fire, because pulse crops tend to dry. Furthermore, while summer fallowed practices used to act as fire breaks, continue cropping practices provides an uninterrupted cover of combustible material for fire events. The use of agricultural equipment (*e.g.,* combines) has also been identified as increasing fire hazards. Agricultural equipments are left on the fields during combining and seeding periods, both of which are happening earlier in the season. July is a particularly sensitive month, due to extremely high temperatures that heat the equipment and start fires.

In terms of household water availability, the lack of water plays an important role for the town of Cabri. Cabri relies on water fluctuations of the South Saskatchewan River and the Diefenbaker Lake. A permanent pipeline is in place in order to fill up the town reservoir. A pump is used due to fluctuations in the Diefenbaker Lake. This water fluctuation is in part attributed, and particularly in term of loss of water in the basin, to ecosystem management practices that protect wildflowers in the Diefenbaker Lake. In addition to the loss of water, participants have noticed an increase in algae in the water of the basin. Town Public Works depends mainly on the snow that is left on the ground in spring (spring runoff).

Participants also expressed their concerns regarding the share of water taken by communities and activities upstream the South Saskatchewan River Basin, and particularly Alberta. Although there is an agreement in place (*i.e.,* The 1969 Master Agreement on Apportionment), where Alberta is entitled to 50% of the natural flow of water arising in or flowing through the Province of Alberta, participants fear that Alberta might take too much water from the SSRB in the future.

Residents of Stewart Valley have no water availability issues for household use. Contrary to Cabri, Stewart Valley obtains water for household use from water wells, which seem to have plenty of water and are considered a reliable source of water.

In relation to domestic and household water adaptations strategies, participants argued that Cabri, as well as Stewart Valley, have in place a water rationing and scheduling system for watering gardens. Restrictions have been more severe some years and watering gardens have been prohibited, as well as carwash. Participants also identified storage of rain water in large containers, and recycling water (*e.g.,* water plants with water previously used for washing dishes) as adaptation measures.

In terms of water quality, there are two levels to be considered. First, water is used for farming activities, such pesticide and herbicide spraying operations. Participants mentioned that the quality of water used for spraying is directly related to drought events. The content of iron in the Riverside RM water wells, and Cabri surrounding area, tends to increase during drought periods.

Water quality at the household level does not seem to be an important concern. Participants were asked to comment specifically about the quality of water for residential use. It was mentioned that in the past there was an "E-coli scare" in Cabri. After this event, residents of Cabri did not go back to regular water and they have been using water bottles since then.

In Stewart Valley, the 'new well' provides good quality of water, although the majority of the population uses water bottles. Rather than struggling with the quality of the water, Stewart Valley is stressed by the role played by external institutions, that is government regulations (*e.g.,* 'the government is regulating us to death'). According to participants, in Stewart Valley '…the only problem, which is not a problem, is magnesium'. There is an issue with the levels of magnesium in the water which reacts with chlorination. This situation has involved the provincial government in the water management of Stewart Valley, translating into the burden of an increasing cost for the residents.

Although there hasn't been any sickness, participants stated that the government is increasingly getting stricter. The water is tested daily at provincial labs which immediately notifies the government of any irregularities. Currently, foremen are required to be certified and this is '… killing rural Saskatchewan' due to the cost involved (high qualification education and higher salaries; water plant equipment).

Despite the stress brought for the communities by the provincial government regulations, participants recognized the role played by these government regulations in terms of water quality, and referred to them as forced governmental water quality adaptation. The domestic use of bottled water for consumption was also identified as an adaptation measure.

Another issue identified by participants in relation to the lack of available water in the area is the lost of wetlands. The latter was directly related to the outfitting business.

Community members have noticed that sloughs are drying up, and that the water table is not as higher as it used to be in the Cabri area.

In terms of excess of water, Fall rain events, although rare, have been identified as having an important negative impact during harvest time, by preventing the crops to be harvested, as well as affecting livestock. In terms of loss of soil due to water erosion, specialty crops (*i.e.*, pulse crops) are particularly sensitive. The latter happens when there is a combination of a good snow cover on the ground and a quick spring runoff. Another issue connected to the excess of water, relates to the management of the Diefenbaker Lake water levels. Sometimes the lake is filled up too fast, and a managerial decision is taken to let the water run causing the flooding of crop lands and pastures in the area.

The last two identified climatic related events that have an impact on the livelihoods and lives of the community members are wind and tornados. Buildings as well as machineries are destroyed and/or suffered severe damage during extreme wind events and tornadoes. In addition, wind is related to soil erosion, and particularly during drought episodes. Participants stated that 2007 has been the windiest year that they have ever had.

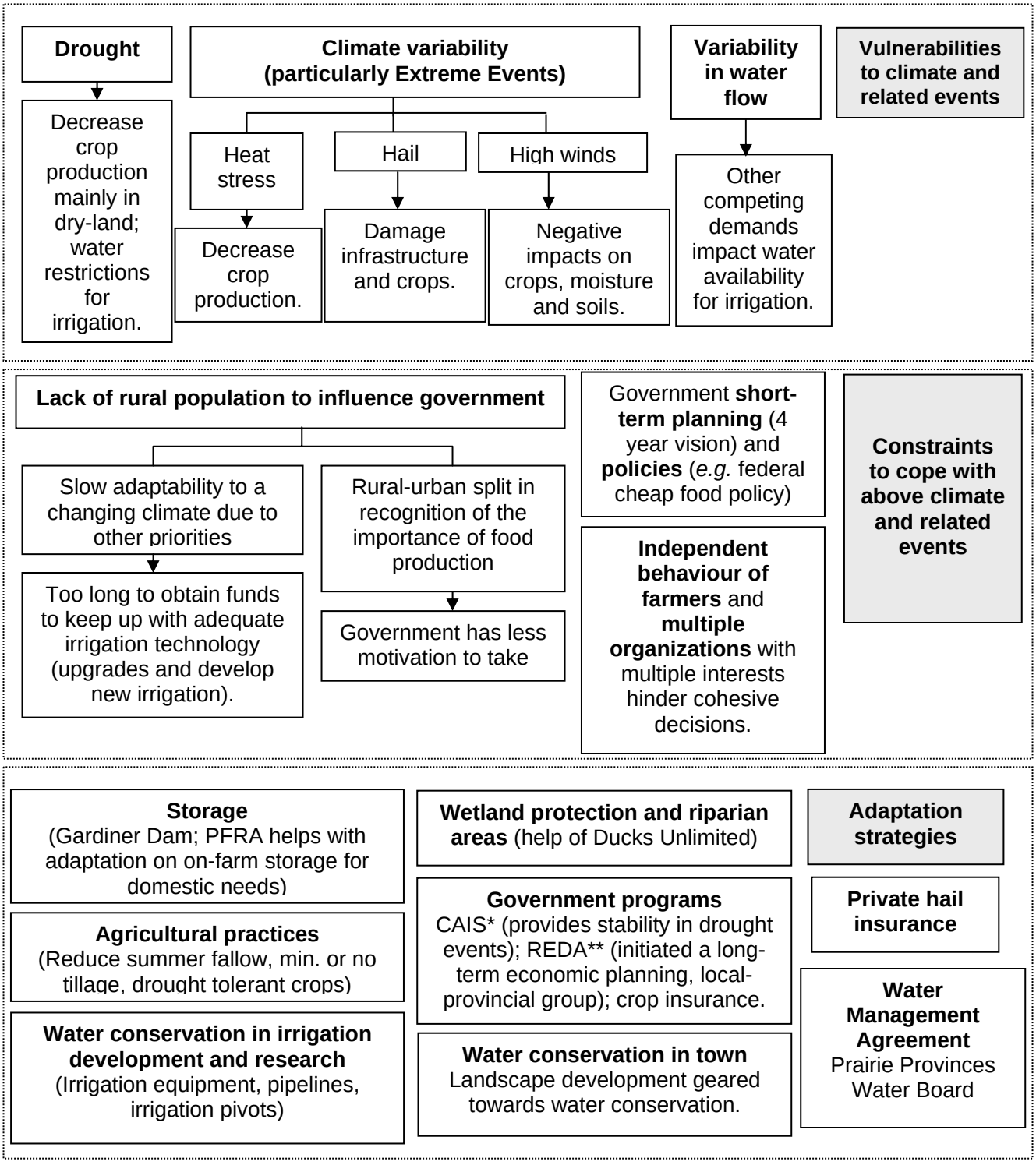
5.1.3 Outlook main current community vulnerabilities to climate events and water related issues scheme

Participants identified and discussed main vulnerabilities to climatic events related to water issues, constraints and impacts, and adaptation strategies. The discussion recognized three main climate and water related vulnerabilities, *i.e*. **lack of rainfall and particularly drought**, **climate variability and particularly extreme events**, and **variability in water flow**. Figure 5 shows the community vulnerability scheme resulting from the above discussion.

The lack of rainfall during the growing season, and particularly drought, has been identified by participants as the most dramatic vulnerability. Past droughts have had devastating impacts on the livelihoods of dry-land farmers due to a significant decrease of the crop production. While irrigation guarantees irrigation farmers a crop and probably higher commodity prices, water restrictions for irrigation during drought periods are considered a problem.

Climate variability, *i.e.* extreme events, has also been identified as an important factor negatively affecting farmers' livelihoods, and particularly since it limits the ability to plan. Participants recognized three extreme climate events in the area, *i.e.* extremely high temperatures during the summer growing season, hail and high wind events. Extremely high temperatures during the summer, such as in the summer of 2007, exacerbates the moisture deficit character of the area, and keeping up with irrigation becomes a challenge.

Figure 5. Current Vulnerabilities to climate Scheme BEFORE Ethnographic Current Vulnerabilities Presentation. Outlook.



*CAIS: Canada Agricultural Income Stability Program
** REDA: Regional Economic Development Authority

Hail occurrences are particularly detrimental by arbitrarily affecting both dry-land and irrigation farmers. Hail events have the potential to severely damage crops as well as infrastructure. High winds were also acknowledged as having a harmful effect on crops and infrastructure/equipment. Perhaps the most devastating effect of high winds relates to the capacity of blowing away valuable soil and soil moisture, becoming particularly harmful during drought periods.

A third vulnerability to climate and water related events referred to changes in the water flow of the South Saskatchewan River. During periods of low river flow all water consumptive uses are affected by the need for imposing water restrictions. These restrictions significantly reduce the amount of water available for irrigation purposes.

Participants identified three clusters of constraints to cope with the above climate and water related events. These are lack of rural population to influence government, government short-term planning, and independent behaviour of farmers. In terms of lack of rural population to influence government, participants felt that other priorities and particularly urban priorities, take precedent over rural necessities. Hence, governments hesitate to provide, as well as delay, funds directed towards the upgrade of the irrigation infrastructure and development of new irrigation areas, for example. Participants stated that in order to cope with the above climate and water related issues, adaptation needs to happen at a faster pace, however the financial constraints hinder such an endeavour. In summary, participants argued that the delay of the availability of governmental funds slows down the ability of farmers to adapt to a changing climate, due to more attractive political priorities.

Related to the above, participants identified a strong rural-urban split in terms of the recognition given to the rural activities. This knowledge/cultural gap is attributed to miscommunication and misunderstanding of the rural activities and their importance by the urban population. As a result, participants saw the urban population as lacking appreciation for the rural activities and the importance of food production. This situation is perceived as hindering, as well as reducing, the motivation of the government to take risks, in terms of investing and developing the required rural infrastructure and entire rural system.

Another constraint to adapt to climate and related water events identified by participants relates to the short-term planning vision and inability of the government to plan for longer periods of time. This situation is attributed to the short time frame of the elected government of four years. Therefore, it is natural to perceive policies as not necessarily having a long term vision. In addition, government policies and regulation are seen as hindering adaptation, particularly those regarding the federal policy on ‘cheap food’ and the imports of food that could be produced in the country.

Other constraints identified by participants relates to the independent character of farmers in the area and the existence of multiple organizations with multiple interests hindering a cohesive decision process. In this sense, signals taken by multiple rural organizations to the different levels of government are fragmented and represent competing interests.

In terms of current and past adaptive strategies to deal with the impacts of the above climate and related events, participants identified water storage, changes in agricultural practices, water conservation as well as development and research in irrigation, wetlands protection, government programs, private hail insurance, and water management agreements.

The first adaptation strategy mentioned by participants refers to water storage, specifically to the construction of the Gardiner Dam and related irrigation system. The Rudy Rural Municipality greatly benefits from irrigation that utilizes water from the dam. In addition, Ducks Unlimited has played an important role is the maintenance and restoration of riparian areas, while Prairie Farm Rehabilitation Administration is acknowledged as helping farmers adopting an on-farm water storage directed towards domestic needs.

Water conservation strategies related to irrigation are considered quite successful, in terms of upgrades, development and research. The installation of pipelines and adoption of low pressure irrigation pivots are examples of upgrades in irrigation infrastructure and changes in the irrigation equipment. In addition, research has made available new crop varieties that require less irrigation and are more resistant to drought conditions. Also, in an effort to conserve moisture in the soil, as well as soil, traditional agricultural practices, such as summer fallow and tillage, are increasingly being replaced by those of continuous cropping and minimum or no tillage, respectively.

Two government programs were identified by participants as important in terms of climate and water related issues. Canada Agricultural Income Stability Program (CAIS) has provided stability to farmers during drought events. Regional Economic Development Authority (REDA) has been identified as a local-provincial group that has initiated a long-term economic planning for the region. In addition, REDA has been recognized as an anticipatory adaptation strategy to the changing climate and social landscape of the area. Provincial crop insurance, complemented with private hail insurance, represents another adaptation strategy adopted by farmers as a mean to cope with climate and weather events.

The last adaptation strategy mentioned by participants relates to water management agreements, and specifically to the Prairie Provinces Water Board (PPWB). The PPWB is an inter-jurisdictional board based on consensus. The board is composed by one representative of each prairie province (Alberta, Saskatchewan, and Manitoba) and two federal representatives. The board reports and provides recommendations to its members' agencies based on two main agreements: (a) the Water Quality Agreement which ensures that water quality at inter-provincial borders is maintained; and (b) the Master Agreement on Apportionment, where the apportionment formula for eastward flowing inter-provincial streams is based on the principle of equal sharing of available water in the Prairies.

5.1.4 Presentation of the results of the community vulnerability assessment pursued by IACC researchers.

As mentioned in the methodological section above, the Taber (Prado, 2007), Cabri – Stewart Valley (Matlock, 2007), and Outlook (Pittman, 2008) community vulnerability assessment reports were extensively reviewed and interpreted prior to the participatory mapping sessions. Participants were exposed to the corresponding results of the community vulnerability assessment in two modes. Initially, the results were presented to participants as a traditional slide show depicting all vulnerabilities, exposures and adaptation strategies. The contextual background of each slide was provided verbally. This presentation provided a detailed overview of the main vulnerabilities, exposures/constraints and adaptations/adaptation strategies, related to climate events and water, as identified and understood by interviewed community members in Taber, Cabri-Stewart Valley, and Outlook. For a details review of the results of the two reports refer to Prado (2007), Matlock (2007), and Pittman (2008).

Participants were then exposed to an alternative perspective of the main vulnerabilities, exposures/constraints and adaptations/adaptation strategies, related to climate events and water, as identified and understood by interviewed community members in Taber, Cabri-Stewart Valley, and Outlook. The above reports were interpreted and translated into a sequence of maps. This sequence of maps attempted to represent the main trends and patterns recognized by community members, and the impact these trends and patterns have had in the livelihoods of community members in Taber, Cabri-Stewart Valley, and Outlook, respectively. The maps portray and relate broad and particular spatial and temporal trends and patterns, by providing an alternative visual regional perspective (*i.e.*, watershed level - SSRB) in conjunction with a more local situation (*i.e.*, municipal level and town level), as well as changes over 5 to 10 years.

These common trends and patterns facilitated the construction of a sequence of maps that provided contextual background to each of the community particularities. For example, while all communities are adopting agricultural moisture conservation practices (*e.g.*, no tillage), access to irrigation and crop selection have taken the communities through different paths. Participants were exposed exclusively to map information. The latter were used as visual knowledge to facilitate an understanding of the main trends and patterns that provide contextual meaning to the current vulnerabilities identified in the above reports.

The review of Taber, Cabri-Stewart Valley, and Outlook vulnerability assessment reports allowed not only for the identification of broad and common trends and patterns, but also enriched and complemented each other. The international market and climatic conditions (particularly drought) have been identified as the two main global stressors that in conjunction have produced a double exposure (O'Brien and Leichenko, 2000, in Leichenko and O'Brien, 2002) situation for all communities. There are a number of derived issues resulted from the compound effect of global stressors and local circumstances, which present each community with its own particular identity. Appendix

8 the examples of Taber and Cabri-Stewart Valley vulnerability stories told through maps.

5.1.5 Refinement of the scheme of community vulnerability to climate and water related issues scheme

Once the presentations on the community vulnerability assessments were completed, including both traditional slides and map story versions, participants were asked whether they needed to refine and/or modify their community vulnerability scheme constructed at the beginning of the session. Following are the refinements/modifications for the Taber session, the Cabri-Stewart Valley session, and the Outlook session.

In relation to the **Taber** session, Figure 6 shows the modifications pursued by Group 1 in Taber. Participants in this group expanded on the 'entrenching bureaucracy' constraint in the section related to 'constraints to cope with above climate and related events'. At the beginning of the session, participants established that an entrenching bureaucracy was related to a communication gap existing between government regulatory boards and local organizations. In addition, while participants recognized that the process of decision-making requires the involvement of all stakeholders, people lack the motivation/incentive to act (*i.e.,* lack of local stakeholders' empowerment, "… Irrigation Council took power away from people').

The main additions to the 'entrenching bureaucracy' constraint refer to the lack of leadership from the top (*i.e.,* government) to implement changes, as well as the lack of long-term vision. At the same time, participants argued that general public has no incentives to act and improve this situation, mainly because they are not informed. Hence, the juxtaposition of lack of government leadership and long-term vision on the one hand, and an unformed mass on the other, results in lack of action from both sides.

Figure 7 shows the additions pursued to the community vulnerability scheme by Group 2 in Taber. Participants focused mainly on the constraints and adaptation strategies sections of the community vulnerability scheme. In terms of constraints, school desertion was identified as a relevant concern. Youngsters are dropping out of high school and not pursuing higher levels of education. This situation can potentially hinder the future development of the area, as education is vital in adapting (*i.e.,* implement change) to future climate change challenges.

Another constraint added by Group 2 relates to the lack of access to capital to implement changes. For example, government regulations require communities to upgrade the water processing infrastructure without providing adequate funding to implement those changes. In addition, limited affordable housing in the area was also identified as an important constraint, as it portraits an additional disincentive to attract agricultural labourers.

Figure 6. Group 1: Modifications pursued by participants to their current vulnerabilities to climate and water related issues scheme constructed at the beginning of the session. Taber.

What constraints the community to deal with the impacts of the above climate and related events.

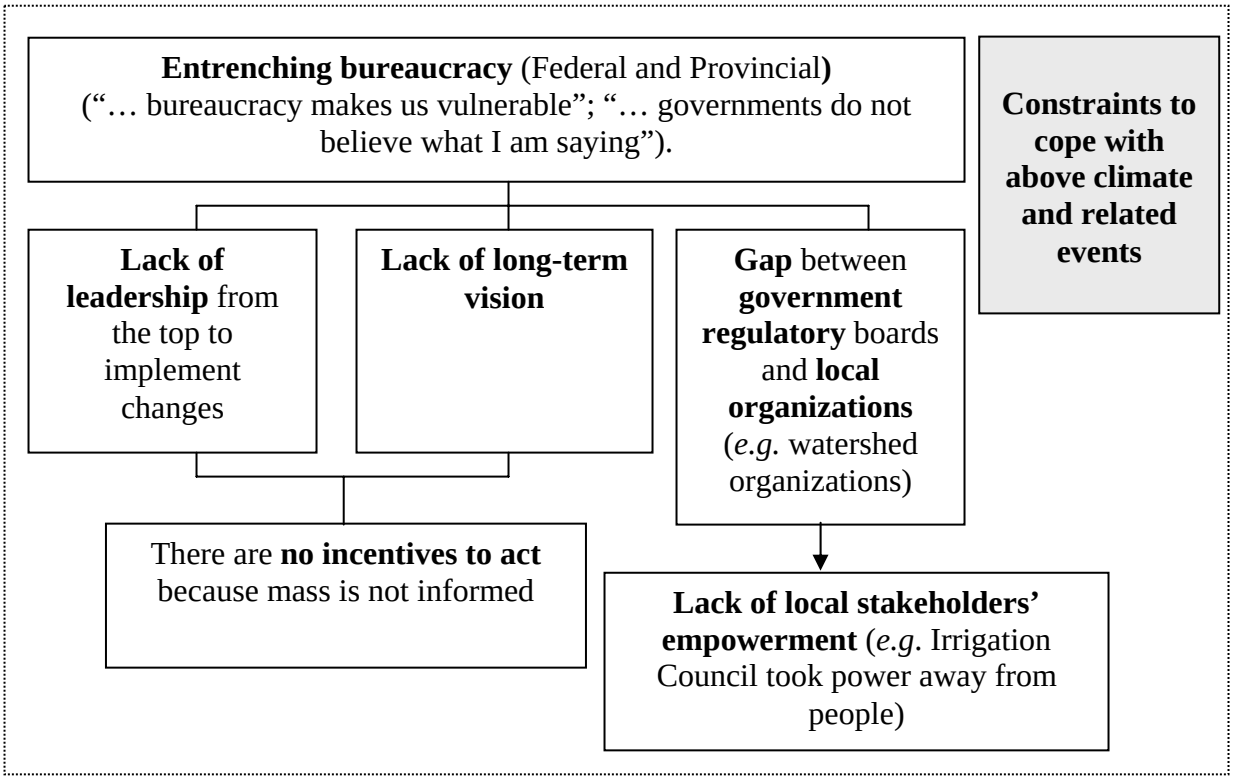
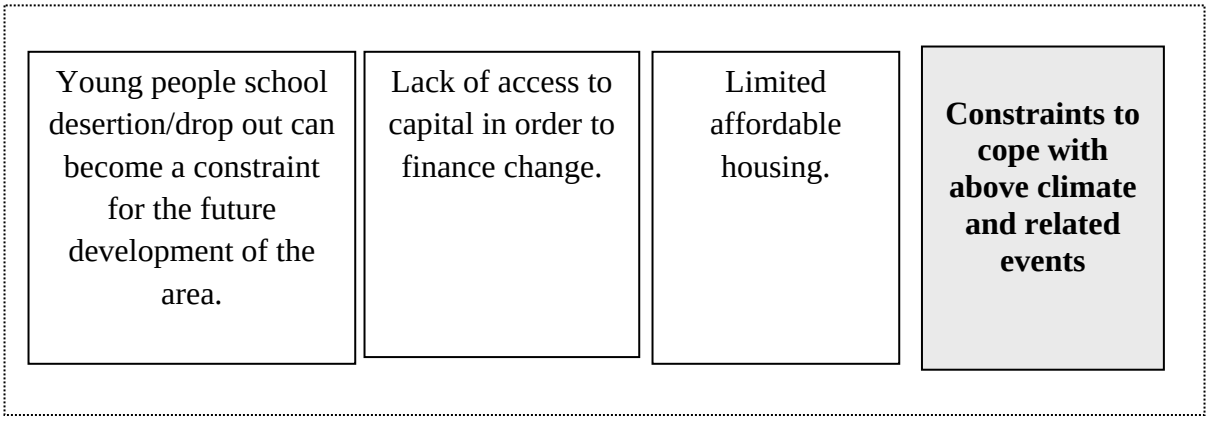
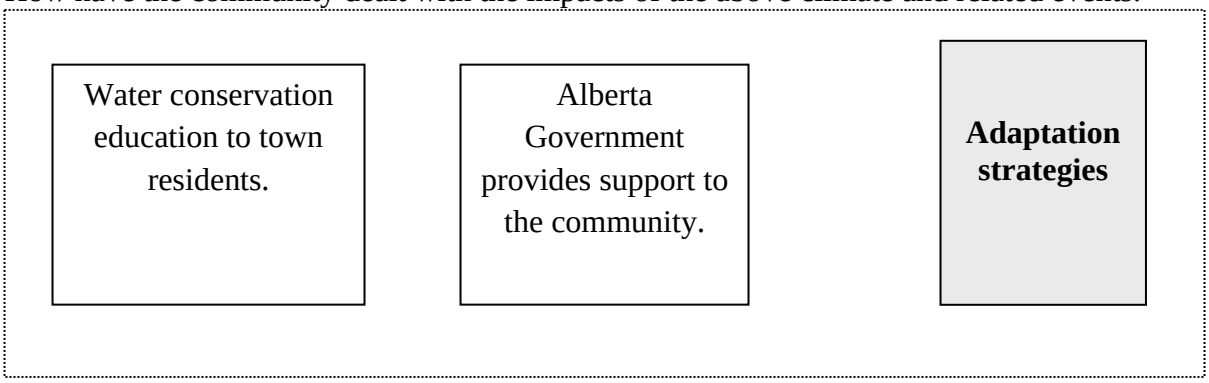


Figure 7. Group 2: Modifications pursued by participants to their current vulnerabilities to climate and water related issues scheme constructed at the beginning of the session. Taber.

What constraints the community to deal with the impacts of the above climate and related events.



How have the community dealt with the impacts of the above climate and related events.



In terms of adaptation strategies, Group 2 recognizes the support of the Alberta Government during disaster situations. For example, communities have received monetary support during flooding events through the Alberta Government Disaster Relief Program. Finally, participants have highlighted the need for continuing water conservation education to Taber residents as an answer to future water shortages.

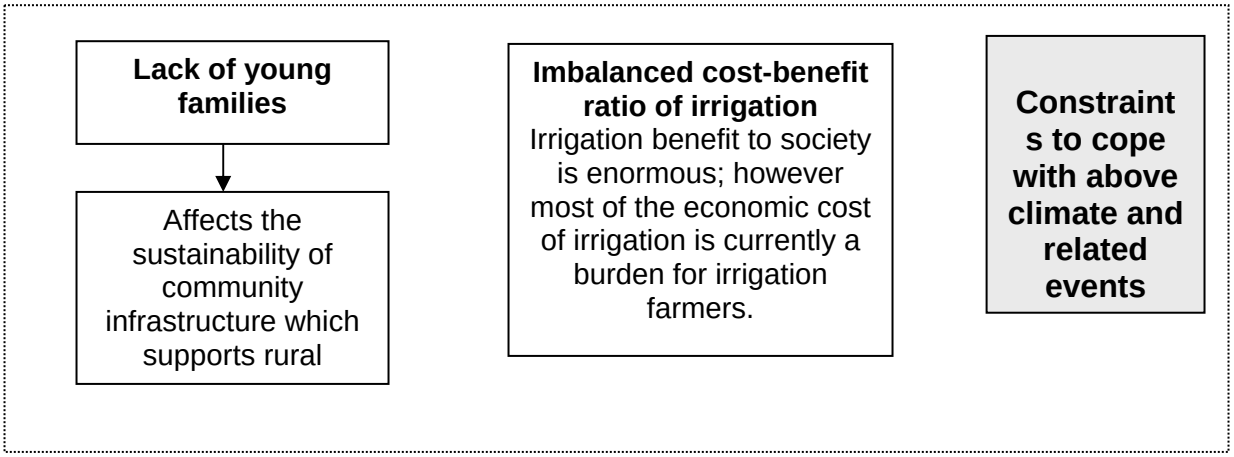
In relation to the **Cabri-Swift Current** session, participants were satisfied with their previously developed scheme on community vulnerability on climate and water events, and did not make any modifications. Rather, participants indicated that the same trends continue, but they realized that they have intensified.

Participants in the **Outlook** session expanded on the constraints to cope with above climate and related events. Figure 8 shows the additions pursued by participants. Participants discussed two main issues. First, in terms of population trends, they identified the lack of young families as affecting and threatening the sustainability of the

community infrastructure and lifestyle. Facilities such as schools, hospitals, and other services have been on a decline for quite sometime in the area. Second, participants perceived an imbalanced in the cost-benefit ratio of irrigation. Participants argued that the benefits of irrigation are enormous for society as a whole. Yet, they farmers in the Outlook area receive about 18% of the economic benefits and carry the burden of about 58% of the cost of irrigation. While such an imbalance cost-benefit ratio constraints farmers' capacity to adapt, a more balanced cost-benefit ratio would facilitate adaptation.

Figure 8. Modifications pursued by participants to their current vulnerabilities to climate and water related issues scheme constructed at the beginning of the session. Outlook.

What constraints the community to deal with the impacts of the above climate and related events.



5.1.6 Participants evaluation of the results of current vulnerability assessment

A short survey was distributed to each of the participants, asking them to rate their degree of agreement or disagreement regarding the results of the community vulnerabilities to climate and water events presented in this session. While the rate ranges from 1 to 5, 1 reflects the least agreement and 5 the most agreement (see Appendix 3).

Table 1 shows the results of the **Taber** evaluation survey. More than half of the participants (*i.e.*, 6) felt that the interpretation of the community vulnerabilities to climate and water related events deserved a rate of 4. Two participants assigned the greatest agreement to the presentation of the community vulnerabilities, while 3 participants assigned a rate of 3, with a final average of a rate of 3.9.

Table 1. Summary of the results of participants' evaluation of Taber current vulnerability assessment

Scale value	Number of responses
1	
2	
3	3
4	6
5	2
Total	11
Average = 3.9	

In addition, when the Taber session participants were asked whether they would like to be contacted in the future regarding this project or any other related activity, 8 out of 10 provided their contact information for future reference.

Table 2 shows the results of the **Cabri-Stewart Valley** evaluation survey. Four participants assigned a rate of 4 to the presented community vulnerabilities, while 3 assigned the highest level of agreement, averaging a rate of 4.4.

Table 2. Summary of the results of participants' evaluation of Cabri-Stewart Valley current vulnerability assessment

Scale value	Number of responses
1	
2	
3	
4	4
5	3
Total	7
Average = 4.4	

Seven people participated in the morning portion of the Cabri-Stewart Valley session. Two of them had other commitments in the afternoon and left the session at 1:00 p.m. At the end of the session, participants were asked whether they would like to be contacted in the future regarding this project or any other related activity. All remaining 5 participants provided their contact information for future references.

Table 3 depicts the results of the evaluation pursued by participants of the **Outlook** current vulnerability assessment presentations. Four participants assigned a value of 4 to the vulnerabilities presented in the participatory session, while one participant assigned a rate of 3, and another a rate of 2. The average rate for the session is 3.5.

Table 3. Summary of the results of participants' evaluation of Outlook current vulnerability assessment

Scale value	Number of responses
1	0
2	1
3	1
4	4
5	0
Total	6
Average = 3.5	

Participants were asked whether they would like to be contacted in the future regarding this project or any other related activity. All participants provided their information for future reference.

5.2 Climate change, climate change scenarios and the implications of the potential impacts of future climate change on current exposures/constraints and adaptive strategies on water

As it was explained in the methodological section of this report, the second section of the participatory mapping session focused on climate change scenarios for the area, and the implications of the potential impacts of future climate change on current exposures/constraints and adaptive strategies related water issues. This section intended to allow participants to reflect on the potential implications of future climate change on their livelihoods and current adaptation strategies, as well as considered future alternatives. It comprises an introductory portion on the concepts of climate change and climate change scenarios, followed by a sequence of maps presenting a medium climate change scenario for the area in terms of temperature, precipitation and climate moisture index.

Participants were encouraged to focus on trends rather than on particular number figures. Suzan Lapp, Ph.D. candidate at the University of Regina, Saskatchewan, and research fellow of the IACC project, provided the climate change scenarios data that was used to create the sequence of maps presented in this section of the participatory mapping section. Appendix 9 depicts the climate change scenarios sequence presented in the sessions. Finally, participants discussed implications of potential impacts of future climate change on current vulnerabilities and adaptive strategies related to water issues (see Appendix 5 for a template of the implications of potential impacts of future climate change on current vulnerabilities).

5.2.1 Discussion of the implications of potential impacts of future climate change on current vulnerabilities and adaptive strategies on water

A discussion on the implications of the potential impacts of future climate change on the current vulnerabilities and adaptive strategies on water was based on three main topics (see Appendix 5): (a) how did you deal with current vulnerabilities in the past? Although participants have already identified adaptive strategies and adaptation measures earlier in the session, they were asked to start the process of visualizing the future implications of climate change by considering what has been working for them so far; (b) would that work in the future under future climate change scenarios, or what would you do different?; and (c) how are you going to deal with it under future scenarios? In other words, how do you see yourselves adapting?

At this point of the session, it was expected that participants would have developed a broader and a more integrated knowledge of their community's current stressors/exposures and adaptive strategies to climate and water, as well as a better understanding of the implications of future climate change for their community.

In **Taber,** the Group 1 discussion regarding 'how did you deal with current vulnerabilities in the past?' identified five adaptation strategies and measures depicted in Table 4. They are: (a) crop science and technology, in terms of plant breeding/seed resistance; (b) water rationing and conservation, both in farming (*e.g.*, irrigation at night time and watering of high value crops only) and in town; (c) "distocked" some of the cow herd (transfer livestock to other pastures); (d) crop insurance, and; (e) water storage. Three new adaptation strategies and measures were added to those previously identified in the first section of this participatory mapping session (*i.e.*, crop science and technology, "distocked" of the cow herd, water rationing and conservation).

Table 4. Taber: Group 1. Current and past adaptive strategies and measures related to climate and water.

Adaptive Strategies and Measures
Crop science and technology
Water rationing and conservation
"Distocked" some of the cow herd
Crop insurance
Water storage

Group 2 identified five main past strategies to deal with current vulnerabilities. Table 5 shows these five main measures: (a) irrigation development; (b) selection of specialty crops; (c) water conservation strategies; (d) increase of water allocation for the area; and (e) improvement of irrigation and cropping techniques.

Table 5. Taber: Group 2. Current and past adaptive strategies and measures related to climate and water.

Adaptive Strategies and Measures
Irrigation
Specialty crops
Water conservation
Acquired more water allocation
Improve efficiency of irrigation and cropping techniques

Once the main adaptation strategies and measures were identified, participants were asked whether the above adaptation strategies and measures would work in the future, under future climate change scenarios, and/or whether they would do something different. Group 1 identified three main issues regarding the appropriateness and/or feasibility of current and past adaptation strategies (see Table 6). Under longer and more intense drought events (*e.g.*, a 3 year drought), water rationing and storage would not work. Instead, participants see the need for increasing the current water storage capacity. In addition, the current water distribution system would not work under longer and more intense droughts. Participants identified a need for improving the efficiency in canals, pipelines (*e.g.*, underground pipelines are more efficient than superficial due to evaporation, and also will reduce the price of pumping the water), etc.

The above two strategies represent positive adaptation measures taken by the community in order to cope with the lack of water. However, participants identified a third strategy

adopted by some community members in an effort to cope with drought, that is, market unequal exchanges. Within this context, participants expressed their concerns in terms of water monopolization, by identifying the need for avoiding powers' monopolization of water during drought events (*e.g.*, during the drought of 2001, rich powerful farmers bought water from smaller farmers, while smaller farmers were not able to compete). This latter strategy is a good example of what it has been referred in the literature as maladaptation (Handmer, 1999).

Table 6. Taber: Group 1. Appropriateness of past and current adaptation strategies/measures under future climate change scenarios.

Under longer and more intense drought events, such as a 3 year event:

Adaptations that will not work	**Needs**
Water rationing and storage	Increase storage capacity
Current water distribution system	Improve the efficiency of the water distribution system
Market unequal exchanges	Avoid powers' monopolization of water

Group 2 acknowledged the benefits of the past and current adaptation strategies mentioned above, and suggested continuing with these measures. However, participants recognized that these strategies are not enough under future climate change scenarios. There is a need for increasing the capture of water, as well as improving and developing technologies and infrastructure for water conservation. Changes in current cropping practices are required to take place, such as selecting less demanding irrigation crops, as well as crops more suitable for climate change in the area; and an earlier start of the growing season. In addition, awareness and education in terms of water as a finite resource was suggested as a relevant water conservation strategy to pursue in the community. Table 7 summarized this discussion.

The discussion continued by asking participants: 'how are you going to deal with it under future scenarios? In other words, 'how do you see yourselves adapting?' Four main cluster of topics were identified in this discussion: (a) agricultural labour shortage; (b) research, technology and agricultural practices; (c) governance and education, and; (d) migration. Table 8 shows the future adaptation requirements identified by participants in Group 1. In relation to the agricultural labour shortage, participants acknowledged this issue as a serious limitation for farmers. While participants recognized the urgent need for finding solutions to the labour shortage, they seem to do not know how to overcome the problem. Labour shortage is considered an important component of the struggle that farmers are currently facing, particularly because vegetable crops are labour intensive. Participants expressed that a strand of the labour shortage problem is somewhat related to the lack of affordable housing in the area.

Table 7. Taber: Group 2. Appropriateness of past and current adaptation strategies/measures under future climate change scenarios.

Under longer and more intense droughts, such as a 3 year event:

Adaptations that will not work	**Needs**
Current water storage	Increase storage capacity; more on farm storage, more dams.
Current agricultural practices	Selection of crops that require less irrigation and/or are more adaptable to changes in climate. Start the growing season earlier; rotational grazing.
	Awareness and education regarding finite water resources

Table 8. Taber: Group 1. Identified potential future adaptation requirements to deal with future climate change impacts on water

Agricultural labour shortage	- Need to find solutions to labour shortage - Somewhat related to lack of affordable housing
Research, Technology and agricultural Practices	- Increase plant research (crop varieties) - Increase and adapt crop practices that conserve moisture (*e.g.* no tillage, crop rotation). - Explore irrigation techniques, such as drip irrigation, although is hasn't been economically feasible so far. - Increase storage by making use of natural coulees by flooding the area. This creates a conflict with rangers for example, because ranchers would rather keep the area for pastures. - Reduce reliance on oil and gas for home use and change to geothermal, solar panels.
Governance	- Education awareness. Educate people on climate change in order to trigger adaptation. - Irrigation districts need to work closer with irrigators and municipalities to conserve water. - Ensure fair distribution of water on drought events.
Migration	- Sell the farm

Participants of Group 2 identified very similar future adaptation strategies under future climate change scenarios. Table 9 depicts the three main adaptation strategies required to deal with future climate change impacts on water, according to Group 2 participants. They are: (a) water storage and conservation; (b) research technology and agricultural practices; (c) governance.

Table 9. Taber: Group 2. Identified potential future adaptation requirements to deal with future climate change impacts on water.

Water storage and conservation	Increase storage (water from May to June); Recycle water; Prioritize water uses; Aggressive capture of run-off from winter and spring storms; Reduce the waste of water by reduce urban use in homes (pursue better irrigation practices, *e.g.* evening watering and cover crops).
Research, Technology and agricultural Practices	New types of energy, *e.g.* geothermal, windmills. Changes in agricultural practices and crops. Utilization of new technology for water saving devices.
Governance	Education in relation to the value of water; Higher water fees; Encourage industries that produce energy and water conservation products.

Advances in research, technology and agricultural practices are considered to play a vital role in future efforts for overcoming future climate change impacts on water related issues. Participants expect an increase in plant research in terms of developing additional crop varieties that require less irrigation and are more resistant to drought conditions. Also, they call for a more widespread use of crop practices that conserve moisture (*e.g.* no tillage, crop rotation), as well as encouraging the application of those practices among farmers. In addition, they suggest the exploration of alternative irrigation techniques, such as drip irrigation, although it hasn't been economically feasible so far. Increase storage by making use of natural coulees and flooding the area was also mentioned, although this strategy creates a conflict with rangers. Ranchers would rather keep the area for pastures than use it for water storage purposes. Finally, and related to technological advances, participants were in favour of reducing the reliance on oil and gas for home use and change to geothermal, solar panels, windmills, and other more environmentally friendly alternatives. It was also proposed to develop technology for water saving devices.

In terms of education and water governance, the discussion centred on the necessity of providing public climate change education and awareness. The latter is considered an important component of a successful adaptation process, particularly because participants see the education of people as a requirement for triggering people to adapt. Although government was not explicitly mentioned, within the tone of the discussion there was a sense of someone's responsibility for providing such education, which implicitly relies on government.

Regarding water governance, participants recognized the need for a more participatory approach, if water conservation is to be accomplished. In this sense, participants suggested that irrigation districts (provincial institutions) need to work closer with irrigators (stakeholders) and municipalities (local government) to conserve water. Also related to water governance, participants identified the need for developing adequate

arrangements to ensure a fair distribution of water during drought events, and avoid situations of power's monopolization of water. In addition, participants foresee higher water fees for domestic water consumption in order to pressure residents to lower their water use. Finally, participants would like to see incentives to industry that relates to the production of energy and water consumption products.

By the end of the discussion, sell the farm and migrate was referred as a last resource to cope with the future impacts of climate change on water.

In the **Cabri-Stewart Valley** session, one new adaptation strategies/measure was added to those previously identified in the first section of this participatory mapping session, when asked 'how did they deal with the current vulnerabilities in the past?' This new adaptation strategy refers to the conversion of marginal lands back into Tame Hay and grass, due to the poor soil quality for crops. Participants explained that the economy drives the changes in the land by defining the prices of grain/crop and cattle, and therefore controls the amount of broken land. Table 10 shows the current and past adaptive strategies and measures related to climate and water referred by participants in this section of the participatory mapping session.

Table 10. Cabri-Stewart Valley: Current and past adaptive strategies and measures related to climate and water.

Adaptive Strategies and Measures	
In town	**In farming**
Water use restrictions (*e.g.*, scheduling, conservation, rationing)	Soil and water conservation through farming practices (*e.g.*, no tillage and continuous cropping)
	Marginal lands back into Tame Hay and grass
	Improve and increase storage/irrigation (dugouts)

Following, participants were asked whether current and past adaptation strategies and measures would work in the future under future climate change scenarios, and/or whether they would do something different. Instead of focusing on identifying strategies and measures that will not work, participants focused on continuing, expanding and exploring those already in place. For example, participants stated that under future climate change scenarios they will continue with current water and soil conservation farming practices, as well as expand and explore new techniques (*e.g.*, stripper head crop harvesting). In addition, participants identified potential adaptation strategies to be tested under future climate change scenarios, and particularly focusing on the advantages of a milder, and probably an expanded growing season. These are: try new varieties of crops such as winter cereals, pulse crops earlier seeding and fall seeding. Table 11 shows the appropriateness of past and current adaptation strategies/measures under future climate change scenarios.

When participants were asked: 'how are you going to deal with the potential impacts of future climate change scenarios? In other words, 'how do you see yourselves adapting?' they identified four main clusters for adapting. The first cluster refers to 'in town' water rationing and strategies, where participants suggested to stop watering lawns, and/or even completely eliminate lawns. A second cluster of potential future adaptation strategies relates to water harvesting and storage. For example, participants referred to water harvesting techniques, such as roof rain harvesting and barrel rain water collection, as possible household measures. Increase water storage was also identified as an important future strategy.

A third cluster refers to the value of water both in terms of monetary value, as well as considering water a scarce resource. Participants feel that Canadians need to change the way in which water is valued, and hence water should not be considered for granted, rather it should be acknowledged as a scarce resource. In addition, participants foresee an increase in the rates of water. The fourth cluster relates to agricultural research, technology and practices. The latter includes the trial of new varieties of crops, explore the possibilities for irrigation, and continue and expand agricultural soil and moisture conservation techniques. Table 12 shows the Cabri-Stewart Valley identified potential future adaptations to deal with future climate change impacts on water.

Table 11. Cabri-Stewart Valley: Appropriateness of past and current adaptation strategies/measures under future climate change scenarios.

Continue and expand current adaptation strategies	**Potential adaptation strategies**
Continue with current water and soil conservation farming practices, such as continuous cropping and no tillage.	Try new varieties of crops such as winter cereals (*e.g.*, due to milder winter climate, try winter wheat)
Expand and explore new conservation farming practices. For example, the stripper head crop harvesting practice to conserve moisture was identified as a possible technique to be explored. This technique removes mainly just the kernel heads, leaving the stubble in the field, which keeps moisture in the soil.	Earlier seeding, particularly for specialty crops such as pulse crops.
Continue with the use of chemicals. Wheat is getting immune, and with a warmer climate, specialty crop insects will worsen.	Try fall seeding for pulse crops. However, fall seeding requires a snow cover to prevent 'winter kill'.

Table 12: Cabri-Stewart Valley: Identified potential future adaptations to deal with future climate change impacts on water.

Adaptation Clusters	
In town water rationing and strategies	Do not water lawns at all. Eliminate lawns.
Water harvesting and storage	Water harvesting, such as roof rain harvesting and barrel rain water collection. Increase water storage.
Water value	Change the way in which we value water. Water should not be taken for granted. Increase rates of water.
Agricultural Research, Technology and Practices	Try new varieties of crops. Explore possibilities for irrigation. Continue and expand agricultural soil and moisture conservation practices.

Participants in the **Outlook** session discussion regarding 'how did you deal with current vulnerabilities in the past?' identified 5 main clusters of adaptation strategies. These are: (a) reactive approach to crisis or 'crisis management'; (b) economic strategies; (c) education and networking; (4) changes in farming practices; and (5) crop and hail insurance. All adaptation strategies identified in this section constitute additions to those previously acknowledged in this report by participants in the Outlook session, with the exception of crop and hail insurance. Table 13 shows the current and past adaptive strategies and measures related to climate and water.

Table 13. Outlook. Current and past adaptive strategies and measures related to climate and water.

Adaptive Strategies and Measures
Reactive approach or 'crisis management'
Economic strategies: Financial 'squeeze' (do more with less; being frugal) Employment diversification
Continuous education and learning through networking
Changes in the farming operation: Mixed farming Diversification of crops Acquisition of solid equipment Irrigation
Crop and hail insurance

The first adaptive strategy acknowledged by participants was referred as ‘crisis management’. This strategy constitutes a reactive approach towards the adaptation to climate and water related events. In this sense, farmers look for solutions once a particular crisis has hit their operations and/or everyday lives. Economic strategies relate to the diversification of employment, and particularly to off-farm employment. In times of economic shortage, farmers have learnt to ‘do more with less’, ‘dealt with less’, and ‘being frugal’ by changing some of their management operations and lifestyles in order to minimize expenses.

Another adaptive strategy identified by participants relates to education and networking. Farmers are continuously educating themselves through different means. In this regard, the internet plays an important role as a source of information and knowledge. In addition, learning is also accomplished by networking. Participants highly value and recognize the benefits of networking. The latter is reflected in one of participants’ comment, ‘Loners suffer the most’. Networking allows farmers to interchange experiences and knowledge by learning from mistakes and successes of one another. These two education strategies are geared towards reduce risks, while enhancing and developing an already existing social capital and social networks.

Changes in the farming operations have also been identified as an adaptation measure. Farmers are increasingly practicing mixed farming and diversifying their crops, hence spreading the risk over a variety of commodities. Farmers are also switching from dry-land farming to irrigation farming and acquiring solid equipment. Irrigation has greatly contributed to those that have adopted it. Finally, the last adaptation strategy identified by participants refers to crop and hail insurance. As already mentioned in this report, crop and hail insurance are another mechanism used by farmers to cope with climate and weather related events.

Following, participants were asked whether current and past adaptation strategies and measures would work in the future under future climate change scenarios, and/or whether they would do something different. Participants are aware of the vast amount of learning gained from past experiences in the prairies. Hence, all of the above adaptation strategies and measures are considered valuable under future climate scenarios, but at a faster and more knowledgeable pace to increase adaptability. In addition, participants expanded on new strategies to develop adaptability and increase adaptive capacity under future climate scenarios. Table 14 depicts the appropriateness of past and current adaptation strategies/measures, as well as potential strategies to develop under future climate change scenarios.

Participants identified the need for economic incentives to drive change. For example, economic incentives directed to the implementation of new and improved techniques/practices geared towards better performance under future climate change scenarios. These types of incentives would facilitate, encourage, and allow for change. Participants also recognized the need of the community and its members to become more open to change.

Table 14. Outlook: Appropriateness of past and current adaptation strategies/measures under future climate change scenarios.

Continue and expand current adaptation strategies	Potential adaptation strategies
All of above strategies but at a faster and more knowledgeable pace.	Economic incentives
	Development of a water culture.
	Development of openness to change.
	Close the urban-rural gap.

In addition, a large portion of the discussion focused on the need for developing a water culture in the area. This endeavour is understood as a deep cultural change, where water is integrated within all the dimensions of sustainability. Participants are quite aware of the education task required in order to create a water culture. This water culture endeavour should include a water management plan in order to keep the community vitalized, as well as water conservation practices. It also needs to be linked to the needs of the younger generations in order to maintain their presence in the area, and foster the development of cultural/economic ties to the South Saskatchewan River.

The fourth potential strategy identified by participants refers to close the knowledge/cultural gap existing between the urban and rural population, in terms of the recognition given to the rural activities and the importance of food production. This gap is seen as a lack of effective communication between the urban and rural population. Participants identified the need for education as playing a central role in enhancing urban population's understanding of the importance of food production and rural activities.

Related to the latter, participants argued that 69% of rural land owners in the area are currently living in Saskatoon. This situation is seen as generating an enormous cultural shock, and producing a detachment from the agricultural environment and the land, in other words these land owners are 'People that do not experience agriculture …'

Following, participants were asked: 'how are you going to deal with the potential impacts of future climate change scenarios? that is, how are you going to adapt? Participants discussed a number of possible options, all of them embedded within a long-term planning framework. Table 15 shows the identified potential future adaptations to deal with future climate change impacts on water by participants in the Outlook session.

In relation to climate change and future climate change scenarios, participants see the opportunity to adopt an anticipatory approach instead of a traditional reactive approach or 'crisis management' identified earlier during the participatory mapping session. They argued for an overall long-term planning in terms of conservation, financial management, education and learning, social capital, agricultural practices, etc. In this regard, participants acknowledged that they need to be 'more prepared for more extremes', by understanding the risks involved, and identifying risks' reducers such as more efficient

equipment, the ability to change crops, the ability to reduce farm expenses, the ability to 'slush funds' from good years to afford poor or drought years.

Table 15: Outlook: Identified potential future adaptations to deal with future climate change impacts on water.

Overall long-term planning
Preparedness for more climatic extremes (identify risks and risks' reduces)
Education, and learning and networking
Changes in agricultural practices (research and technology)
Financial (explore carbon credits, save for tough years, and explore existing conservation programs)
Water capture
Facilitate adaptation (knowledge, training, funds)
Lack of affordable labourers and immigration target towards vegetable farmers
Benefit study by Saskatchewan Irrigation Projects Association

Participants have recognized for quite sometime the strengths and benefits of education, learning and networking. In order to increase farmers' ability to adapt, they see the need for educate themselves to adapt, by increasing education, and continuing learning and networking. The internet has been referred as an important venue currently use as a source of information and knowledge.

In the past, research and technology have facilitated the adaptation to climatic conditions by changing some agricultural practices. Participants see the opportunity to plan for future climatic conditions changing to more appropriate agricultural practices. For example, change from dry-land to irrigation farming, put the organic matter back into the soil, explore crop diversification (*e.g.* watermelon), introduce more drought tolerant crop varieties, introduce higher value crops, use of shelter belts, prepare by changing equipment, etc. Participants also mentioned the prospects of water capture by trapping snow.

In terms of financial adaptation, participants recognize the need for saving up money in order to be better prepared for 'tough years', as well as to assess the ability to reduce farm expenses. In addition, participants see themselves more inclined to search and adopt existing conservation/incentive programs such as wetlands conservation. These programs provide a monetary reward as well as represent good agricultural practices. Participants also refer to the possibility of exploring the carbon credit program.

Participants also identified the need for allocating more resources in order to help them to adapt, … 'Help me to adapt, provide more resources to help people to adapt'. The latter refers to transfer of knowledge, training and resources to farmers in order to be able to fully utilize what is available in the area (*i.e.* the currently underutilized irrigation

potential of the area). Participants see the possibility of a collaborative effort between government and the private sector.

Another issue identified by participants refers to the lack of affordable labour and the necessity to target immigrants experienced in vegetable farming. Participants argue that the lack of development of the vegetable farming in the area relates in part to the lack of training, and also to farmers' bias towards grain and cattle.

Finally, participants see the potential benefits derived from the Saskatchewan Irrigation Projects Association study by influencing government policy, not only in terms of irrigation, but on taking a balanced approach to water management.

5.3 Discussion on the role of governmental institutions under potential impacts of future climate change on water.

The third and last section of the participatory mapping session focused on the role of governmental institutions, at federal, provincial and municipal levels, under potential impacts of future climate change on water. Appendix 6 provides a template of the topics discussed within this section. The purpose of this section was to allow participants to discuss the current role of government institutions, and reflect on how government could facilitate community members to adapt to the potential future impacts of climate change and water. The outcome of this section constitutes a set of community recommendations to policy-makers related to climate change and water issues.

Two central topics were discussed in this section. First, participants were asked 'what does (government) need to be changed to make things easier for you? And, 'What will you tell your government officials, at different governmental levels, under such climate change scenarios?'

5.3.1 Taber discussion on the role of governmental institutions under potential impact of future climate change on water

Participants identified a number of changes to be pursued by government in order to make things easier for them. Tables 16 and 17 list the identified changes. First, government needs to develop a clear climate change and conservation political leadership and a long-term plan, were rules are relatively stable and are not changed. In addition, participants see the need for a political power to set policies of best management practices for conservation purposes, as well as political power to enforce the existing legislation. Simultaneously, participants call for a broader input of stakeholder groups into the decision making process, hence local empowerment.

Table 16. Taber: Group 1. Governmental changes needed to facilitate community members' adaptation under potential impacts of future climate change on water.

Clear political leadership for conservation
Long-term plan for conservation
Political power to set policies of best management practices to conservation
Political power to enforce existing legislation
Local empowerment by allowing more stakeholders' input in the decision making process
Better and more effective plant and climate research
Invest in developing the technology that supports a changing agricultural industry
Develop new and promote existing conservation programs
Create incentives for environmental farming
Invest in people to adapt to change (make it possible for people to change)

Table 17. Taber: Group 2. Governmental changes needed to facilitate community members' adaptation under potential impacts of future climate change on water.

Improve measurement of the water available and standardized water quality control.
Fund research and development of agriculture and irrigation.
Provide aggressive climate related funding.
Provide the necessary funding to support change.

Regarding agriculture, and particularly farming, participants considered that government needs invest in a better and more effective plant and climate research, as well as in developing the technology that supports a changing agricultural industry. In addition, government needs to come to the realization of the current oil false economy, particularly in terms of the price of agricultural land, which is currently excessively high.

Furthermore, government needs to develop conservation programs to help people, as well as create incentives for environmental farming, and promote programs that are already in place. In other words, government needs to invest in people to adapt to change (make it possible for people to change), for example, through incentives. In terms of encouraging environmental farming, participants suggested to provide tax offsets for climate related capital improvements on private land, and allowing property owners to generate power on their land.

In summary, participants call for a clear conservation/climate change long-term plan/strategy, with its corresponding defined and established BMP legislation, means to enforce the legislation, and with stakeholders input in the overall decision-making process. It should include investments in research and technology that supports a

changing agricultural industry, as well as investments in people to help them to adapt to change.

Once completed the discussion on required governmental changes, participants were asked 'What will you tell your government officials, at different governmental levels, under such climate change scenarios'. Participants expressed their concerns regarding the lack of communication among the different levels of government (*i.e.* Federal, Provincial and Municipal), stating that governments need to listen to each other. Participants discussed the idea of some kind of an umbrella independent body (*e.g.*, a board), that listens to all three levels of government underneath (although the comment was, "… not that we need more bureaucracy"), and whose mission is to bring them together. Figures 9 and 10 depict a simple interpretation of the discussion pursued by Group 1 and Group 2 during the Taber session. Figures 9 and 10 also depict the identified roles and changes that governmental institutions need to undertake under the potential impacts of future climate change and water issues.

Regarding environmental concerns at the federal level, participants expressed their desire for the government to support world wide climate change efforts. They also recognized the need for providing long-term funding for planning and research institutes with climate change mandates. In addition, participants call for a better watershed management, and particularly to stabilize watersheds at the top heads to avoid reservoirs' siltation (*e.g.* less mountain grazing, logging, more storage). In relation to the oil industry, participants demand regulations on best management practices for the oil companies. Finally, participants asked the federal government to provide the provincial and local governments the authority to develop change.

Furthermore, participants see the federal government as playing a greater role in negotiating and administrating international treaties in relation to cross boundary water flows, particularly by resolving outstanding freshwater debates. In addition, participants call for the federal government to pursue a better measuring of the national water resources, as well as to provide funding for the construction of more water storage capacity.

At the provincial level, participants expressed their discontent with the high cost of crop insurance premiums, and would like to see a cut back on crop insurance. Also, participants see the need for the provincial government to invest in water conservation research. Finally, participants identified the lack of provincial government involvement with the local level, and advise provincial government to listen to the local government.

In addition, participants call for long term solutions that balance both economic and environmental concerns at the provincial level. Participants also identify the need for developing water management strategies to support future water shortages.

Figure 9. Taber: Group 1. Participants' perspectives on the role of governmental institutions under potential impact of future climate change on water.

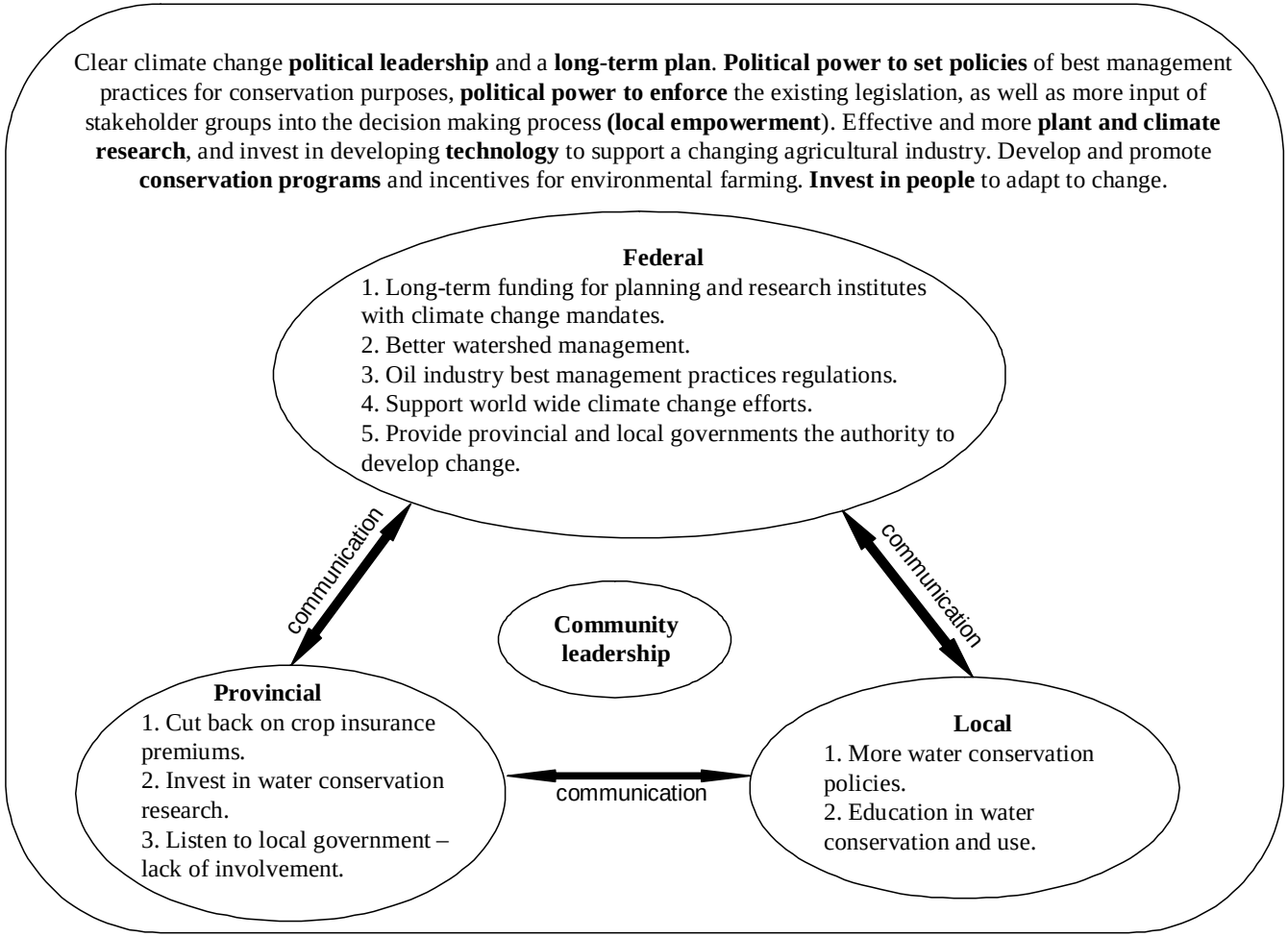
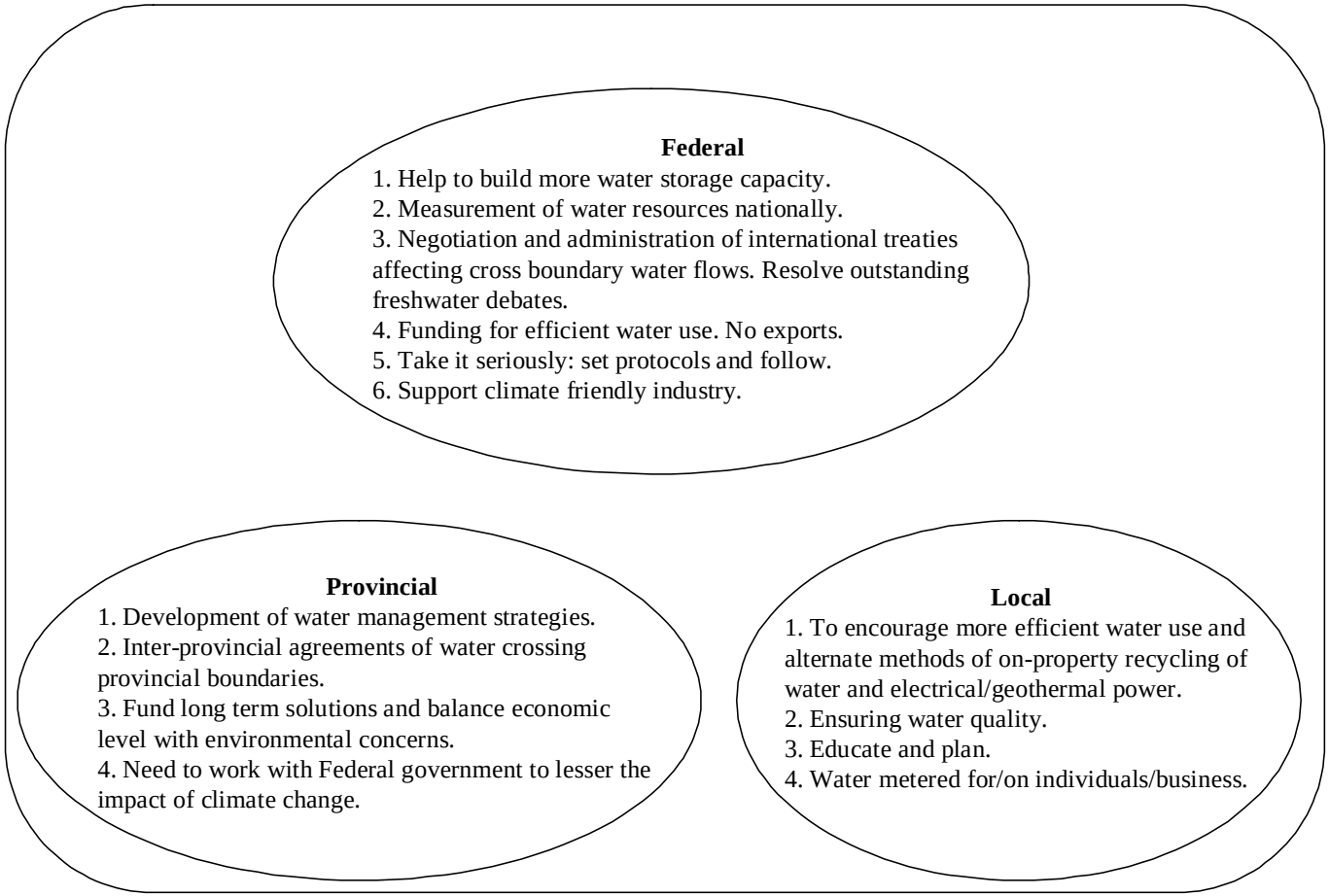


Figure 10. Taber: Group 2. Participants' perspectives on the role of governmental institutions under potential impact of future climate change on water.



While participants are quite content with the general receptiveness of the local government, they see their local government taking a major role in two main areas in terms of climate change and water issues. First, local government needs to focus in developing more water conservation policies and encouraging more efficient water uses. In addition, local government needs to plan and educate the public in water conservation and use. Besides from the role that local government should play in terms of climate change and water, the discussion evolved around the concept of community empowerment and responsibility. Communities need to take leadership themselves, as well as all stakeholders need to be involved (*e.g.*, hay and potatoes growers, etc.)

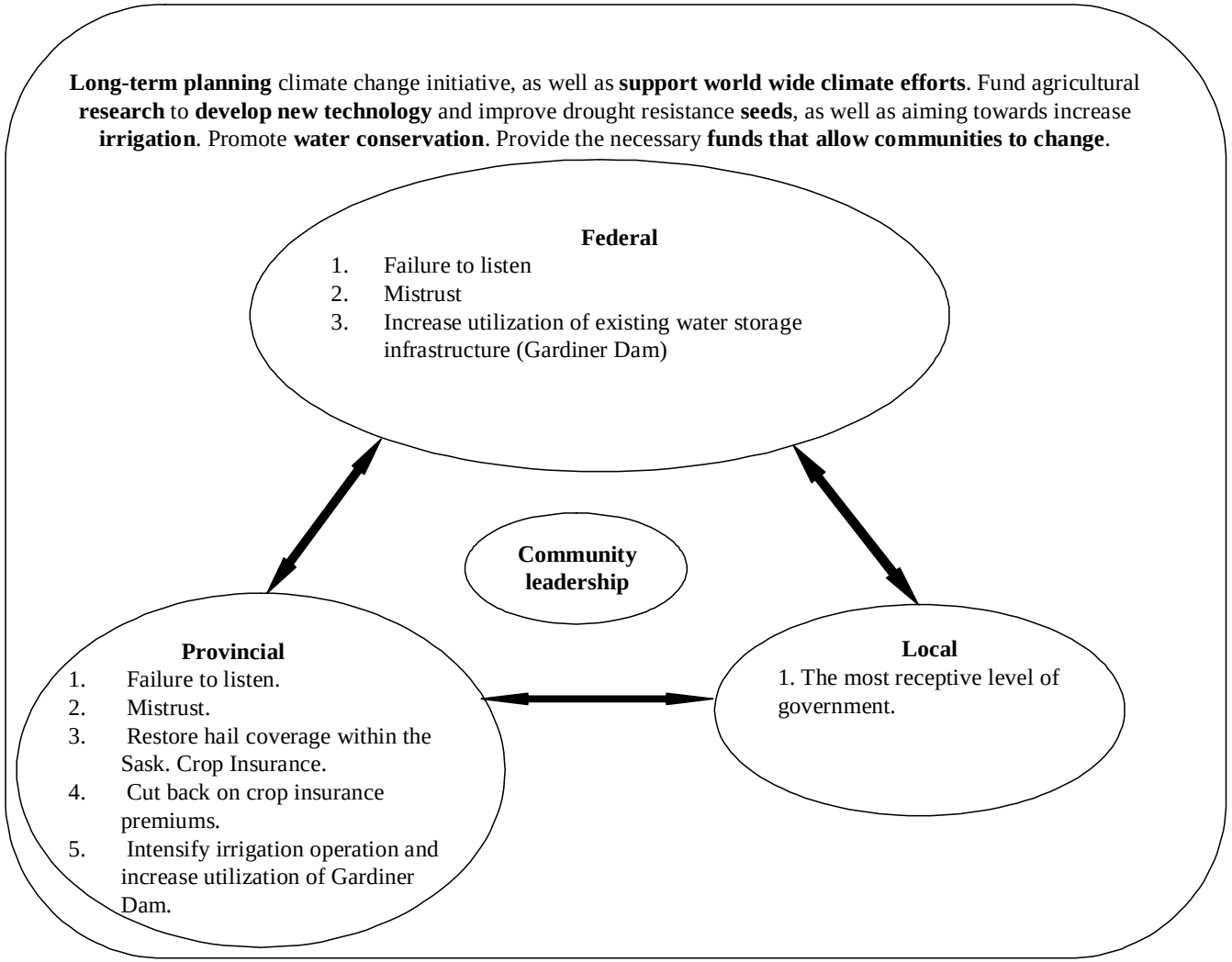
5.3.2 Cabri-Stewart Valley discussion on the role of governmental institutions under potential impact of future climate change on water

Participants identified a number of changes that government needs to undertake in order to facilitate people's adaptation to potential impacts of future climate change. First, government needs to address the climate change issue as a long-term planning initiative, instead of a 4 year plan, as well as support world wide climate change efforts, such as the Kyoto protocol. In addition, government needs to provide research funds to develop new technology and improve drought resistant seeds. Also, participants identified the need for improving and increasing irrigation and related research.

While recognizing the role played by the legislation in terms of enforcing change, for example in terms of town water quality infrastructure and personal qualifications, participants criticized the government for not providing the means to allow communities to change. In this sense, participants call for the government to supply the necessary funds that would allow them to change, such as the required funds for upgrading the town water system. Finally, participants identified the need for promoting water conservation. Figure 11 depicts a simple interpretation of the discussion pursued in the Cabri-Stewart Valley session. It follows the same structure used in Figures 9 and 10 and indicates roles and changes, identified by participants, that governmental institutions need to undertake under the potential impacts of future climate change and water issues.

When asked to discuss what would they tell to each governmental level (*i.e.*, federal, provincial, local) under the presented climate change scenarios, participants started by amalgamating the federal and provincial levels into one entity. The first issue recognized by participants was the failure of government to listen. Participants did not request or identify the need of government to listen, instead, they expressed their frustration and mistrust through statements such as, '… we have to look for our own solutions in agriculture', '… we do not depend on government', '… the question is not what the government is going to do for us, but what is it going to do to us'. In addition, such type of statements indicates participants' perceptions of community self-reliance and existence of social capital.

Figure 11. Cabri-Stewart Valley: Participants' perspectives on the role of governmental institutions under potential impact of future climate change on water



Participants continue by identifying the global market as a major stressor, if not the main stressor, in farmers' livelihoods. While stating that the global market needs to change they also acknowledged the limitations of the federal government in these matters, as well as recognized that the federal government can't invest the amount of funds necessary to deal with this issue.

Participants see both federal and provincial governments responsible for increasing the utilization of the Gardiner dam. Although participants recognized that the cost required for irrigating Cabri and Stewart Valley surrounding areas makes irrigation prohibited, they would like to see other areas developed. They acknowledged the potential of such a resource and the waste of such an investment if the Gardiner dam continues under the current underutilized situation. Participants argued that only 10% to 20% of the area previously predicted is under irrigation.

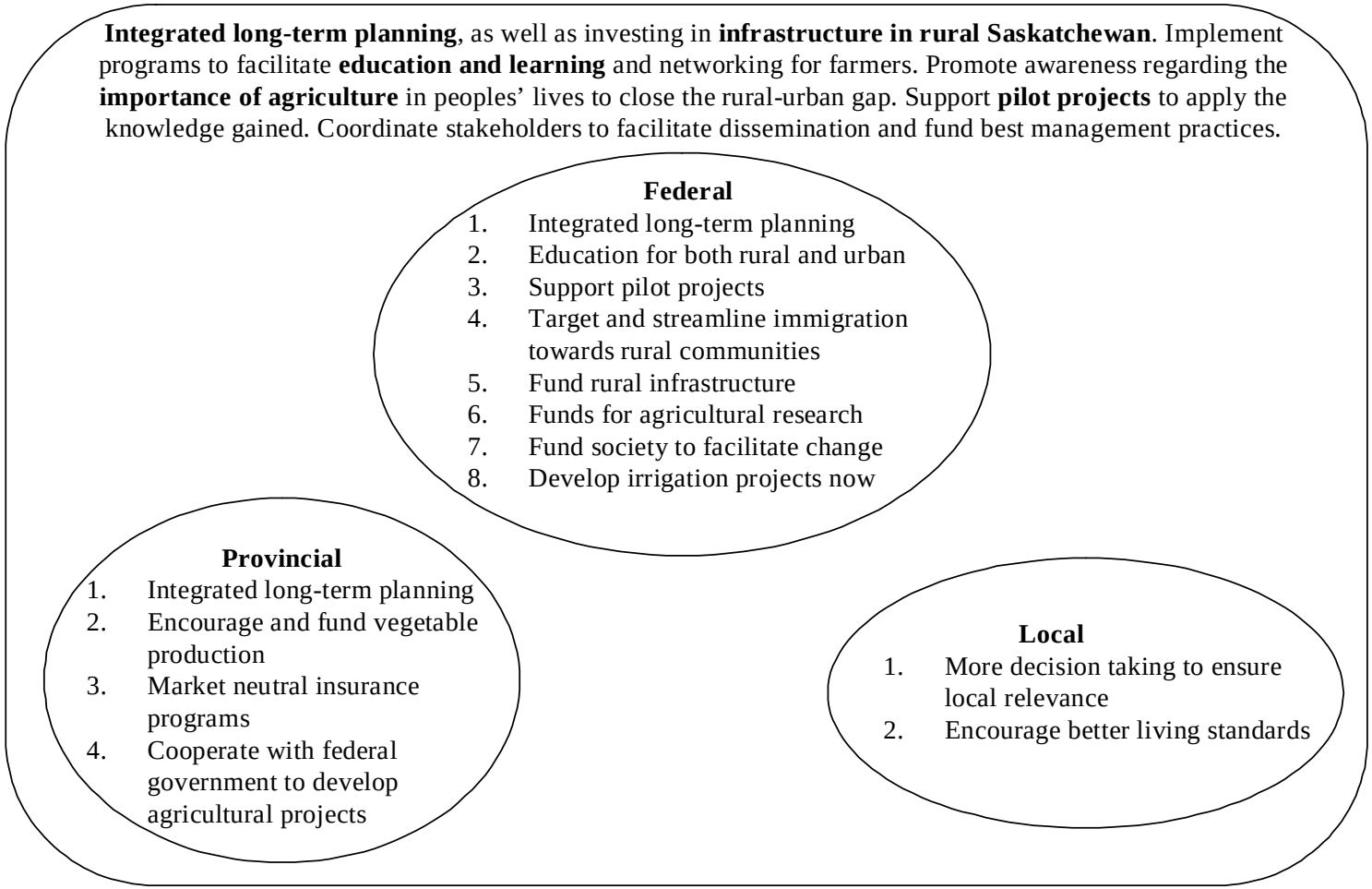
Referring to the provincial government level, participants call for the reincorporation of hail coverage into the Saskatchewan Crop Insurance. Hail insurance premiums are currently extremely high and farmers have not being able to afford it. Participants also see the need for lower crop insurance premiums. In addition, participants see the provincial government playing a more active role in increasing irrigation, in terms of a more intensive operation.

The municipal level is recognized as the one level that listen the most of the three governmental levels. In general, participants seem to be quite content with their local government and there were no further comments.

5.3.3 Outlook discussion on the role of governmental institutions under potential impact of future climate change on water

As previously identified and discussed above, participants' focused on the need of an integrated long-term planning scheme that extends beyond the four year frame of the Canadian electoral system. Particular importance was attributed to the urgent need for investing in infrastructure in rural Saskatchewan, and mainly in roads, water storage and supply. In addition, and within this long-term planning vision, participants identified the need for implementing programs to facilitate education and learning to farmers. Ideally, these programs would incorporate public and private organizations, and governments are seen as the institutions in charge for fostering such integration. In this regard, governments are seen as facilitators of learning, as well as facilitators of 'access to education' (*e.g.* 'Fund a facility where I want to go'). Figure 12 depicts Outlook participants' perspectives on the role of governmental institutions under potential impact of future climate change on water.

Figure 12. Outlook: Participants' perspectives on the role of governmental institutions under potential impact of future climate change on water



Participants discussed the implementation of a facility (*e.g.* an internet facility) that allows for a networking environment, and provides access to relevant agricultural issues, practices, applications, etc., for farmers to see and learn. Such an endeavour should also include national and international best management practices (BMP). Participants foresee government as coordinating stakeholders in order to facilitate the dissemination of BMP, as well as providing incentives to allow for initiating the utilization of these BMP.

Related to the rural-urban gap previously identified in the discussion, participants attributed the government with the responsibility of facilitating awareness between Canadians regarding the importance of agriculture in peoples' lives. In addition, participants feel that there has been a substantial research effort so far, and they call for governments to support pilot projects to apply the knowledge gained on these research efforts.

When participants were asked: 'What will you tell your government officials, at different governmental levels, under such climate change scenarios?' both federal and provincial governments were identified as requiring to adopt an integrated long-term planning scheme, that is considering economic, social and biophysical aspects simultaneously. Regarding the federal level of government, participants assigned the government with the responsibility for educating both urban and rural population, not only in terms of the importance of agriculture, but also on climate change and related issues. Participants also call for an immigration policy that focuses more towards rural communities, by attracting entrepreneurial farm operators, as well as streamlining the process of application. The federal government is also foreseen as providing more funds for rural infrastructure and agricultural research, as well as fund society in general to facilitate change.

Participants strongly call for the development of pilot projects based on past and current research. They feel that there has been a substantial research endeavour, and it is time to apply the knowledge gained so far. In addition, participants encourage the federal government to be prepared for future drought and food shortages by developing irrigation projects now.

When initiating the discussion regarding the provincial level of government, one participant stated, 'This is one level of government that we can do without.' These types of statements reflect the same kind of frustration and mistrust expressed in the Cabri-Stewart Valley participatory mapping session. Participants continue the discussion by calling for endeavours that encourage vegetable production. These efforts should include the funding of training facilities directed towards the young population in order to facilitate the transition to vegetable farming.

In relation to crop insurance, participants call for an efficient and market neutral provincial crop insurance program that offers complete coverage, including all crops. In general, participants argue that farmers can manage all climatic and weather related adversities except for hail therefore, currently farmers in the area tend to buy hail insurance and avoid purchasing the current provincial crop insurance. In addition,

participants encourage the provincial government to cooperate with the federal government in order to develop projects to help agriculture.

Regarding the local level of government, participants see the need for increasing the role on decisions taken at the local level in order to ensure relevance to local communities. Participants encourage local government to listen to all opinions, and then focus on main issues to develop a set of informed, fact based recommendations to present to the provincial and federal levels. Such kind of approach, would allow for providing the provincial and federal levels of government with specific and clear directions in terms of policy development, instead of portraying a wide range of potential solutions and/or directions coming from a large number of local organizations. Finally, participants foresee local government as encouraging better living standards.

5.4 Community recommendations to policy-makers under the potential impact of future climate change on water

The above discussion reflects the Taber, Cabri-Stewart Valley, and Outlook communities' commonalities as well as particularities in terms of climate change issues, and the role played by governmental institutions as an external force capable of improving or hindering the adaptive capacity of communities. The above discussion also provides the bases for defining a set of community recommendations to policy-makers.

An interesting issue relates to the identified gap in communication existing between government levels (as identified by the Taber session participants), and/or between government and communities (as identified by the Cabri-Stewart Valley participants in terms of government failure to listen, or by Outlook participants as lack of clear directions from the local to higher levels of government). The Taber session recognized the need for improving communication between governmental levels, and incorporating more stakeholders' involvement in the decision-making process. The Outlook session referred to lack of clarity in communication that flows from the local level to the provincial and federal governmental levels. The latter is seen as the result of the co-existence of a wide range and number of local organizations, simultaneously providing uncoordinated and multiple directions to policy-makers.

In addition, Cabri-Stewart Valley referred to the failure in communication (*i.e.*, failure to listen) to indicate the existence of a certain degree of community leadership or empowerment[1] ('… we have to look for our own solutions in agriculture'; '… we do not depend on government'). Outlook identified learning through social networking as a mean of community resilience. The issue of community leadership/empowerment was also brought up during the Taber session. While the Cabri-Stewart Valley and Outlook sessions recognized the existence of certain social capital within their communities, the

[1] 'Empowerment is the process of increasing the capacity of individuals or groups to make choices and to transform those choices into desired actions and outcomes. Central to this process are actions which both build individual and collective assets, and improve the efficiency and fairness of the organizational and institutional context which govern the use of these assets.' (World Bank, 2008).

Taber session acknowledged the need for developing community leadership and incentive to act.

The adaptive capacity of a community is somewhat dependant on the existence, and accessibility to social capital (*i.e.,* community leadership and existence of social networks). However, the development, enhancement, and maintanence of a solid social capital also rely on the ability of government institutions to be responsive to community needs. A set of community recommendations to policy-makers constitutes one of many venues to support and enhance a communities' social capital, as well as to develop responsive policies and strategies capable of addressing community needs.

In general, participants in the three communities call for the development of policies and strategies based on: (a) long-term planning; (b) improve communication between different levels of government (*i.e.* federal, provincial, local); (c) increase funding for agricultural research and technology; (d) fund and promote conservation programs (including water and climate change); and (e) fund communities and people to allow change (*i.e.* adaptation). Table 18 show recommendations identified by participants in the three communities.

Table 18. Recommendations identified in the three community session: Taber, Cabri-Stewart Valley, and Outlook.

Long-term planning on climate change, water, and all initiatives.
Improve communication between government levels
Increase funding for agricultural research and technology
Fund and promote conservation programs (including water and climate change)
Fund communities and people to allow change

Table 19 depicts recommendations identified by at least two of the three communities: Taber, and/or Cabri-Stewart Valley, and/or Outlook. These recommendations relate to the federal and provincial levels of government. Table 20 shows recommendations identified by participants only at the Taber, or Cabri-Stewart Valley, or Outlook session.

Table 19. Recommendations suggested by at least two of the communities: Taber, Cabri-Stewart Valley, and Outlook:

FEDERAL	PROVINCIAL
Long-term planning initiatives.	Cut on crop insurance premiums and/or develop useful crop insurance (*e.g.* market neutral crop

	insurance; re-incorporation of hail into crop insurance).
Support world wide climate change efforts.	Listen to and get involved with the local government.
Increase existing utilization/construction of water storage capacity and associated irrigation operations.	
Fund research and technology, including agricultural research and technology and climate change institutes.	

Table 20. Recommendations identified only by Taber, or Cabri-Stewart Valley, or Outlook participants.

	FEDERAL	PROVINCIAL	LOCAL
TABER	Clear climate change leadership.	Invest in water conservation research.	More water conservation policies.
	Political power to set policies of best management practices for conservation purposes.	Develop water management strategy.	Education in water conservation and use.
	Political power to enforce existing legislation.	Inter-provincial agreements of water crossing boundaries.	
	More input of stakeholder groups in the decision making process.	Fund long-term solutions and balance economic level with environment.	
	Long-term funding for planning and research institutions with climate change mandate.	Need to work with federal government to lesser impact of climate change.	
	Better watershed management.		
	Oil industry best management practices regulations.		
	Provide provincial and local governments the authority to develop change.		
	Resolve outstanding water issues.		
	Measure water resources nationally		
CABRI-STEWART VALLEY	Increase utilization of existing water storage infrastructure (Gardiner Dam).	Intensify irrigation operation Increase utilization of Gardiner Dam.	

Table 20. Recommendations identified only by Taber, or Cabri-Stewart Valley, or Outlook participants. (Continue)

	FEDERAL	PROVINCIAL	LOCAL
OUTLOOK	Education for both urban and rural population.	Encourage and fund vegetable production.	More decision-taking to ensure local relevance.
	Support agricultural/climate pilot projects.	Cooperate with federal government to develop agricultural projects.	Encourage better living standards.
	Target and streamline immigration towards rural communities.		
	Fund rural infrastructure.		

5.5 Participatory mapping session evaluation

Finally, an evaluation form of the overall participatory mapping session was distributed among participants (see Appendix for a template the participatory mapping session evaluation form). The objective of this evaluation form was to collect participants' thoughts regarding the usefulness of the visual representations of vulnerabilities and climate change scenarios through maps. Particularly in terms of defining whether participants found value in using a combine approach, based on contextual mapping and discussion groups, in order to provide meaning to community vulnerabilities.

5.5.1 Taber: Participatory mapping session evaluation results

Three main groups of questions were asked in this evaluation form. Table 21 shows the results of question 1, that is, 'Did this session help you to better understand the potential impacts of future climate change on water in your community?' All 10 participants answered 'yes'. Regarding question 2, 'Did the use of maps and images help you to better understand the ideas and concepts involved during the presentation?', Table 22 shows that again all 10 participants answered 'yes'.

Table 21. Taber: Answers to question 1: Did this session help you to better understand the potential impacts of future climate change on water in your community?

Yes	No
10	0

Table 22: Taber: Answers to question 2: Did the use of maps and images help you to better understand the ideas and concepts involved during the presentation?

Yes	No
10	0

In addition, question 2 continues by asking 'why' if the answer was 'yes' to the question. Following are participants' explanations to 'why' the use of maps and images helped them to better understand the ideas and concepts involved during the presentation.

a) The maps did show areas affected by drought.
b) If we think we have water problems now, if we don't make changes we will be facing a water crisis in the very near future. The patterns (climate change) are changing – with our usage of water – we must start thinking about ways to protect our future.
c) Demonstrated trends very clearly.
d) Though climatic effects will be similar in AB and SK, the impact will be different here because our population is increasing.
e) To better understand the concepts and explanation during the presentation. With maps is easier to understand. I learned a lot.
f) The maps were very helpful to see how things have changed in the area, and to see how they could change in the future.
g) The maps were informative and gave a better context of the issue.
h) See over all water use needs to be looked at more storage.
i) By giving me a better understanding of the history of the region and its impacts on the area.
j) I realized the maps etc. were used to trends in a spatial context (how it has change and how if could change). That climate change was accelerating and so did most of us that might show up. So … it may not be necessary to spend so much time validating your statements.

In summary, the above explanations show that participants recognized the value in using maps and images to better understand the potential impacts of future climate change on water in their communities. Maps and images enhanced participants own understanding of their vulnerability to climate change, by providing context to participants' relevant issues, such as drought, water and water storage, and population patterns. In addition, maps and images allow participants to identify and recognize spatial and temporal trends and patterns in terms of exposures, adaptation strategies and climate change issues. These provide participants with a better understanding of the context, trends and patterns, in order to pursue a meaningful discussion in terms of community climate change issues and government roles.

Comments and suggestions are following as responses to the third question of the evaluation form, 'Do you have any comments or suggestions regarding this session or the presentations?' Seven of the ten participants commented under this point.

a) Has been a good discussion – more people need to understand the impact of climate change. An update on the outcome of this session compared to the start of this impacts study. Very good.
b) Done very well. Need to be done more often.
c) Perhaps a comparison of the Taber Irrigation District with the Riverhurst/Outlook area would have been more comparative.
d) This session was very informative, and helped me to think of the 'big picture', and not just my own area.
e) This presentation was really good. I will suggest to have this type of presentation every year. Excellent presentation. Come back again.
f) Good use of small group discussion as well as technology (information and maps etc.) to drive the point home.
g) Timely and appropriate.

In general, participants expressed their satisfaction with the overall mapping-discussion session. The session was not only considered informative and well done, but also recognized as a venue for discussion. The above comments reflect some participants' desire for pursuing further similar sessions in the future.

5.5.2 Cabri-Stewart Valley: Participatory mapping session evaluation results

Five participants were present at the time of pursuing this evaluation. The five of them answered 'yes' to the question: 'Did this session help you to better understand the potential impacts of future climate change on water in your community?' Table 23 shows these results. Table 24 depicts the results to question 2: 'Did the use of maps and images help you to better understand the ideas and concepts involved during the presentation?' showing again that the 5 participants answer 'yes' to the question.

Table 23. Cabri-Stewart Valley: Answers to question 1: Did this session help you to better understand the potential impacts of future climate change on water in your community?

Yes	No
5	0

Table 24: Cabri-Stewart Valley: Answers to question 2: Did the use of maps and images help you to better understand the ideas and concepts involved during the presentation?

Yes	No
5	0

Question 2 continues by asking 'why' if the participant answered 'yes' to question 2. Following are the explanations given by participants regarding the usefulness of maps and images in helping to better understand the ideas and concepts involved during the presentations.

a) Gives a more complete and broader picture of what is needed for our area and that can be used for other areas in the world. All countries must be part of the world picture.
b) Visual is always better remembered and pictured, than audio. Helped to see the affected areas and some comparisons to other areas.
c) I am a visual learner, and therefore maps and visual aids are very helpful. I found the presentation very useful as well as the discussion groups.
d) Very much so good to see past data and how this relates to future projections.
e) Understand climate change and moisture levels.

The above explanations shows the powerful impact of the visual capabilities of maps, particularly by enabling participants to simultaneously visualized local and regional information, and allowing for the identification of trends and patterns. The comments also reflect an enhancement in understanding and learning.

Finally, question 3 asked for any comments or suggestions regarding the session or the presentations. Four out of five participants chose to comment as follow:

a) The presentations were adequate for the time frame available. Public awareness is important and must continue. The presentation did a supper job.
b) None that I can think, except the presentation was very good.
c) I wish more people had come out but I don't know how to overcome the problem.
d) Very well done.

In general, participants seem to be quite content with the session, and expressed their satisfaction with the overall mapping-discussion session.

5.5.3 Outlook: Participatory mapping session evaluation results

Six participants attended the participatory mapping session, and all of them answered 'yes' to the question: 'Did this session help you to better understand the potential impacts of future climate change on water in your community?' Table 25 shows these results. Table 26 depicts the results to question 2: 'Did the use of maps and images help you to

better understand the ideas and concepts involved during the presentation?' All participants answer 'yes' to the question.

Table 25. Outlook: Answers to question 1: Did this session help you to better understand the potential impacts of future climate change on water in your community?

Yes	No
6	0

Table 26: Outlook: Answers to question 2: Did the use of maps and images help you to better understand the ideas and concepts involved during the presentation?

Yes	No
6	0

Question 2 continues by asking 'why' if the participant answered 'yes' to question 2. Following are the explanations provided by participants:

a) Numbers were interesting and informative.
b) Love visualization.
c) I like to see trend lines and factual data that backs up projection.
d) Much easier to visualize the material.
e) Easier to visualize, my imagination isn't what it used to be.

The above comments portray the importance provided by participants to maps and visuals, in terms of facilitating understanding and visualizing trends, information and data.

Question 3 of the evaluation asked for any comments or suggestions regarding the session or the presentations. Four out of six participants chose to comment:

a) Need a bit more time for more discussion
b) Enjoyed visuals.
c) I would like some resource websites.
d) The more visual material you can use the better.

The comments denote participants' appreciation for self-explanatory visual material, as well as the desire for carrying further discussion and searching for more information and knowledge regarding climate change adaptation in dry-land areas.

5.6 Government official suggestions and comments

As mentioned in the methodological section of this report, one government official was invited to attend each participatory mapping session as an observer. Government officials

were asked to provide feedback of their observations, comment, suggestions, and concerns they might have regarding the sessions. Following are government officials' feedbacks regarding the participatory mapping sessions.

In comparison to traditional meeting sessions, such as workshops, seminars, public consultations, and others, the participatory mapping session was found more interactive with the audience. Although not specifically said, the latter comment reflects the sense of ownership and active engagement adopted by participants thought the development of the session. In addition, a government official noticed that the material (*i.e.*, maps and images) presented in the participatory mapping session provided a good overview of issues as well as climate change scenarios, facilitating participants to elucidate what future climate and water might mean to the agricultural sector in the future.

In terms of the participatory mapping session structure, the combination of maps and discussion groups was considered valuable by a government official, and particularly the visual representation that maps provides to the discussion. Maps are considered to bring a better understanding to all people (including lay persons) of the climate and water, economic, and social issues.

Although challenging, a government official suggested exploring the possibility of generating additional mapping of social and economic aspects of the rural community vulnerability to climate change. This social and economic information could probably be derived from work pursued currently by other IACC researchers.

An interesting comment of one government official relates to the realization that rural community members seem not frightened by the prospect of climate change. On the contrary, community members see the potential to adapt to future climate change (*e.g.* growing crops earlier, harvesting earlier).

A government official considered the participatory mapping session a valuable approach in terms of bridging government and communities. Maps are open to interpretation, and hence convey different realties as well as provide a self-sufficient approach to reach the public's needs. In this sense, a participatory mapping session was considered a valuable tool in terms of supporting the process of policy making. The session developed a series of maps to represent and interconnect complex phenomena, such as climate, economic and social impacts, in a visual fashion and open to interpretation and discussion.

Government officials' comments indicated that there is a need to develop this type of mapping-discussion approach, which simultaneously targets, *i.e.* in the same session, the general public and bureaucrats (*e.g.* Agriculture and Agri-Food Canada in Ottawa, Prairie Farm Rehabilitation Administration in Regina). However, the biggest challenge is to get these types of people together. On the one hand, policy-makers do not live in rural Canada, and even those policy-makers in Regions live in cities. This gap is affecting the development of policies that are connected to the real needs of Regions and rural communities. Conversely, rural communities do not understand the limitations of policy-

makers. Government does not and never will have all the answers. 'We travel the journey together, sometimes successfully, sometimes not.'

6. Discussion

The results of the participatory mapping sessions have provided a wealth of information, improving both participants' and researchers' understanding of the adaptive capacity and vulnerability to climate change and water of the farming communities of Taber, Cabri-Stewart Valley, and Outlook. Participants have identified a number of stressors/exposures that either mirror and/or complement those identified in the community vulnerability assessment reports. In particular, the juxtaposition of multiple stressors has been dramatically highlighted through the sessions. Participants also identified a number of constraints that hinder their ability to cope with those stressors/exposures.

While the concepts of 'double exposure' (O'Brien and Leichenko, 2000, in Leichenko and O'Brien, 2002) and 'double losers' (Olmos, 2001) are generally used to refer to the negative impacts of the compound effects of economic globalization and global climate change on developing countries, they also apply to the prairie rural communities of Taber, Cabri-Stewart Valley and Outlook. These prairie farming communities face two main external stressors/exposures, *i.e.* the international market and global climate (*e.g.*, drought). These external stressors interplay with particular regional and local conditions, generating a number of derived issues resulting from that interaction.

In terms of the capacity of the farming communities of Taber, Cabri-Stewart Valley, and Outlook to cope with lack of water availability and drought, past and current adaptation strategies suggest a relatively successful endeavour. Progressively, farmers have adopted techniques and practices, as well as developed social mechanisms that have enhanced their capacity to reasonably deal with water stress and drought. Notwithstanding such an accomplishment, farmers feel the threats of the potential impacts of future climate change, in terms of more intensive, frequent and longer drought events. They recognize the potentially serious challenges that more extreme climatic events might bring on to an already stressed water situation.

While these farming communities have demonstrated an impressive development of their ingenuity to cope with water stress and drought, the impacts of the international market have proven to impose quite a challenge on their livelihoods. The uncontrollable nature of the global market fluctuations, in terms of commodity prices and input costs, has seriously impacted the agricultural landscape of the SSRB. The adaptive capacity of the farming communities of Taber, Cabri-Stewart Valley, and Outlook have been tested during periods of simultaneously occurring droughts and increasing input costs and low commodity prices, such as in 2001 and 2002 (Wittrock *et. al*, 2006).

While the compound effect of the above global stressors impose serious challenges to the livelihoods of the farming communities of Taber, Cabri-Stewart Valley, and Outlook, governmental institutions, and particularly the federal and provincial levels, have been

identified as constraining the ability of these communities to adapt to climate stress and water issues. This third external stressor or force, *i.e.* governmental arrangements, is seen by the participatory mapping session participants as not responsive to community needs, and have become what has been labeled as 'entrenching bureaucracy', governmental failure to listen and mistrust.

The sustainability of these rural communities relies in part on the capacity of government institution to identify and address current and future community vulnerabilities in terms of climate change and water issues (Patiño and Gauthier, *in press*). Federal and provincial policies, strategies and programs can seriously benefit from considering communities' input in the development on public policies and programs, particularly because community vulnerabilities are site-specific (Klein and Smith, 2003; Smit, B. & Pilifosova, 2003). Within this context, government institutions have the opportunity of potentially enhance the adaptive capacity of rural communities by addressing relevant community issues, and positively impact the elastic character of the adaptive capacity of the communities in question.

The participatory mapping session approach developed in this study provided an alternative mean capable of facilitating community input, while at the same time built capacity in those participating in the session. Participants engaged in a reflective and learning process that enriched their own perspectives in terms of climate and water stress, and also provided them with the opportunity for making informed and conscious recommendations to policy-makers.

Participants engaged, interacted and contributed to the participatory mapping session. Five important components of the participatory mapping session facilitated the latter: (a) participants took *ownership* of the session; (b) mapping presentations were *meaningful* to participants; (c) maps *validated* community and participants perspectives; (d) maps facilitated the visualisation of *patterns and trends* enriching participants' perspectives, providing context, and promoting discussion; and (e) the combined mapping-discussion sequences were not only *informative* but also facilitated a *progressive learning process*.

From the beginning to the end of the session, participants took ownership of the session by defining their own current community vulnerabilities (*i.e.*, exposures and adaptation strategies) to climate change and water issues. Once participants understood the concept of vulnerability explained at the beginning of the session, participants provided their perspectives and identified stressors, constraints and adaptive strategies regarding climate and water issues. Progressively, through the development of the session, participants' built on their own understanding of their community vulnerability to climate change and water issues, supported by informative and meaningful maps and discussion.

Maps presented during the session depicted information regarding community vulnerability to climate change and water issues, derived from the ethnographic work previously pursued in the communities by IACC researchers. Hence, the maps were expected to reflect, at least in part, community vulnerabilities identified by participants at the beginning of the participatory mapping session. In this sense, maps were meaningful

to participants, and therefore, relevant. In addition, while maps had meaning to participants, the use of official data in the development of the maps validated community and participants' perspectives.

Probably the most important contribution of the participatory mapping session resides in the use of maps as visual facilitators of knowledge and discussion. Maps provided the visualisation of meaningful patterns and trends, enriching participants' perspectives, providing context, and promoting discussion. For example, the agricultural landscape of the area is currently changing from the traditional family farm into large farm enterprises. Maps that showed the change in the number and area size of farms over time, as well as maps that showed the change in the number of farm operators over time, had a deeper meaning in participants minds. The latter did not only reflect an adaptation strategy in an effort to cope with, in part, the international market driven crop prices, but also had embedded a community dynamic component that is attached to the family farm. With the disappearance of the family farm, the attached community dynamic is also disappearing or changing.

The combination of sequences of mapping and discussion provided participants with the means for building and reflecting on their knowledge of vulnerability to climate change, promoting a progressive learning process. The visualization of patterns and trends allowed participants to enrich their perspectives and build discussion. Maps offer regional and local context to those global forces (*i.e.,* international market and climate/drought) that seriously impact the livelihoods of farmers in a differential mode. For example, although broad trends and patterns, such as the international market and climate/drought, are impacting all three communities, the interplay with the local characteristics (contextual) results in a differential outcome. Both Taber and Outlook communities count with a strong irrigation development. However, the Taber community is based on high value crops (*e.g.* vegetable production), and it is heavily supported by a booming oil economy. On the other hand, the Cabri-Stewart Valley community lack of an irrigation development, hence it relies on dry-land crops, and it is somewhat supported by the oil economy.

An organized sequence of series of maps and discussions allowed participants to connection and link different pieces of information, patterns and trends, to better understood their community's particular place within the SSRB, as well as their community's place as an integral component of the SSRB. Such reflective and progressive learning process allowed for the development of conscious community recommendations to policy makers in terms of climate change and water issues.

7. Conclusions

A participatory mapping session, which combines sequences of meaningful maps and images with small group discussions, allowed participants to interpret, discuss and reflect on community vulnerabilities to climate change and water issues, by enabling and opening a dialogue. Such dialogue provided the means for integrating in participants'

minds the science and their everyday life experiences. The participatory mapping sessions allowed community members to reflect on community vulnerability to climate change, and provided the venues to validate, reject, and/or modify participants' perceptions and experiences. Participants were then equipped with knowledge and empowered to provide meaningful recommendations to policy-makers.

This report has concluded that a participatory mapping session, as understood and defined in this document, allows for knowledge transfer, the integration of people's perceptions and the science, and the development of community recommendations to policy-makers in terms of climate change and water issues.

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Appendix 1: Example of agenda. Community perspectives on climate change impacts on water survey session.

Cabri and Stewart Valley, December 6th, 2007.

The survey session is intended to:

1. Develop a scheme of the current community vulnerabilities to climate and related water events.
2. Present to participants the findings of the interviews pursued during the summer of 2005 by Stephanie Jeanes. This section will present community exposures and adaptive strategies to deal with current impacts of climate related events on water.
3. Present to participants potential future climate change scenarios in the South Saskatchewan River Basin, and their potential impacts on water.
4. Listen to participants' reactions/concerns/recommendations/feedback to potential impacts of future climate change on water.

08:45 Coffee and muffins.

09:00 Welcome, presentation of the goal of the research, introduction to the idea of vulnerability and related concepts, and the purpose and expected outcomes of this session.

09:15 Group discussion and development of community vulnerability scheme of the impacts of current climate related events on water.

10:15 Refreshment break

10:30 Presentation of current community exposures and adaptation strategies to the impacts of climate change on water.

11:15 Refinement of scheme of community vulnerability to climate, if necessary.

11:30 Presentation of potential impacts of future climate change on water.

12:00 Lunch (will be provided)

13:00 Discussion of implications of potential impacts of future climate change on current exposures and adaptive strategies.

13:45 Discussion of the role of government institutions under potential impacts of future climate change on water.

14:30 Thank you and wrap up.

Appendix 2: Community Vulnerability to climate.

In terms of climate events and water, list the main climate and related events and their impacts that you consider relevant for the community livelihood and every day lives.

Vulnerabilities to climate and related events

What constraints the community to deal with the impacts of the above climate and related events.

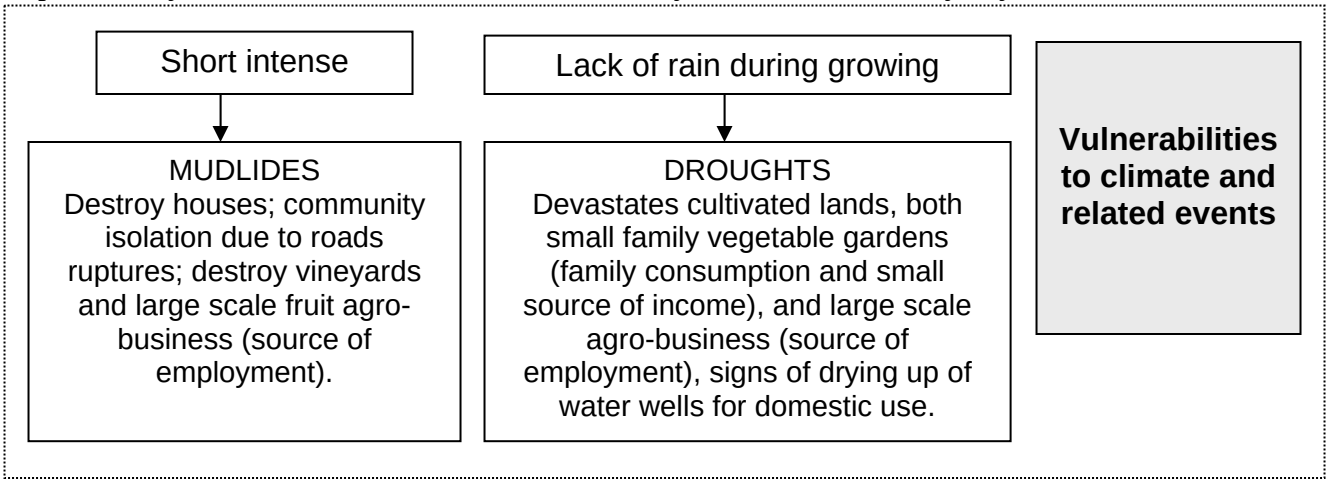
Constraints to cope with above climate and related events

How have the community dealt with the impacts of the above climate and related events.

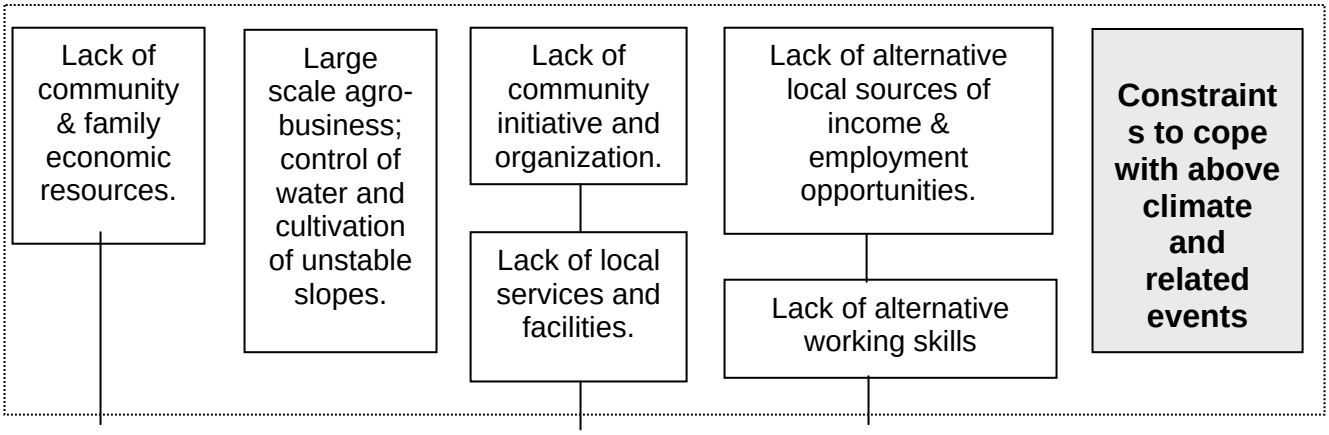
Adaptation strategies

Appendix 3: Example of community vulnerability to climate.

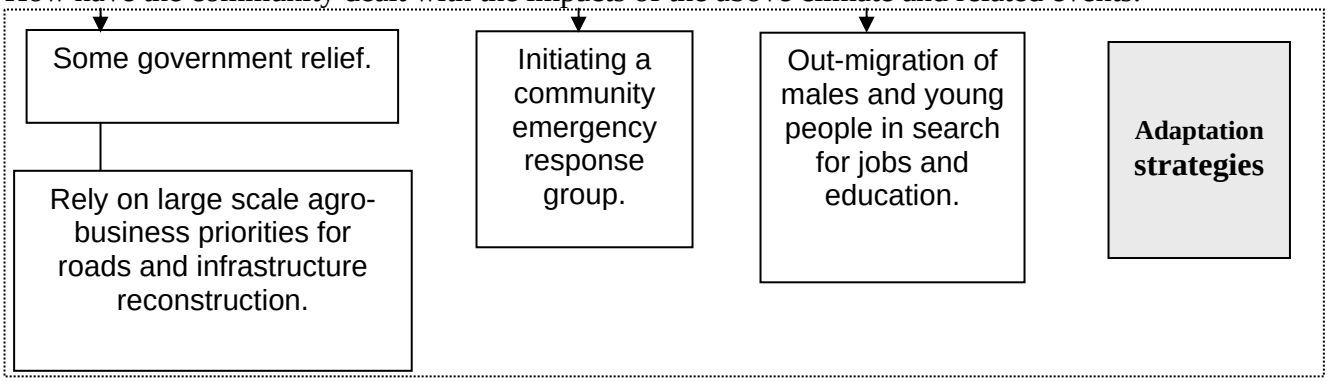
In terms of climate related events and water, list the main climate events and their impacts that you consider relevant for the community livelihood and every day lives.



What constraints the community to deal with the impacts of the above climate and related events.



How have the community dealt with the impacts of the above climate and related events.



Appendix 4: Evaluation of the results of the community assessment.

Do you agree or disagree with the results of the community vulnerabilities to climate change presented to you in this session?

Please circle one number, from 1 to 5, being 1 reflecting the least agreement and 5 the most agreement.

1 2 3 4 5

Appendix 5: Discussion of implications of potential impacts of future climate change on current vulnerabilities (current exposures and adaptive strategies).

(1) How did you deal with current vulnerabilities in the past?

(2) Would that work in the future under future climate change scenarios, or what would you do different?

(3) How are you going to deal with it under future scenarios? In other words, how do you see yourselves adapting?

Appendix 6: Discussion of the role of government institutions under potential impacts of future climate change on water.

(1) What does (government) need to be changed to make things easier for you?

(2) What will you tell your government officials, at different governmental levels, under such climate change scenarios.

Federal:

Provincial:

Local:

Appendix 7: Participatory mapping session evaluation

1. Did this session help you to better understand the potential impacts of future climate change on water in your community?

   ☐ yes ☐ no

2. Did the use of maps and images help you to better understand the ideas and concepts involved during the presentations?

   ☐ yes ☐ no

   If yes, how?

   _____
   _____
   _____
   _____
   _____
   _____

3. Do you have any comments or suggestions regarding this session or the presentations?

   _____
   _____
   _____
   _____
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   _____
   _____

Appendix 8: The Taber and Cabri-Stewart Valley vulnerability stories told through maps

The Taber vulnerability story told through maps

The resulting sequence of maps for the Taber community vulnerability assessment comprises a total of 41 maps. This series of maps is currently available at the IACC website, www.parc/ca/mcri/taber.php. The story told by the maps starts by localizing and placing the Taber, Cabri and Stewart Valley communities, and their corresponding municipal districts, within the context of the South Saskatchewan River Basin (SSRB). From this point forward, all maps highlight the particularities, trends and patterns of these communities and their municipalities. The particular information for Cabri and Stewart Valley was deliberately included in the maps to provide some benchmarks for participants. Drought (*i.e.*, climatic feature) and the volatile international market have been identified as the main global stressors faced by the farming community in the Taber area. In addition, the booming oil industry adds to a mixture of advantages and disadvantages to the current situation of the farming community. There are a number of derived issues resulted from the compound effect of the interaction between the latter three stressors with the particular local conditions. Following is an explanation of the relationships existing between the constructed sequence of maps that reflect and contextualize the relationships among exposures/stressors, adaptation strategies and derived issues.

The maps place the communities in question and their corresponding municipalities within the natural boundaries of the SSRB. The later is situated within the Prairie Ecozone of Canada, and the communities and municipalities within the Mixed Grassland Ecoregion. In other words, maps show these communities immersed within a region that presents semi-arid conditions. The real meaning of such climatic characteristics relies in that communities within this ecoregion are subject to moisture deficits, particularly in the late summer, caused by low precipitation and high evapotranspiration, and hence are subject to drought events.

The above sequence is followed by a selected series of maps that shows percent of average precipitation during years of past drought events (Agriculture and Agri-Food Canada, 2007). The percent of average precipitation covers from April 1st to August 31st (*i.e.*, extended growing season) for the years of 1936, 1961, 1988 and 2001, respect to the historical thirty year average 1961-1990. Each map shows the deficit in average precipitation for the area. Despite the regional overall lack of moisture and drought propensity, the Mixed Grassland Ecoregion presents ideal agricultural soils as well as heat per unit conditions. The communities of Taber, Cabri and Stewart Valley and surrounding areas are laid within the rich brown soils region and enjoy an abundance of sunlight. Not surprising, agriculture constitutes the main land use of the Mixed Grassland Ecoregion, regardless of the severe moisture and water availability limitations. A sequence of maps showing the communities and their municipal districts, in conjunction

with the extent of brown soils and the prairie ecoregions, and agricultural land use, within the context of the SSRB, depicts the above characterization of the area.

Maps continue to provide context by depicting an agricultural landscape where about 60% of the agricultural land of the Taber municipal district was comprised by cropland, and 38% of pasture land, in 2001. The traditional crop in the prairies of Canada, as well as in the Taber municipal district, has always been dry-land wheat. Still by 2001, 44% of the crop land of the municipal district of Taber was dedicated to dry-land wheat. Although 38% of the agricultural land was dedicated to pasture land in 2001, livestock operations in the area did not seen to be of a mayor concern for community members at the time of the ethnographic work, during the summer of 2007.

The core story derived from the Taber vulnerability assessment portrays a rural community that has been constantly in search of, and adopting and implementing adaptation strategies to cope with the lack of water, soil moisture, and drought. Agricultural conservation techniques and practices, such as no tillage and continuous cropping, are recognized as improving the conservation of soil moisture, as well as reducing the impact of soil erosion. These conservation cropping techniques have in part meant an increase in the input cost of the farming operation, including chemicals, and specialized machinery and equipment.

Notwithstanding the importance of the above moisture and soil conservation techniques and practices, the main adaptation strategy identified by community members refers to water storage (construction of dams) and related access to irrigation. Fifty-eight percent of the crop land in the Taber municipal district was under irrigated in 2001. Community members considered irrigation as a vital component in the agricultural success of the Taber area. Efforts are constantly driven to improve the efficiency and provide technological solutions to an increasingly expensive irrigation infrastructure (*i.e.*, pipes, canals, irrigation systems such as pivots, etc.).

The access to irrigation, in conjunction with high heat units, has allowed the Taber area to diversify their crops, earning a special place as the ‘vegetable garden’ of Alberta. A number of high-value specialty crops, such as sweet corn, potatoes, and sugar beet, have allowed farmers to make a living. A sequence of high-value crop maps depicts this specialty crops dominant situation of the Taber area within the SSRB. Furthermore, the food processing industries (*e.g.*, canneries) complement perfectly the diversified agricultural sector.

All of the above agricultural adaptation measures have certainly improved one or more aspects of an agricultural activity that is constantly struggling with the reality of an area characterized by the lack of water availability. However, these adaptation measures (*i.e.*, irrigation and conservation cropping techniques) have somewhat increased the input cost of the farming operation. In addition, the oil industry has dramatically impacted the cost of the land, adding to the burden of an increasing agricultural input cost, and making it practically impossible for younger generation to start a farm operation.

Despite the enormous efforts and accomplishments pursued to cope with the lack of water availability and drought, the volatile international market has dramatically impacted the agricultural landscape of the Taber area, as well as of the entire SSRB. The main impacts refer to low crop prices and higher input cost, although crop prices have recently improved. Regarding crop prices, international subsidies are blamed for lowering the price of crops, which in conjunction with higher input cost, translate into low income.

The compound effect of the above adaptation strategies to cope with the lack of available water and drought, and the impacts of the international market, can be somewhat depicted through a series of maps that shows the following economic trends for the Taber area, from 1995 to 2000: (a) 76% increase on the average farm receipt; (b) 58% increase on the average farm capital; (c) 40% increase on the average farm interest expenses, including bank loans for land purchase, machinery and equipment, between others; (d) 28% increase on the average farm crop expenses (include fertilizers, herbicides, insecticides, fungicides, etc., and seeds and plants); (e) 78% increase in average total farm business operating expenses (including crop insurance). Despite the considerable increase on the average farm receipt, average farm expenses have significantly affected farmers' net income. The simultaneous and compound impact of climatic and economic conditions on the community categorized them as what has been called 'double losers' by Olmos (2001).

The impact of a low farm income has transformed the agricultural landscape of the SSRB, including the Taber area. In an attempt to cope with low crop prices, farmers have expanded the area size of their farms, facilitated in part by technological development. While the average area size of a farm had increase 14%, the number of farms and the number of farm operators had decreased 13% and 12% respectively, in the Taber municipal district from 1996 to 2001. In addition, farmers have diversified their income by acquiring an additional job in order to compensate for the lost of agricultural income. In 1995, 16% of farm operators pursued an average of 20 or more hours of paid work a week not related to the agricultural operation. By 2000, 23% of farm operators pursued an average of 20 or more hours of paid work a week not related to the agricultural operation.

Larger farm sizes and the demands of specialty crops, particularly vegetable crops, have increased the need for agricultural labourers. Although the Taber municipal district has experienced a significant population growth during the last 10 years, of about 12% from 1996 to 2006, farmers are constantly struggling to find agricultural labourers. Farmers are faced with agricultural salaries that can not compete with the high salaries paid by the booming oil industry existing in the area. In addition, the lack of affordable housing for temporal agricultural labour adds to the problem.

Still, the oil industry has brought to the Taber municipal district the required population base, including an 11% increase of population less than 30 years old for the period of 1996-2006. The existence of such population contingency guarantees an adequate infrastructural system that supports the sustainability of the rural communities in the area (*e.g.*, hospitals, roads, schools, financial institutions, retail, etc.). Notwithstanding the

economic benefits of the oil industry, as well as its implications for the local economy, community members are concerned with the lack of interest of the young population to complete high school and pursue higher levels of education. The latter is mainly attributed to the oil industry high salaries.

In summary, the compound effect of the current climatic conditions (lack of water availability and drought), the volatile international market, and the oil industry, have impacted the livelihood of the traditional family farm, altering the agricultural landscape of the Taber community and surround area. The entire farming community structure is shifting from the traditional family farm into large farm operations, and with it, the entire social rural community arrangements. This transformation is occurring within the context of a diversified and interconnected local agricultural economy (specialty crops and food processing industry), in great part facilitated by irrigation. Despite the latter, rural communities in the area are currently mainly sustained by a booming oil economy that attracts the required population base (including young population) capable of maintaining the necessary infrastructure (*i.e.*, schools, services, hospitals, roads, etc.) to support the rural communities and agricultural sector.

The Cabri-Stewart Valley story told through maps

The forty-one maps sequence resulted for the Cabri-Stewart Valley community vulnerability assessment can be accessed at the IACC website, www.parc.ca/mcri/cabstew.php. This series of maps is quite similar to the Taber maps story, and follows the same structural organization as the map sequence presented in Taber. It starts by localizing and placing Cabri and Stewart Valley, Taber, and their corresponding municipalities within the natural watershed boundaries of the South Saskatchewan River Basin. All maps highlight the particularities, trends and patterns of these communities and their municipalities (*i.e.*, Cabri, Riverside RM, Stewart Valley, Saskatchewan Landing RM, and Taber, Taber municipal district), however the focus this time is on Cabri and Stewart Valley instead of Taber.

In addition, the particular information for Taber was deliberately included in the maps to provide some benchmarks for participants. As in the case of the Taber community, drought and unpredictable extreme climate (*i.e.*, climate) and the international market, have been identified as the main exposures/stressors faced by the farming community, and drought as the most dramatic climate and water related event. In addition, Cabri-Stewart Valley are also experiencing a number of derived issues resulted from the compound effect of these two broader exposures/stressors and their interaction with local conditions. Following is an explanation of the relationships existing between the constructed sequence of maps that reflect and contextualize the relationships among exposures/stressors, adaptation strategies and derived issues.

The development of the Cabri-Stewart Valley vulnerability story told by the sequence of maps situates these communities within the Prairie ecozone of Canada, specifically within the Mixed Grassland ecoregion. The importance of being placed within the Mixed

Grassland ecoregion relies in that the area is subject to semi-arid climatic conditions, characterized by moisture deficits in late summer, caused by low precipitation and high evapo-transpiration, hence susceptible to drought events. The latter is depicted by a series of 5 selected maps that show percent of average precipitation, throughout the extended growing season (*i.e.*, April 1st to August 31st), during some known drought years (*i.e.*, 1936, 1961, 1984, 1988, 2001).

On the other hand, the Mixed Grassland ecoregion is localized within the Brown Chernozemic soil zone, therefore also the communities of Cabri and Stewart Valley. Despite the moisture deficit conditions existing in the Mixed Grassland ecoregion, rich brown soils, in conjunction with adequate heat per units, facilitated a spread wide agricultural activity in the area. Today, the dominant land use in the Mixed Grassland ecoregion corresponds to agriculture (including cropland and pasture land). However, cropland dominates the agricultural landscape in both Cabri and Stewart Valley areas. While 75% of the agricultural land in the Riverside RM (Cabri municipal unit) is dedicated to cropland, only 23% is used as pasture land. Also, 77% the Saskatchewan Landing RM (Stewart Valley municipal unit) agricultural land is dedicated to cropland compare to 20% of pasture land.

Wheat has been recognized as the traditional crop in the Canadian prairies, and still constituted 54% of the cropland area in the Riverside RM (Cabri) and 49% in the Saskatchewan Landing RM (Stewart Valley), by 2001. Furthermore, a particular type of wheat, *i.e.* durum wheat, is strongly rooted in the traditional farming culture of the area, comprising 88% of all types of wheat acreages in the Riverside RM, and 77% in the Saskatchewan Landing RM. The land is considered by community members as 'durum land'.

To cope with the lack of soil moisture and drought, farmers have increasingly adopted soil moisture and soil conservation practices. The percent of no tillage prior to seeding of the total land prepared for seeding, has increased considerably in the area. The no tillage practice has doubled in both the Riverside RM (*i.e.*, 30% no tillage in 1996, and 58% no tillage in 2001) and Saskatchewan Landing RM (*i.e.*, 32% no tillage in 1996, and 68% no tillage in 2001) from 1996 to 2001. In addition, the percent of sumerfallow land of the total farm land has decreased from 31% to 20% in the Riverside RM, and from 28% to 16% in the Saskatchewan RM, from 1996 to 2001.

Although these conservation cropping techniques are considered effective in terms of soil and moisture conservation, they have also contributed to an increasing input cost in the farming operation, including chemicals and fertilizers, and specialized machinery and equipment. The effect of these farming techniques over input cost is in part reflected in the farm crop expenses from 1995 to 2000. Farm crop expenses include fertilizer and lime purchases, herbicides, insecticides, fungicides, other chemicals, seeding and plant purchases. The Riverside RM faced an increase of 15% in the farm crop expenses, while the Saskatchewan Landing RM experienced an 11%, from 1995 to 2001.

The increase in the average farm capital from 1995 to 2000, also reflects somewhat the impact of the above cropping conservation techniques. The latter has forced farmers to acquire expensive and sophisticated machinery and equipment to pursue no tillage seeding, for example (*e.g.*, air pressure seeders). While the Riverside RM has experienced an increase of 10% in the average farm capital from 1995 to 2000, the Saskatchewan Landing RM has seen a 20% increase in the average farm capital.

Notwithstanding the constant efforts to adapt to the above climate and water related stresses, these rural communities have been severely impacted by the international market, in terms of low grain prices and increasing input cost. Although the price of grain has improved recently, the compound effect of moisture deficit, low grain prices and higher input cost, has already made an impact in the farming operation of the area, and particularly at the level of the family farm operation.

In an attempt to cope with low grain prices, hence low income, and sometimes no income, farmers have introduced dry-land specialty crops, such as lentils, chick peas and dry filed beans to the area. Such an adaptation is quite a challenge for local farmers, because these specialty crops require an entire new set of machinery and equipment, than those used in the grain operation, contributing also to an increase in the average farm capital. In addition, the variety of specialty crops that can be introduced is restricted by the impossibility of irrigation. Although irrigation is available, the cost for pumping the water to the farm operation is extremely high, making irrigation inaccessible. Less than 0.5% of the crop land in the Riverside RM is irrigated, and only on areas adjacent to the South Saskatchewan River.

All of the above farming adaptation strategies to cope with the lack of moisture and drought, and/or the international market, have impacted the agricultural landscape of the area. Some of this impact can somewhat be depicted in the following series of maps that shows the economic trends of the area, from 1995 to 2000. The average farm receipts increased a modest 1% in the Riverside RM, and 22% in the Saskatchewan Landing RM. Simultaneously, farm interest expenses have increased 15% in the Riverside RM, and 11% in the Saskatchewan Landing RM. The latter includes bank loans to acquire land, machinery, and others. In general, the total farm business operating expenses increased 9% in the Riverside RM, and 28% in the Saskatchewan Landing RM (including increasing premiums for crop and hail insurance). Although there has been an increase in farm receipts, average farm expenses have significantly affected farmers' net income. The simultaneous and complex interaction of the climatic and economic conditions experienced by these communities, portray them as what it has been referred in the literature as 'double losers' by (Olmos, 2001).

In an effort to cope with low crop prices and high input cost, reflected mainly in a low income, farmers have adopted two main adaptation strategies; (a) increase the farm size, in part facilitated by the advances in the agricultural technology; and (b) diversify the source of income to compensate for the loss of agricultural income. Regarding increased farm size, the whole agricultural landscape of the area has been transformed, not only in terms of spatial patterns, but also in terms of demographic patterns. While the family

farm is disappearing, the young portion of rural communities is being seriously halted. In addition, the input cost involved in start a farming operation is unreachable for the young population and, hence they leave in search for better job opportunities and/or higher education. A sequence of maps depicts this trend and its related outcomes.

The average farm size in the Riverside RM has increased by 4%, while an increase of 23% has occurred in the Saskatchewan Landing RM, from 1996 to 2001. The latter has meant that the number of farms in the area has been reduced by 7% in the Riverside RM, and 9% in the Saskatchewan Landing RM, during the same period of time. Hence, the number of farm operators has also decreased, and with them have left entire families. From 1996 to 2001, the number of farm operators in the Riverside RM decreased 10.5%, and the Saskatchewan Landing RM lost about 5% of farm operators in the area, from 1996 to 2001.

During the last 10 years, from 1996 to 2006, Cabri and the Riverside RM have experience a 17% and 7% decrease in their population, respectively. Stewart Valley and Saskatchewan Landing RM have lost 1% and 9% respectively, during the same period of time. The loss of population in the area is seriously debilitating the already diminished rural infrastructure, and with it, the sustainability of rural communities. As mentioned before, the sustainability of these rural communities depends strongly on a successful agricultural activity, mainly because agriculture is the predominant economic activity that sustains the livelihoods of rural community members. However, the main concern in terms of population patterns for community members refers to the loss of the young portion of the population. Without a young population base, the future sustainability of the rural communities and current community lifestyle is seriously jeopardized.

In addition, in an attempt to compensate for the loss of farm income, farmers have diversified their source of income. It is not unusual that community members commute to larger centres, such as Swift Current, in search for a secondary job. In addition, the oil industry has also provided some supplementary source of income that is welcome by the community. For example, farm operators in the Riverside RM pursuing an average of 20 hours and more of paid work a week not related to the agricultural operation, increased from 19% to 27% from 1995 to 2000. Similarly, farm operators in the Saskatchewan Landing RM pursuing an average of 20 hours and more of paid work a week not related to the agricultural operation, increased from 23% to 39%, in the same period of time.

The compound effect of larger farm sizes, depopulation and in some degree higher salaries pay by the oil industry, have added to farmers struggle by producing a shortage of agricultural labour. Although the local economic benefits of the oil industry are recognized, school desertion is in part also attributed to the oil high pay salaries.

In summary, the complex interaction of the current climatic conditions (drought and unpredictable extreme climate) and the international market has impacted the livelihood of the traditional family farm, favouring larger farm operations and transforming the agricultural landscape of the area. The family farm is disappearing and the young population is leaving, while the rural community infrastructure (*i.e.*, schools, services,

hospitals, roads, etc.) weakens and deteriorates and the traditional rural community arrangements become unsustainable.

Appendix 9: Climate change, climate change scenarios and potential impacts of future climate change on water

The story told by this sequence of slides and maps starts by providing a simple and brief explanation of what climate change is. The complete sequence of slides and maps is available at www.parc/ca/mcri/taber.php for the Taber participatory mapping session and at www.parc.ca/mcri/cabstew.php for the Cabri-Stewart Valley participatory mapping session. It begins by differentiating weather from climate, and inserting weather as a part of climate. Climate is presented as the total of weather that happens over a period of years in a particular place. This includes average weather conditions, regular sequence of weather such as seasons, and special and extreme weather events such as tornados, floods and storms. To illustrate the latter, a map of the Koeppen's climate classification of the world was presented to participants, along with pictures portraying climate-related landscapes for specific regions of the worlds. For example, pictures of the Amazon portrayed the rainforest, while semi-arid areas are represented by grasslands and savannahs pictures. Afterwards, and in a very simplified fashion, participants were explained that climate is driven by the sun. Basically, the sun warms the air and the warm air raises bringing moisture from the oceans and other water bodies. While the moist air raises, it expands and gets cooler, hence the moisture in the air condenses making clouds. Clouds bring rain, and rain helps things grow, such as plants, trees and crops.

Participants were explained that there is much more than the above involved in climate. The complex interaction of a number of interrelated cycles, factors and components are involved in the definition of climate as we currently know. Some of them are the water cycle, the human activity, including land use and land cover changes, the ecosystems and carbon cycle, the volcanic activity, the glaciers and ice sheets, and the atmospheric composition. When changes occurred to one or more of the latter, there is the possibility of climate change. In general, climate change is understood as a variation in climate over many years, from decades to millions of years, and there have been a number of climate changes in the past. But climate change does not only mean a change in average climatic patterns, such as temperature and precipitation, it also includes changes in the frequency and intensity of extreme climatic events, such as rainstorms, monsoons, droughts, windstorms, etc. Scientists have reasons to believe that extreme climatic events will intensify and will occur more frequently is some areas of the world.

Participants were explained that there are natural and human causes for climate change. Some of the known natural causes are; (a) solar activity which can causes warming or cooling of the Earth depending on the intensity of the sunlight that reaches the surface of the planet; (b) volcanic activity can affect the climate due to the emission of aerosols and carbon dioxide; and (c) changes in the Earth's orbit can also affect the climate. In terms of human causes for climate change, the Industrial Revolution in the 1850s brought an accelerated transformation of the economy and the market. While manual labour was replaced by machinery and the industry, a large-scale use of fossil fuels took place in order to maintain the industrial activities. These industries created jobs in the cities and over the years, people moved from rural areas to the cities. This trend is still continuing.

More and more land that once was covered by vegetation has been cleared to allow cities to grow. Natural resources are being used extensively for construction, industries, transport, and consumption, to support this new way of lifestyle.

Participants were explained that as a result of the large-scale use of fossil fuels, a large amount of gases have been realized into the atmosphere. Some of these gases are known as the greenhouse gases because they have the capacity of warming up the air, and carbon dioxide is the most important of the greenhouse gas currently emitted into the atmosphere. Simultaneously, the Earth's natural carbon sinks, such as the vegetation cover, has been reduced due to the intensive and extensive use of natural resources, as well as changes in the land use patterns (e.g., deforestation, land clearing). In summary, the emissions of carbon dioxide has increased substantially since the Industrial Revolution, while natural carbon sink areas of the world have been reduced, hence the content of carbon dioxide in the atmosphere is constantly rising, and the Earth continues warming up.

Currently, scientific consensus is that the climate of the world is changing. It is the rapid rate at which this change is occurring that makes this climate change different from past climate change events. The average Earth's temperature is rising, and there are indications that this trend will continue in the future. Scientists have been able to construct a relatively clear picture of the last 1,000 years of the Earth's climate. While, average mean temperatures before the 1850's were reconstructed based on proxy data, since the 1850's scientists have been able to rely on the thermometer to monitor and record the temperature of the Earth.

In order to compare a series of temperature over time, scientists select a 30 year period and calculate its average temperature, or 'normals'. In this particular situation, the 'normals' are the average temperature from 1961 to 1990. Of course, this is an arbitrary period selection and its sole purpose is for comparison. In this sense, temperatures prior to 1850s are located below the 'normals', by the 1850s temperatures started to constantly increase, and finally temperatures show a steep increase starting in the 1990s, and continues today.

It was explained to participants that in an attempt to try to elucidate possible future climates, scientists use global climate models (GCMs) and climate scenarios. GCMs are computer-driven models that are used to project future climate, between other uses. GCMs are judged according to their ability to reproduce past climates, and are also calibrated according to past climates derived from proxy data (*e.g.*, seafloor and ice cores, tree rings, etc.) Scenarios are neither specific predictions, nor forecasts of future climate. They are plausible alternative futures, where each scenario is an example of what could happened under particular assumptions on the use of fossil fuel and other human activities (*e.g.*, population growth trend, economic structure, climate initiatives, etc.). All scenarios are equally valid, and no particular scenario is necessarily better than any other. Scenarios are useful to scientists because they assist in climate modeling and help to explore potential climate change impacts, as well as humans and ecosystems

vulnerabilities. Regardless the scenario and the global climate model used, all of them are indicating an increase in average temperature in the future.

What does the above increase in average temperature mean for the SSRB and its communities, such as Taber, Cabri and Stewart Valley? In a few words, it means more and more intensive drought events. Future climate change scenarios indicate that more frequent, intense and widespread droughts are expected to occur in the Mixed Grassland ecoregion, placing a larger area at risk of desertification unless management strategies are developed (Sauchyn *et al*., 2002). The following sequence of maps begins by depicting areas in the SSRB presenting below average precipitation in conjunction with dry, unfertile soils. This kind of representation constitutes a visual image that provides meaning to drought, and that it is widely understood by the community members of Taber, Cabri and Stewart Valley. It is meaningful particularly because these rural communities have socially evolved and are economically dependent, at least in part, on an agricultural sector that sustains farmer's livelihoods, while constantly struggled with water scarcity.

Participants are again exposed to the meaning of living within a region presenting semi-arid condition (*i.e.*, the Mixed Grassland ecoregion). That is, subject to moisture deficits, particularly in the late summer, caused by low precipitation and high evapotranspiration, and hence subject to drought events. Hence, it is not surprising that scientists have identified the Prairie Ecozone of Canada as 'the only major region of Canada where drought is a landscape hazard' (Sauchyn *et al*., 2002: 247). The dramatic impacts of droughts in the prairies of Canada have been widely documented in the literature (Wittrock *et al.*, 2006; Lac and Conlan, 2004). In addition, participants are already aware of and have experienced the impacts of drought in their livelihoods. Furthermore, they have identified drought as the main climatic-water exposure/stressor when constructing the main current community vulnerabilities to climate events and water related issues scheme.

To facilitate an understanding of the potential impacts of future climate change, participants are taken through a sequence of maps that led them to the concept of climate moisture index. Prior to the display of the maps, participants were explained that generally scientists present extreme scenarios to depict both best and worst case scenario for future climate change. However, for the purposes of this participatory mapping session, participants are asked to focus on trends rather than on extremes or particular number figures. Hence, the sequence of maps that they will see have been derived from a median climate change scenario, based on the Canadian Centre for Climate Modeling and Analysis, specifically CGCM3.1 T47 B1(2).

This sequence of maps comprises both 'normals' (*i.e.*, average 1961-1990) and 2050s (*i.e.*, 2040-2069) scenarios of average precipitation, mean temperature and climate moisture index. The first map depicts the SSRB inserted within the larger Saskatchewan and Alberta Prairie Ecozone context, showing average annual total precipitation for 1961-1990 in mm. The pattern depicted in this map shows that the Mixed Grassland ecoregion, as well as Cabri, Stewart Valley and Taber, are within the area that receives the least

amount of precipitation. While a second map focused mainly on the SSRB, and shows a more detailed (*i.e.*, larger scale) average annual total precipitation for 1961-1990 in mm, a third map depicts the average annual total precipitation for the 2050's. In general, all areas in the SSRB are expected to receive a small increase in the average annual total precipitation by 2050s. For example, Cabri is expected to receive 29 extra mm. of average annual precipitation by the 2050's, while Taber 14 mm. and Stewart Valley 32 mm, respectively.

However, the importance of precipitation relates to the time of the year when this extra amount is expected to happen. Precipitation is most valuable for farmers during the growing season (*e.g.,* PFRA defines the extended growing season from April 1st to August 31st), or as snow during the winter. This median scenario, CGCM3.1 T47 B1(2), suggests that the main increase in precipitation will occur during the Fall (September-October-November) by the 2050s. Taber is expected to receive 55 more mm. of precipitation in the fall by the 2050s, while Cabri and Stewart Valley are expected to receive 41 and 42 more mm. respectively. On the other hand, summer is the season of the year that is expected to receive the least increase on average precipitation by the 2050s. While Cabri and Stewart Valley are expected to receive an extra 2 and 3 mm. in summer by 2050s, Taber is expected to suffer a decrease of 8 mm. Notwithstanding the trends marked by this median scenario, it is worthy to mention that extreme scenarios for the SSRB are showing that the main increase in precipitation is expected to occur during the winter months. Nevertheless, extreme scenarios also expect to have an increase in the winter minimum temperatures, which implies that winter precipitation will see an increase on its share of rain, rather than snow.

In terms of annual mean temperature (1961-1990), basically the SSRB is localized within the warmest area of the prairies of Canadian, particularly Taber and its surrounding area. A comparison of the maps showing the annual mean temperature for 1961-1990, and the annual mean temperature scenario for the 2050s, expects an increase of 2.2°C for Taber, and 2.3°C for both Cabri and Stewart Valley. However, temperature also has a temporal significance, such as precipitation. This median scenario suggests that the winter and summer months are the ones that will experience la larger increase. Hence, while it is expected to receive more rain during winter and less snow, summer is expected to be warmer, and probably longer. Some scientists interpret the latter as an increase in the growing degree days for agriculture.

However, an isolated representation of temperature and precipitation does not provide a complete picture of the moisture situation of the SSRB, neither of the conditions faced by the communities in the area. Currently, scientists have been using the Climate Moisture Index (CMI) as an alternative indicator to measure drought. Although this index is an artificial measure, it does provide the means to measure the variation in the content of moisture in the climate, hence climate moisture deficit, a particularly interesting issue for farmers in the Canadian prairies. CMI is a fairly simple indicator of soil moisture, and it is calculated as the difference between annual precipitation and annual potential evapotranspiration (Hogg, 1997).

A sequence of maps depicting the climate moisture index for the SSRB was presented to participants. These maps were also created based on the median climate change scenarios (CGCM3.1 T47 B1(2)) data provided by Suzan Lapp (2007). A climate moisture index map shows the average climate moisture index for the growing season (*i.e.*, May-June-July) for the period of 1961-1990. In general, most of the SSRB is characterized by deficit in moisture that increases toward the Medicine Hat – Taber municipality area. The exception to the latter happens towards the west of the SSRB, which corresponds to the Rocky Mountains. Following the latter, a map depicts the average climate moisture index for the 2050's. All areas east of the Rocky Mountains in the SSRB are expected to experience an increase in moisture deficit, including Cabri, Stewart Valley and surroundings, and particularly towards the Medicine Hat-Taber-Lethbridge area.

Following the moisture climate index maps, participants are introduced to the idea of prairie vegetative transitions and its relationship to soil moisture. A collaborative pilot project study, pursued by the University of Regina and Saskatchewan Environment, defined ecologically valid vegetative transition for the Saskatchewan prairie vegetative regime under conditions of increasing water deficit (James *et al.*, 2001). That is, these vegetative transitions occur as a prairies ecosystem dries. The vegetative transitions range from coniferous woodland (dominated by *coniferous* tree species) to desertification (transition towards an arid ecosystem with establishment of *xerophylic* species), and it is presented to participants on a slide showing current desiccating grassland in south-western Saskatchewan. At this point, participants are explained that currently Central North America experiences 30 days without rain every 50 years, but by 2070, global climate models suggest that Central North America will experience 30 days without rain every 18 years (Kharin and Zwiers, 2000). The latter implies a substantial increase in the frequency of consecutive dry days. Here concludes the climate change presentation to the Cabri and Stewart Valley participants.

Taber participatory mapping section on climate change was comprised of additional maps and images. The majority of latter were courtesy of Dr. David Sauchyn and the Prairie Adaptation Research Collaborative (PARC). These maps and images are intended to illustrate the potential impact of future climate change mainly on irrigation. A map depicting all Canadian prairie basins, including the SSRB boundaries, shows all those areas that do not contribute to the drainage areas system, based on the median annual runoff. This map shows that 40% of the area of the Saskatchewan River Basin (SRB) does not contribute to the annul runoff of the SRB rivers. At the same time, the glacier cover, in the Rocky Mountain, has decreased quite rapidly in the last few years, and scientists believe that the phase of increase stream flow from global warming has past (Demuth and Pietroniro, 2001). Most likely, the dramatic flooding events seen in the last few years in the SSRB, are somewhat related to this declining glacier melting trend resulted from global warming.

In addition, PARC has been involved in a research project that has modeled water flows and climate change in the SSRB. Some results of this study are in a map that shows GCM scenarios depicting cumulative flows for 2039 – 2070 for the SSRB sub-basins. All sub-basins reflect a decrease in their cumulative flow during the specified period of time. The

Bow River at the mouth shows a decrease of 10%, while the Old Man River at the mouth shows a decrease of -4%. The question is how is this going to affect the irrigation of the area in the future.