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Manitoba's Involvement in the Prairies Regional Collaborative: Synthesis Report
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Written by Jo-Ellen Parry, Susan Taylor, Daniella Echeverría, Matt McCandless and Phil Gass

Executive Summary

Awareness is growing of the potential vulnerability of Manitoba to the impacts of climate change, including warmer and wetter winters, hotter summers with possibly more variable rainfall, and potential increases in the frequency and intensity of droughts and floods. These changes will have socio-economic ramifications for water resources, agriculture, human health, transportation and other sectors. In response, the provincial government is beginning to plan for these anticipated impacts, such as by becoming aware of the tools, programs and policies needed to understand and respond to identified risks and strengthen adaptive capacity. However, Manitoba has yet to put in place the basic building blocks required to engage in more comprehensive and longer term adaptation planning. These foundational steps include:

- Strengthening governance capacity by establishing clear objectives for managing the impacts of climate change and an effective mechanism for coordinating adaptation action across government.
- Gaining the commitment of senior government leaders in efforts to prepare for the adverse impacts of climate change and take advantage of emerging opportunities.
- Improving access to the knowledge and tools required by different levels of government and civil society to engage in adaptation planning and action.
- Establishing mechanisms for ensuring the involvement of stakeholder groups in adaptation planning.
- Putting in place processes for monitoring, evaluating and improving the effectiveness of current policies and programs with respect to their capacity to reduce the adverse impacts of climate change and take advantage of emerging opportunities.

Putting in place these building blocks is necessary for the establishment of an enabling environment for adaptation to climate change. This will require the adoption of a long-term, proactive approach to policy development and planning, and the commitment of appropriate financial, personnel and technical resources. Creating this environment will help ensure Manitoba's future sustainable development and prosperity.

These observations emerged from Manitoba's participation in the Prairies Regional Adaptation Collaborative (PRAC). Undertaken between April 2010 and March 2012, this $6.6 million, federal-provincial cost shared program was undertaken in partnership with the provinces of Alberta and Saskatchewan, Natural Resources Canada (NRCan) and the University of Regina. Its objective was to increase the capacity of decision-makers to advance the integration of adaptation into policies, programs and planning. Through the PRAC, the three Prairie Provinces were able to address shared concerns regarding the potential implications of climate change on the region's hydrological regime through activities related to the following themes:

- Water Resources Management

- Drought and Excessive Moisture
- Terrestrial Ecosystems

In Manitoba, implementation of the PRAC was led by Manitoba Conservation and Water Stewardship in partnership with Manitoba Agriculture, Food and Rural Initiatives (MAFRI) and Manitoba Local Government. Partnerships were also established with Saskatchewan Watershed Authority, Alberta Environment and Alberta Sustainable Resource Development. In addition, the province established collaborative relationships with other levels of government (City of Winnipeg, City of Brandon, TransCanada West Planning District, Little Saskatchewan River Conservation District), research organizations (International Institute for Sustainable Development, Saskatchewan Research Council, non-governmental organizations (Friends of the Earth) and private consulting firms (Deloitte, GENIVAR, MMM Group and Stantec Consulting).

Overview of Areas of Work

A number of projects were completed in Manitoba under each theme of the PRAC. Under the **Water Resources Management theme**, Manitoba sought to better understand the potential vulnerability of its water resources to climate change, and to identify measures that could be taken to reduce this vulnerability. Activities completed under this theme included: the development of scenarios for future water supply and demand in the Assiniboine River Watershed; strengthening municipal capacity in the Pembina Valley Conservation District to reduce future water demand through use of the Water Soft Paths approach; and provision of guidance on the implications of the PRAC's findings for provincial water policy over the short, medium and long-term.

To address concerns related to the potential economic and social risks associated with more frequent occurrence of **drought and excessive moisture** conditions due to climate change, activities undertaken included: working with the City of Brandon and the TransCanada West Planning District to test a tool that would help municipalities plan for climate change; assisting with City of Winnipeg in providing training on climate impacts, adaptation needs and implementation strategies; examining options in the Interlake Region for increasing capacity to adapt to excessive moisture conditions; drafting an Interprovincial Drought Communication Framework in collaboration with Alberta and Saskatchewan; developing a Provincial Drought Management Plan; and completing a pilot study that assessed the degree to which established provincial policies and programs are currently helping to build rural producers' adaptive capacity.

Under the PRAC's **Terrestrial Ecosystems** theme, Manitoba focused on deepening understanding of potential climate change impacts and adaptation options for the province's forests and grasslands, and promoting the integration of adaptation considerations into MAFRI's policies and programs. Key initiatives included: undertaken an assessment of Sandilands Provincial Forest to better comprehend its potential vulnerability and adaptation options; completing an assessment of the vulnerability of Manitoba's grasslands to climate change and identify potential adaptation options; and exploring

options within MAFRI for minimizing the potential impacts of climate change for the forage and beef sectors.

Manitoba also participated in series of PRAC forums that promoted inter-provincial knowledge sharing, capacity building, and identification of common adaptation challenges, options and needs. These forums included the *Living with a Changing Climate* conference held in November 2010; a *Terrestrial Forum* held in March 2011 in Saskatoon; a *Combined Water and Drought Management and Excessive Moisture Forum* held in September 2011 in Winnipeg; and the final PRAC inter-provincial forum, *Adaptation to Climate Change on the Canadian Prairies*, held in February 2012 in Regina.

Additional projects that complemented the PRAC work plan were also undertaken, including: hosting a workshop on climate data, modelling and applications for planning in January 2012; and hosting the *Manitoba Prairies Regional Adaptation Collaborative Final Forum* in March 2012. With supplemental funding from NRCan, Manitoba also undertook an assessment of the Land and Infrastructure Resilience Assessment (LIRA) Tool in the Little Saskatchewan River Watershed.

Lessons Learned

Through the PRAC, a series of insights were gained regarding Manitoba's efforts to prepare for and adapt to climate change. Some of these findings were cross-cutting and should inform the province's overall approach to climate change adaptation. Others pertained specifically to the water, agriculture and municipal sectors.

- **Provincial Adaptation Planning**. Participation in the PRAC further raised understanding of the need to complete a provincial vulnerability assessment and develop provincial and/or departmental adaptation strategies. It also demonstrated the need for, and benefits of, greater coordination between departments and programs such as might be achieved through an inter-departmental adaptation working group. Challenges to engaging in effective adaptation action were also identified, such as insufficient funding, staff time and technical capacity to engage in long-term projects, along with a focus within the provincial government on reactive rather than proactive planning. Options for improving climate change adaptation governance capacity were identified as including establishing an inter-departmental adaptation working group, establishing a provincial adaptation framework to coordinate departmental strategies, maintaining dedicated staff time on long-term adaptive initiatives, and monitoring and evaluating existing policies and programs on a regular basis to assess their ongoing suitability under changing circumstances.
- **Inter-provincial Collaboration.** Engagement with representatives of the governments of Alberta and Saskatchewan helped identify mutual concerns, common constraints and barriers to inter-provincial collaboration. The ecological and economic inter-connectedness of the Prairie Provinces suggest that stronger collaboration in areas of mutual interest could reduce future vulnerability. Identified options for achieving this goal included: continuing to create opportunities for knowledge sharing and policy collaboration in areas of shared concern; establishing stronger links

with boundary organizations and academia; and building on the draft Inter-Provincial Drought Communications Framework produced by the PRAC.

- **Access to Climate Projection Data.** A common challenge identified through implementation of a number of PRAC projects in Manitoba was difficulty accessing high quality, standardized climate projection data and robust climate scenarios specifically tailored to provincial needs. The absence of this information impeded implementation of some of the PRAC's activities and led to the production of findings insufficiently robust to guide decision-making. Engagement in the PRAC also highlighted the absence of an official process for coordinating provincial climate data holdings and the development of an inventory of climate data for the different regions of Manitoba. To overcome these challenges, and thereby improve Manitoba's capacity to engage in sound adaptation planning, suggested options were: have the government dedicate capital and make operational investments in climate data; and establish a provincial data coordination centre that will be responsible for collecting, standardizing, managing and making available to the public regional climate projection datasets.
- **Water Resources Management.** Research on the projected impacts of climate change in the Prairie Provinces has communicated a common message that historical assumptions related to hydroclimatic stationarity can no longer form the basis for planning and decision-making. However, definitive statements regarding the future variability of soil moisture conditions compared to historical norms could not be drawn from the limited research completed as part of the PRAC. Demand for water in the Assiniboine River Basin, however, is expected to increase, particular if climate change encourages the production of high water demand crops (such as corn, soybeans and sunflowers). Possible no-regrets options for strengthening adaptive capacity in the water sector include: improving the management of existing drainage systems; adjusting planning and financial compensation programs in anticipation of more regular, multi-year flooding; improving coordination and management of provincial water resources by strengthening legislative and planning frameworks; reducing water demand through methods such as the Water Soft Paths approach; identifying and implementing options to increase the supply of water and strengthen provincial drought management capacity; improving understanding of the potential impact of climate change on the province's hydrology; and continuing to engage in consultations with a diversity of stakeholders to gain insight on water supply concerns.
- **Agriculture and Grasslands.** Projects completed under the Terrestrial and DEM Themes of the PRAC strengthened understanding of how vegetation zones in Manitoba's grassland ecosystems are likely to change even under the coolest and wettest of climate scenarios. Studies completed also suggest that average production of grasslands will moderately decline even in warm, dry climate scenarios, and that a deeper understanding is needed of the extent to which current policies and programs are helping to build adaptive capacity in the agricultural sector. Ways to enhance adaptive capacity identified through the PRAC included undertaking an in-depth review of existing agriculture policies, programs and initiatives to assess their "adaptive fitness;" continuing to promote ecosystem conservation and the maintenance of ecosystem services; and reviewing insurance and financial compensation programs for their long-term suitability and sustainability.

Specific adaptation measures could include retaining wetlands, linking fragmented native prairie ecosystems, enhancing agricultural extension services and maintaining community pastures.

- **Municipalities.** At the municipal level, a range of interest in climate change adaptation exists among municipal officials, with some communities beginning to act. Responding to climate change at this level was found to be impeded by limited financial and staff resources, conflicting demands on officials' time, and limited awareness of potential impacts and vulnerabilities. For risk-based adaptation planning to move forward at the municipal level, options include: integrating climate risks into existing land-using planning frameworks, development plans and secondary plans; working with conservation districts and Planning Districts as they provide a strong entry point for adaptation planning; tailoring the *Risk-based Guide for Local Governments* originally developed by NRCan for application in Manitoba; and strengthening collaboration between municipalities and other levels of government and research institutes.

Recommendations

To establish these building blocks for climate change adaptation, it is recommended that Manitoba:

1. *Fully integrate adaptation into Manitoba's next climate change plan.* Development of an integrated plan would not only advance adaptation efforts in Manitoba but also facilitate the identification of potential synergies and conflicts between mitigation and adaptation actions, and improve efficiency of implementation.
2. *Raise awareness among senior government officials regarding the need to adapt.* Leadership within government is required to ensure commitment to long-term planning and provision of the additional investments required to prepare for the unavoidable effects of climate change.
3. *Establish an inter-provincial adaptation working group*. An active inter-provincial adaptation working group is needed to facilitate the inter-disciplinary collaboration and coordination across government required for effective adaptation planning and implementation.
4. *Establish a Provincial Climate Data Centre.* The purpose of this centre should be to: collect, standardize, manage and share historic and projected climate data for Manitoba; support the development of climate projections; and create communication products such as maps, graphs, guidance documents and training materials.
5. *Establish a provincial roundtable on adaptation.* Bringing together experts from different communities and organizations within Manitoba, this roundtable could provide a venue through which information on adaptation action in the province is shared, research gaps are identified, and input on emerging policies, strategies and plans that support adaptation is provided.
6. *Ensure continued engagement with stakeholders.* Effective consultations with a diversity of local stakeholders in the adaptation planning processes will help ensure the development and implementation of effective policies, and minimize the occurrence of unexpected outcomes.

7. *Act now and build on existing programs.* Although significant gaps in understanding persist regarding how Manitoba's climate will change in the future and the implications of these changes, efforts can be made today to strengthen resilience. Opportunities include integrating climate projections into existing resource management, land use and watershed protection policies; expanding native grasslands and wetlands; facilitating the integration of adaptation into municipal planning processes as required under the Provincial Planning Regulations; enhancing flood forecasting and drought monitoring capacity; strengthening ecological goods and services programs; and modifying insurance and compensation mechanisms to strengthen their capacity to respond to multi-year drought and excessive moisture events.
8. *Take advantage of emerging opportunities.* In seeking to prepare for the impacts of climate change, the Manitoba Government should continue its efforts to establish partnerships with others within and outside of the province. Ongoing dialogue with NRCan, Alberta and Saskatchewan in particular is likely to facilitate more efficient, cost-shared efforts to facilitate adaptation.
9. *Establish systems for monitoring, evaluating and adjusting programs to build adaptive capacity.* A better understanding of the efficacy of existing programs and policies in the context of climate change is required to assess the extent to which they already or could enhance capacity to adapt to changing circumstances. More generally, adaptation concerns could be integrated into existing enterprise risk management systems.

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Abbreviations and Acronyms

AARD	Alberta Agriculture and Rural Development
AEW	Alberta Ministry of Environment and Water
APAT	Adaptive Policy Analysis Tool
ASRD	Alberta Sustainable Resource Development
CDC	Centre for Disease Control and Prevention
CRCM	Canadian Regional Climate Model
DEM	Drought and Excessive Moisture
FoE	Friends of the Earth
GCM	Global Circulation Model
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
LIRA	Land and Infrastructure Resilience Assessment
MAFRI	Manitoba Agriculture, Food and Rural Initiatives
MANA	Manitoba Aboriginal and Northern Affairs
MCWS	Manitoba Conservation and Water Stewardship
MLG	Manitoba Local Government
NRCan	Natural Resources Canada
PARC	Prairies Adaptation Research Collaborative
PRAC	Prairies Regional Adaptation Collaborative
PVCD	Pembina Valley Conservation District
RCM	Regional Climate Model
SRC	Saskatchewan Research Council
SRES	Special Report on Emissions Scenarios
SWA	Saskatchewan Watershed Authority
WSC	Water Stewardship Council
WSP	Water Soft Paths

1.0 Introduction and Background

This report provides an overview of the key activities undertaken in Manitoba as part of the Prairies Regional Adaptation Collaborative (PRAC) and their key outcomes. It assesses the implications of these outcomes for policy and planning in the province and identifies options for moving forward on adaptation to climate change in Manitoba.

The PRAC was formed by the Provinces of Alberta, Saskatchewan, University of Regina and Manitoba in 2009. The objective of this three year, approximately $6.6 million program, cost-shared with Natural Resources Canada (NRCan),[1] was to increase the capacity of decision-makers to advance the integration of adaptation into policies, programs and planning. It sought to achieve this objective by providing decision-makers with "regionally relevant policies, networks, knowledge and tools" (Anon., n.d.). The PRAC was launched in partnership with NRCan as one of six Regional Adaptation Collaboratives formed across Canada within the Regional Adaptation Collaborative Climate Change Program.[2]

Through the PRAC, the Prairie Provinces were able to address shared concerns regarding the potential implications of climate change for the region's hydrological regime—particularly the potential for changes in the distribution (temporally and physically) of water supplies and greater likelihood of water scarcity. Building upon this shared concern, the PRAC undertook work related to four themes: Water Resources Management; Drought and Excessive Moisture; Terrestrial Ecosystems; and Coordination, Integration and Management. Within these themes, the PRAC specifically addressed (Anon., n.d.; PRAC, n.d; NRCan, 2011):

- *Water Resources Management* – focused on providing information on water supply, use and demand in a changing climate, assessing its potential socio-economic implications, and making recommendations for options to enhance water policy and planning at the regional, provincial and inter-provincial levels. Goals related to this theme included: developing hydro-climatic scenarios; undertaking integrated analysis of future water supply and demand to identify areas potentially at risk of experiencing water deficits; and developing innovative water conservation approaches.
- *Drought and Excessive Moisture* – focused on enhancing risk-management capabilities, identifying good practices, and promoting integrative approaches for drought and excessive moisture planning at the municipal, provincial and inter-provincial levels. Activities included engaging decision-makers at different levels in the development of strategies for reducing climate related risks, and developing an inter-provincial drought communication framework.

[1] Of the approximately $6.6 million in total funding provided to support implementation of the PRAC, up to $3.3 million was provided by NRCan, with federal expenditures cost matched by the Prairie Provinces, the University of Regina and other PRAC partners (Shymko, per comm, May 2012).

[2] The Regional Adaptation Collaborative Climate Change Program was announced by the Government of Canada in December 2007. The program's goal is to "catalyze coordinated and sustained adaptation planning, decision-making and action, across Canada's diverse regions." Undertaken in six regions of Canada (British Columbia, the Prairies, Ontario, Quebec, the Atlantic Provinces, and the Northern Territories), the program allowed each region to tailor activities to address their individual concerns. A total of $30 million was allocated to this three year program. (NRCan, 2011)

- *Terrestrial Ecosystems* – focused on understanding the vulnerability of the southern boreal forest to climate change and its implications for forest management, planning and policy; and the vulnerability of grasslands ecosystems and associated implications for rangeland management, biodiversity retention and grasslands conservation/restoration.
- *Coordination, Integration and Management* – focused on bringing together decision-makers within individual provinces and across the prairie region to discuss common themes, share lessons learned, build capacity and promote identification of potential adaptation options and policy measures.

At the provincial level, implementation of the PRAC was led by Manitoba Conservation, Saskatchewan Watershed Authority (SWA), Saskatchewan Research Council (SRC) and Alberta Environment. Work in each province on the PRAC's themes was undertaken in a manner that reflected their individual needs and objectives. Coordination between provinces allowed for the sharing of information, capacity building and mutual learning. Activities were administered by the Prairie Adaptation Research Collaborative (PARC) based at the University of Regina. The governance structure for the PRAC is presented in Appendix 4.

Alberta's PRAC activities were led by the Ministries of Environment and Water (AEW), Sustainable Resource Development (ASRD),[3] and Agriculture and Rural Development (AARD). The water theme projects implemented by AEW focused on the South Saskatchewan River Basin and Regional Planning areas. They looked at potential future impacts of climate change on water levels and stream flows within the river basin area. The terrestrial ecosystem projects implemented by ASRD concentrated on understanding potential changes in the boreal forest fringe and grasslands, and possible adaptation strategies. ASRD also continued to develop a climate change adaptation framework to guide identification of climate change risks and integrate response measures into its existing Enterprise Risk Management process. The DEM projects looked at improving AARD's capacity to simulate and report on these conditions across Alberta, coupled with the ability to provide key recommendations to decision makers on policies, regulations and strategies surrounding these stressors. Throughout the PRAC process, efforts were made to share knowledge of best practices that emerged through implementation of the different projects.

In Saskatchewan, projects surrounding the PRAC themes of DEM, terrestrial ecosystem and water resources management were implemented by SWA, SRC and PARC, respectively. The DEM projects included: review of indicators used to monitor drought and excessive moisture conditions; evaluation of a tool developed to assess the adaptive capacity of a suite of existing programs; an in-stream flow needs gap analysis; watershed extreme events preparedness planning; and extreme climate events characterization. The terrestrial ecosystem projects concentrated on agriculture and grassland, including an agricultural vulnerability assessment to extreme climate conditions in Old Wives Lake

[3] The Ministry of Environment and Water and the Ministry of Sustainable Resource Development have now merged to form the Ministry of Environment and Sustainable Resource Development.

Watershed and North Saskatchewan River Basin, as well as a vulnerability assessment of the forestry sector on the southern boreal forest across the prairie region. Water resources management theme projects involved a hydroclimatic variability analysis and projections focused on the South Saskatchewan River Basin, as well as a water demand analysis in key Saskatchewan watersheds.

This report highlights the outcomes of the PRAC and provides guidance regarding the future direction of adaptation policy and planning in the Province of Manitoba. To set the context for the discussion, it begins with a brief review of how climate change is expected to impact Manitoba, giving particular attention to the southern portion of the province. It then provides an overview of the key activities completed as part of the PRAC and the implications of their outcomes for policy and planning in the province. Recommendations for strengthening the capacity of the province to respond to climate change are provided at the close of the report.

2.0 *Review of Climate Change Impacts and Adaptation in Manitoba*

Across the Canadian Prairies, signs of a changing climate are beginning to be observed. Since the 1970s, mean annual temperatures across the region have increased, rising by 1.6^{o}C since 1895. The greatest warming has been experienced in the last 50 years, particularly in January, March, April and June. This time period has also witnessed a general decline in precipitation during the period of November to February (Sauchyn & Kulshreshtha, 2008). Overall, the Prairie region is characterized as the driest in Canada and drought is a frequent occurrence in the region. However, southern Manitoba also regularly experiences excess moisture and flooding conditions, reflecting its geographical placement where major watersheds flow into Lake Winnipeg, namely the Red, Assiniboine and Saskatchewan River basins, in addition to the Winnipeg River and drainage from Lake Manitoba. The greater risk of excessive moisture and flooding in Manitoba distinguishes it from the other two Prairie Provinces (Sauchyn & Kulshreshtha, 2008).

Climate projections for the Prairies suggest that mean annual temperatures could rise by 3°C (with a potential range of 2° to 5°C) over the remainder of this century. As illustrated in Table 1, a greater increase in annual mean temperature is projected to occur in the southern portion of the Prairies compared to the northern portion. Projections related to changes in mean annual precipitation are less certain, but generally suggest that it will increase. A greater increase in precipitation is projected to occur in the northern forest zones than in the southern grasslands. Existing research also suggests that the greatest increase in temperature and precipitation could occur during the winter and spring (Sauchyn & Kulshreshtha, 2008). Despite the projected increase in average precipitation, there is a concern that drought could become a greater issue in the region.

For Manitoba, Global Circulation Model (GCM) climate projections estimate that mean annual temperatures will increase by 1 to 3°C, with an average of 2°C, by the 2050s (Blair, 2012; McCandless, 2012). Temperature increases are projected to be greatest during the winter, rising by 3° to 5°C in this time period (Blair, 2012). There is high confidence that mid-winter thaws will become more frequent,

winter cold snaps will become shorter and less frequent, warm-season heat waves and heat extremes will increase in frequency, the number of frost-free and growing-degree days will increase, and the number of cooling-degree days will increase while the number of heating-degree days will decrease (Blair, 2012). By the 2080s, temperatures could rise more dramatically, potentially increase by up to 7°C (based on a comparison of several GCMs) (McCandless, 2012).

TABLE 1: PROJECTED MEAN ANNUAL TEMPERATURES AND PRECIPITATION IN THE PRAIRIE REGION

	Southern Grasslands		Northern Forests	
	Annual Mean Temperature	Annual Mean Precipitation	Annual Mean Temperature	Annual Mean Precipitation
2020s	+ 2°C	-	<2°C	+5%
2050s	+ 3-4°C	+ 5%	+ 2-3°C	+10%
2080s	+ 5°C	+ 10%	+ 4-5°C	+15%

Derived from Sauchyn and Kulshreshtha (2008: 286)

Projected changes in precipitation patterns are less certain. In southern Manitoba, projections for an increase in precipitation range from a decline of 10 percent to an increase of 15 percent, with a 3 percent mean annual increase by the 2020s (McCandless, 2012). By the 2050s, the range of uncertainty increases from a potential decrease of 5 percent to a potential increase of 25 percent, with a mean projection of a 6 percent increase per year. While it is similarly a challenge to project changes in the seasonality of these changes in precipitation patterns, on average GCM projections suggest an increase in winter and spring precipitation of up to 20 percent (McCandless, 2012), with some winter precipitation occurring in the form of rainfall (Blair, 2012). In the summer, precipitation could decrease by up to 5 percent by the 2050s, and increase in the fall by up to eight percent (McCandless, 2012). It is highly likely that droughts will be longer and more frequent, and rainfall events will be more intense and numerous (Blair, 2012). Overall, it is projected that winters will become warmer and wetter, and summers hotter and potentially with more variable rainfall. Positive impacts are noted to be less and decreasing with time, whereas negative impacts are many and increasing with time (Blair et al., 2012).

Current and projected climatic changes will impact numerous sectors in southern Manitoba, including agriculture, forestry and human health. Many of these impacts will be mediated by changes in water quantity and quality as this resource lies at the heart of numerous socio-economic activities within the province. While considerable attention has been given to the potential impact of climate change on water quantity—particularly droughts and floods—impacts on the quality of surface and groundwater supply[4] is also a concern. Water quality can decline through physical disruptions, chemical contamination, biological contamination and reduction in stream flows (Sauchyn & Kulshreshtha, 2008). Lake Winnipeg already suffers from nutrient enrichment due to the quality of water flowing into it from

4 Groundwater supplies 21 percent of household water consumption in Manitoba (Sauchyn & Kulshreshtha, 2008: 290)

rivers from the U.S., Alberta, Saskatchewan and Manitoba (Bourne et al., 2002), and this vulnerability could increase in the future (Environment Canada & MWS, 2011).

The agriculture and forestry sectors are at risk due to their direct dependence on optimal climatic conditions for productivity. The distribution and survival of plants could be altered by changes in freeze-thaw events, daytime temperature patterns and hydrological events (Sauchyn & Kulshreshtha, 2008; MANA, 2011). Changes in the characteristics and distribution of provincial grasslands will in turn influence the future success of Manitoba's livestock operations. Although an increase in temperature could lengthen the growing season for agricultural products and allow forests to expand northward, drier conditions could lead to decrease in crop yields, higher evapotranspiration levels, increased risks of forest fires, and reduce trees' defenses against diseases and pests (Cloutis et al, 2001; Sauchyn & Kulshreshtha, 2008; MANA, 2011; Thorpe, 2011). Moreover, warmer temperatures are expected to push the ideal conditions for boreal forest growth northward, and southern portions of the province's boreal fringe are projected to become increasingly suitable for grasslands (Thorpe, 2011). Moreover, some species will be unable to keep up with the changes in soil conditions, methods of seed dispersal and habitat fragmentation (MANA, 2011; Thorpe, 2011). Climate change can aggravate these risks and reduce productivity in the agriculture and forestry sectors.

Human health is also vulnerable to climate change. Warmer weather creates favourable incubating conditions for vector borne diseases and pathogen development. There is rising concern about infectious diseases (such as Lyme disease[5] and E.coli[6]) as well as environmentally mediated non-infectious diseases (e.g. cardiovascular illness[7]). West Nile virus is another rising health concern as higher temperatures and increased frequency in heavy rainfall could create longer incubating periods for the Culex tarsalis mosquito. Also, extreme climatic events, such as heat waves, floods and forest fires increase health stressors in vulnerable individuals (Henderson & Sauchyn, 2008; MANA, 2011; Manitoba Health, n.d). Forest fires can lead towards increase in respiratory conditions, contributing to a rise to morbidity and mortality rates (Henderson & Sauchyn, 2008). Extreme heat events in Manitoba cause health risks such as dehydration, exhaustion, heat stroke and other heat related illnesses (Manitoba Health, n.d.). Projected rising temperatures may elevate the propensity of these events (Health Canada, 2012).

5 Some studies show that the potential spread of the black legged tick will increase the risk of Lyme disease in southern Manitoba (Roberecki, 2012).

6 For example, with a projected rise in temperatures, the open water season in Lake Winnipeg may be extended (particularly during winter months). This change in turn could length the period of risk of exposure to E. coli from animal and human sources (Environment Canada & MWS, 2011).

7 Cardiovascular disease is sensitive to changes in weather and climate. Increase in temperature contributes to the expansion of ozone, which it is directly associated with acute myocardial infarction. Extreme climatic events, such as a tornado or flood, can also indirectly affect this disease, including: (1) heart attacks caused by stress and anxiety due to the event; (2) inability to access medical care for chronic medical conditions; and (3) strokes triggered by exposure to vector-borne and zoonotic disease (CDC, 2010). On the positive side, milder winters might reduce mortality and morbidity due to hypothermia and by encouraging greater outdoor activity, contributing to health improvements such as lowering obesity.

3.0 Overview of Areas of Work

Between April 2010 and March 2012, Manitoba implemented activities related to the PRAC's four themes: Water Resources Management; Drought and Excessive Moisture (DEM); Terrestrial Ecosystems; and Coordination, Integration and Management. Manitoba Conservation and Water Stewardship (MCWS) led implementation of activities related to the themes of Water Resources Management, Terrestrial Ecosystems, and Coordination, Integration and Management; it jointly implemented work on the theme of DEM with Manitoba Agriculture, Food and Rural Initiatives (MAFRI) and Manitoba Local Government (MLG). In addition, the province established collaborative relationships with other levels of government (City of Winnipeg, City of Brandon, TransCanada West Planning District, Little Saskatchewan River Conservation District), research organizations (International Institute for Sustainable Development [IISD], SRC, non-governmental organizations (Friends of the Earth) and private consulting firms (Deloitte, GENIVAR, MMM Group and Stantec Consulting). The University of Regina provided overall project management and governance services on the PRAC. New partnerships were also forged with the Saskatchewan Watershed Authority, Alberta Environment and Alberta Sustainable Resource Development.

3.1 Theme 1: Water Resources Management

Under the theme of Water Resources Management, Manitoba sought to better understand the potential vulnerability of its water resources to climate change, and to identify measures that could be taken to reduce this vulnerability. The five activities completed under this theme are described below. They included the development of scenarios for future water supply and demand in the Assiniboine River Watershed, and strengthening municipal capacity to manage future water demand. More detailed descriptions of these studies can be found in Appendix 1.

A. *Assiniboine River Basin Hydrologic Supply Study*. To achieve a better understanding of the Assiniboine River basin's vulnerability to changes in water supply under projected climatic conditions, a hydrologic model was developed and examined under a potential future climate scenario.

B. *Assiniboine River Basin Water Demand Study*. This study assessed current water use and demand along the Manitoba portion of the Assiniboine River, and the degree to which this level of demand will transform in the future considering population increase, economic growth and climate change. The study included the development of a water demand baseline, consultations with stakeholders on their vision for the region's future development, creation of socio-economic projections, and development of projected future demand for water with and without the occurrence of climate change.

C. *Water Soft Paths*. Between 2009 and 2011, MCWS led efforts to establish a community of practitioners using the Water Soft Paths approach in the Pembina Valley Conservation District. The goals of this community of practice were to encourage incorporation of the Water Soft Paths

approach into municipal and conservation district planning, and to increase decision-makers' capacity to move forward with climate change adaptation.

D. *Workshop on Climate Data, Modelling and Applications for Planning*. Responding to concerns identified during implementation of the PRAC's water and DEM activities, a workshop focused on the needs of climate data end-users (planners, policy makers, researchers and modellers) was held in January 2012. The workshop aimed to: increase understanding of current climate data and climate projection data needs; defining the conditions by which climate data of sufficient quality and usability could be created for use in provincial adaptation assessments; and how to better share climate data for different regions of Manitoba.

E. *Water Policy Guidance*. In light of findings from the other components of the Water Resource Management Theme, guidance was provided on their implications for provincial water policy over the short, medium and long-term.

3.2 Theme 2: Drought and Excessive Moisture Planning

The PRAC theme on drought and excessive moisture planning sought to better understand and reduce the economic and social risks associated with a potential increase in the frequency of drought and a greater probability of flooding or excessive moisture conditions due to climate change. As part of this theme, Manitoba pursued the five initiatives described below. Appendix 2 of this report provides further information about each of these projects.

A. *Municipal Adaptation Planning*. The goal of this component of the PRAC was to increase the capacity of municipal decision-makers to integrate climate adaptation into local planning decisions. Efforts to achieve this goal were led by MCWS in partnership with MLG. Activities were undertaken in three locations. First, in partnership with Brandon and the TransCanada West Planning District, MCWS and MLG undertook a process to identify, review and test a tool that would help municipalities understand their vulnerability to the impacts of climate change and develop appropriate adaptation strategies and plans. The guidance tool tested as part of the PRAC, *Adapting to Climate Change: A Risk-based Guide for Local Governments*, was originally developed by NRCan and subsequently modified by British Columbia.[8]

   Second, in the City of Winnipeg, the PRAC supported a Climate Change Adaptation workshop that provided key members of the city's administration with training on climate impacts, adaptation needs and implementation strategies. Development of a corporate educational video on climate change impacts and vulnerabilities was also initiated.

   Third, in parallel with and complementary to the PRAC, MCWS and MLG received funding from NRCan to undertake an assessment of the Land and Infrastructure Resilience Assessment (LIRA) Tool in the Little Saskatchewan River Watershed. The LIRA Tool was introduced to local government

[8] This guide also has been adapted by Alberta and Ontario for use within each of these provinces.

officials and interested administrators and assessed for its potential future application in the watershed or other regions in Manitoba.

B. *Provincial Planning on Adaptation to Excessive Moisture in the Interlake Region.* To support the development of a provincial-level strategy for increasing the agriculture sector's capacity to adapt to excessive moisture conditions, a case study was undertaken in the Interlake Region. The study included a review of relevant literature, modelling of potential water flows in the Icelandic River watershed, and consultations with local stakeholders.

C. *Development of an Inter-Provincial Drought Communications Framework.* To strengthen communications between Alberta, Saskatchewan, Manitoba and the federal government regarding drought risk and management, a draft Interprovincial Drought Communication Framework was prepared. This project was jointly implemented by all three Prairie Provinces.

D. *Development of a Provincial Drought Plan.* MCWS undertook a process to develop a Provincial Drought Management Plan that describes recommended preparedness, monitoring, response and mitigation actions to different drought stages. A plan was drafted that defines four stages of drought, identifies primary and secondary indicators for these different stages, presents protocols for drought preparedness, monitoring and response, and lays out protocols for communication and coordination within government and with external stakeholders.

E. *Evaluation of Existing Drought and Excessive Moisture Programs.* To assess the degree to which established provincial policies and programs are currently helping to build the capacity of rural producers to adapt to more frequent DEM conditions, a pilot study was undertaken using the Adaptive Policy Analysis Tool developed by IISD. Five provincial policies were reviewed and assessed with respect to their contribution to building adaptive capacity in the East Interlake Conservation District.[9] The pilot project lead to further analysis of another seven MAFRI programs using an updated version of the Adaptive Policy Analysis Tool (APAT). This analysis was undertaken to support MAFRI's departmental adaptive planning initiative and provided an opportunity to test the refined tool.

3.3 Theme 3: Terrestrial Ecosystems

The Terrestrial Ecosystems theme in Manitoba focused on deepening provincial understanding of the potential impacts of climate change on Manitoba's forests and grasslands, and potential adaptation options. Effort was also made to promote the integration of adaptation into MAFRI's policies and programs. Information about the projects undertaken as part of this theme is summarized below and presented in greater detail in Appendix 3.

- Vulnerability Assessment of the Sandilands Provincial Forest. To better understand the potential impacts of climate change on Manitoba's southeast boreal forest, a case study approach was used

[9] The five DEM programs evaluated using APAT were: Environmental Farm Plans, Manitoba Agricultural Services Corporation's AgriInsurance, AgriStability, the Agri-Food Research and Development Initiative, and the Manitoba Sustainable Agriculture Practices Program.

that focused on the Sandilands Provincial Forest. The assessment aimed to better understand projected climatic changes in the region, detect sensitivities, and identify vulnerabilities to climate change. With this understanding, potential adaptation options are being identified. Led by the Forestry Branch, this project is currently being completed.

- Vulnerability and Adaptation Options for Grasslands Management. This two phase project sought to understand the vulnerability of Manitoba's grasslands to climate change and identify potential adaptation options. The first phase used eco-climate modelling to assess how native grasslands in Manitoba's Prairie Ecozone might change under different climate change scenarios. In the second phase, a review of potential options for resisting, building resilience to, and responding to climate change in Manitoba's grasslands were identified. Both phases were implemented under the direction of MAFRI.
- Integration of Adaptation into MAFRI's Planning Processes. To determine an effective process for integrating considerations into MAFRI's planning processes, a series of workshops were undertaken to: raise awareness about the potential impacts of climate change on the forage and beef sectors; demonstrate the Adaptation Framework developed for ASRD; and better understand existing and potential adaptation options. The outcomes of this process were used to inform the development of MAFRI's departmental climate change adaptation strategy.

3.4 Theme 4: Coordination, Forums, Integration and Management

The final theme of the PRAC, Coordination, Forums, Integration and Management, focused on facilitating inter-governmental knowledge sharing, capacity building, and identification of common adaptation challenges, options and needs across the Prairies. Regular interaction between PRAC participants was punctuated by a series of Adaptation and Resilience Forums that linked together the thematic activities being undertaken in each province. The following inter-provincial forums took place as part of the PRAC:

- *Living with a Changing Climate Conference*. The first PRAC forum was held November 24-25, 2010, in Calgary. It provided senior decision-makers from each province with an overview of the challenge posed by climate change, its potential implications for the prairies, possible strategies for advancing adaptation efforts, and the thematic areas and plans for the PRAC.
- *Terrestrial Forum.* Held March 15, 2011, in Saskatoon, this forum brought together individuals actively engaged in the PRAC's Terrestrial Theme. Knowledge was increased regarding the potential impacts of climate change on grassland and forest ecosystems in the Prairies, decision-making applications, and successful/best practices. Progress and lessons from the different PRAC activities were discussed, along with potential policy options and recommendations.
- *Combined Water and Drought Management and Excessive Moisture Forum*. Held in Winnipeg from September 20-21, 2011, this third inter-provincial forum updated individuals on outcomes of and lessons emerging from PRAC projects under the water and DEM themes. It also sought to identify policy options and recommendations emerging from these different initiatives. Group work during

the forum was used to gather input into the draft Interprovincial Drought Communication Framework

- *Adaptation to Climate Change on the Canadian Prairies*. The final inter-provincial PRAC forum was held in Regina from February 15-16, 2012. Bringing together individuals from within and outside of government, the forum provided participants with an opportunity to learn more about the activities completed in each province under the PRAC's four themes, share best practices and lessons learned, identify potential policy recommendations, and explore potential next steps for adaptation planning on the Prairies. The draft PRAC synthesis report prepared by Rescan Environmental Services Ltd. was also reviewed during the workshop.

Reports from each of these forums have been published on the PRAC web site by the University of Regina and may be found at http://www.parc.ca/rac/index.php?page=forumsButton.

Provincially, MCWS hosted a final workshop on March 22, 2012, that brought together individuals active in implementing the different PRAC activities, representatives of other provincial departments and members of the research community. The *Manitoba Prairies Regional Adaptation Collaborative Final Forum* provided an opportunity for participants to discuss successes, acknowledge gaps and identify priority options for advancing climate change adaptation in the province.

4.0 Lessons Learned

Through engagement in the PRAC's activities related to Water Resource Management, DEM and Terrestrial Ecosystems, lessons were learned of relevance to Manitoba's future efforts to prepare for and adapt to climate change. Some of these findings were cross-cutting and should inform the province's overall approach to climate change adaptation. Additional insights were gained specifically regarding adaptation needs in the water, agriculture and municipal sectors. As the PRAC's research related to Manitoba's forestry sector is not yet completed, lessons pertaining to this sector are not yet available.

4.1 Provincial Adaptation Planning

Involvement in the PRAC significantly increased awareness within participating provincial departments of the current or potential impacts of climate change, the need and benefits of adaptive planning, and has generated further momentum towards more in-depth adaptation planning. Those active in the PRAC process generally agree on the need to complete vulnerability assessments and subsequently develop adaptation strategies, either at the departmental or provincial level, which would ideally be incorporated into the decennial strategic planning process. MAFRI is already taking concrete steps in this direction, having initiated the development of an internal climate change adaptation strategy. As well, the August 2011 Cabinet decision to establish an Interdepartmental adaptation working group and

proceed with a three phase[10] provincial adaptation planning process provides direction and guidance for future action.

Participation in the PRAC has also demonstrated the need for greater coordination between departments and programs. This observation reflects the multifaceted nature of climate change impacts and the associated need for integrated, coordinated, multi-year climate risk management and adaptation actions in which multiple government agencies, producers, technicians, and scientists are involved. Establishment of an inter-departmental adaptation working group which can share information and provide support was recommended in various contexts as a necessary step towards greater intra-governmental collaboration on adaptation.

Along with these positive outcomes, engagement in the PRAC has also clarified some of the key challenges to furthering adaptation planning in the province. These inter-related challenges include: insufficient funding for long-term and substantial projects such as vulnerability assessments; a lack of staff time and technical capacity; and an emphasis on reactive rather than proactive planning. It was observed that the participating departments of MCWS, MAFRI and MLG are generally "caught in crisis mode," focusing on short-term decision-making and engaging to a limited degree in proactive, long-term planning. Increased interdepartmental collaboration was seen as one means by which these barriers might be alleviated. It was also noted that there is a need to continually engage stakeholders in decision-making to ensure that actions and policies are well-designed.

Experience gained through implementation of the PRAC suggests that **options for improving climate change adaptation governance capacity** in Manitoba include:

- Establishing an interdepartmental adaptation working group to promote coordination, collaboration and the sharing of knowledge regarding identified climate risks and adaptive planning processes and strategies.
- Establishing a provincial adaptation framework that will bring together adaptation strategies developed by individual departments in an integrated manner.
- Maintaining staff time assigned to long-term, adaptive initiatives even in periods of crisis. Achieving this objective will require changes in funding and an increase in resources directed towards pre-emptive disaster management.
- Monitoring and evaluating existing policies and programs on a regular basis to assess their ongoing suitability under changing circumstances.

10 These three phases are: (1) completion of a government-wide risk assessment; (2) undertaking a risk assessment for the province; and (3) preparation of a provincial adaptation strategy and action plan (Cunningham, 2012).

4.2 Inter-Provincial Collaboration

Manitoba's participation in the regional forums held as part of the PRAC helped raise awareness of the measures being taken across the Prairies to support adaptation to climate change. These collaborative efforts helped identify mutual concerns around which specific initiatives could be developed and to share frameworks, tools, and approaches that could be used to improve adaptation programming. They also clarified some common constraints, such as the limited availability of sufficient funding to support adaptation efforts, a focus on short-term needs, and the challenge of coordinating adaptation efforts across disciplines and departments (Rescan, 2012). The PRAC process has also revealed some of the barriers to greater inter-provincial collaboration. These include differences in regulatory requirements, local stakeholders understanding of the need to adapt, and adaptation needs and priorities (such as Manitoba's higher degree of concern regarding excessive moisture conditions), with restricted the effectiveness of knowledge sharing (Rescan, 2012).

Given the Prairie Provinces' inter-connectedness ecologically and economically, and that they are expected to experience a number of similar climatic changes and socio-economic impacts, stronger collaboration in areas of mutual interest could reduce future vulnerability. **Options for strengthening inter-provincial collaboration** include:

- Continuing to create opportunities for knowledge sharing, identifying options, hearing different perspectives, and promoting greater policy collaboration in areas of shared concern. Mechanisms for achieving these outcomes could include establishing a formal community of practice of Prairie adaptation practitioners, hosting regular webinars on topics of regional interest, and holding joint learning forums either annually or biannually.
- Establishing stronger links with boundary organizations and academia to support information generation and provision, and the communication of adaptation needs between the public and government (PRAC, 2012).
- Building upon the draft Inter-Provincial Drought Communications Framework produced as part of the PRAC (Rescan, 2011). It proposes a framework that builds upon existing institutional structures, is supported by firm commitments between jurisdictions, and involves civil society stakeholders. It also suggests creating a Prairie Interprovincial Drought Working Group under the Western Water Stewardship Council that will bring together relevant experts from the provincial and federal levels.

4.3 Access to Climate Projection Data

A common challenge identified through implementation of a number of PRAC projects in Manitoba was a difficulty in accessing high quality, standardized climate projection data and robust climate scenarios specifically tailored to the needs of Manitobans. Completion of the hydrologic water supply modelling and water demand studies for example, was hindered by their limited access to climate data sets and background information about these sets. As discussed in section 4.4, the outputs of these studies

therefore provide only a narrow view of how climate change might affect Manitoba's water resources in the future and they are insufficiently robust to guide decision-making. As well, municipal officials participating in the PRAC noted their need for improved access to regional climate projections to support planning. Overall, as expressed at the Workshop on Climate Data, Modelling and Applications for Planning, there is a desire for (Rempel, 2012):

- More robust hydrometeorological monitoring networks to ensure the collection of data useful for climate modelling and vulnerability assessments. There is concern that the current network in the province is degrading due to a lack of sufficient funding at the provincial and federal levels.
- Better systems of climate data exchange to bring together the data collected by different entities throughout the province (e.g., Environment Canada, Manitoba Hydro, industry).
- Greater access to easy to use climate projection data sets (GCM, Regional Climate Model [RCM] outputs) and accompanying background information that explains the methodology used to create these sets, their limitations, etc. Data sets should be able to meet the needs of different users, such as those responsible for flood planning, infrastructure management and forest management. They also should be available to timeframes appropriate for adaptation planning and of high enough resolution to represent different regions of the province.
- Improved access to Manitoba specific climate projections suitable for use in decision-making, such as statements on the probability that large floods or long droughts will occur, and the degree to which future climatic conditions will be different from those that have been experienced in the past.

Engagement in the PRAC has also highlighted the absence of an official process for coordinating provincial climate data holdings and the development of an inventory of climate data for the different regions of Manitoba. Filling this gap would improve Manitoba's capacity to develop provincial vulnerability assessments and engage in sound adaptation planning.

Options for improving access to climate data in Manitoba were identified as being (Rempel, 2012):

- Having the government dedicate capital and make operational investments in climate data.
- Establishing a provincial data coordination centre either at one of the universities or within the provincial government that would be responsible for collecting, standardizing, managing and making available to the public regional climate projection datasets. This centre could:
- Provide access to quality controlled data sets, guidance on limitations for using this data, and references to additional data support;
- Make available data trends and results, mapping products, communicable graphics, training materials, procedural guidance, adaptation assessments, and case studies; and
- Distribute climate data to different end users in a manner similar to "SaskAdapt" (http://www.parc.ca/saskadapt/), a web portal that provides access to the latest information

about Saskatchewan's historic and possible future climate, potential climate change impacts, and ways that communities, businesses and individuals could adapt.

4.4 Water Resources Management

Many of the impacts of climate change will be mediated through changes in the availability and quality of water resources. The prairies already experience considerable variability in water supply, reflective of the natural influence on the region of various hydroclimatic cycles, such as the El Niño Southern Oscillation and the Pacific Decadal Oscillation. The PRAC provided an opportunity to explore how the region's hydrology might be altered in the future due to climate change's potential to alter the distribution, timing and abundance of water sources. Combined with previous analysis of the potential implications of climate change for the prairies, these results highlight that historical assumptions related to hydroclimatic stationarity can no longer form the basis for planning and decision-making. In particular, there is concern that the occurrence of more severe droughts in the future could exceed existing coping capacity, and could potentially require "fundamental policy and systematic institutional changes" in response (Rescan, 2012: 3-4). A greater understanding of the hydroclimatic cycles that currently influence the Prairie Provinces would enhance capacity to engage in planned adaptation (Rescan, 2012).

In Manitoba, particular attention was given to the potential for water scarcity in the Assiniboine River basin and excessive water conditions in the Interlake Region. These studies suggest:

- *Assiniboine River Basin Hydrologic Supply Study.* Results from the hydrologic model developed for the Assiniboine River basin suggest that: precipitation levels in the winter and spring may increase; spring melt might occur earlier but at a rate comparable to current trends; summer precipitation levels could be unchanged; and lower moisture conditions in the fall could reduce the potential for heavy runoff and flooding in the spring. Overall the model results from this single study using a single model suggest that soil moisture conditions in the Manitoba portion of the Assiniboine River basin are not expected to significantly change in the future. However, these results are not sufficiently robust to form the basis for sound policy development, as they are based on a single climate scenario.
- *Assiniboine River Basin Water Demand Study:* Even in the absence of climate change, water demand is expected to grow over the remainder of this century, with the potential for it to exceed the firm annual yield estimate toward the 2080s as calculated according to current allocation policies. Much of this growth will be due to greater demand from the City of Brandon and irrigation. With climate change, demand for irrigation is projected to increase significantly by 2050, particularly if the projected rise in temperatures and lengthening of the growing season encourages a shift towards greater production of corn, soybeans and sunflowers (high water demand crops) in the Brandon area.
- *Provincial Planning on Adaptation to Excessive Moisture in the Interlake Region:* Results from the modelling showed considerable range in the projected flood frequency curves, with hydrologic

response varying significantly depending on the climate change scenario used. Conclusive results regarding whether there will be an increase or decrease in the hydrologic peak in the future therefore could not be drawn. Study findings did suggest that hydrological conditions in the Icelandic Watershed are likely to follow currently observed hydrographs trends, with peak stream flow coinciding with spring snow melt.

As noted, each of these three studies was undertaken using limited runs of climate projections; in the case of the water supply study, only one run using one set of data from a Global Circulation Model was able to be completed. Consequently, these results do not represent the full range of climate change projections for Manitoba, and therefore are not sufficiently robust to be used in policy and decision-making.

Despite this limitation, outcomes of the PRAC project focused on water resources do provide some additional insights regarding the potential for practice and policy changes to support adaptation. Possible no-regrets **options for strengthening Manitoba's water resource sector's** adaptive capacity include:

- *Improving drainage management*. Improved management of the existing drainage system was highlighted as necessary to increasing capacity to reduce the adverse consequences of excessive moisture conditions. Steps towards this goal could include: creating a high-level, integrated provincial drainage strategy; improving research on natural drainage patterns; and establishing maintenance schedules, such as by establishing a rolling, multi-year plan jointly implemented by municipal and provincial governments.
- *Planning for repeat flooding*. In areas of the province such as the Interlake, the government may need to accept that flooding will occur on a more regular basis and with greater intensity in the future. Policies related to planning and financial compensation for loss of land could be modified to accommodate the occurrence of multi-year flooding.
- *Strengthening legislative and planning frameworks for managing provincial water resources*. The government should increase its emphasis on ensuring a coordinated and multi-year approach to water management. Actions could include:
    - Completing a review of existing legislation governing water resources management in the province to ensure that this framework is sufficient to meet current and anticipated future needs;
    - Reviewing existing funding programs related to excessive moisture to ensure that they are consistent and sustainable;
    - Establishing a need for rural municipalities, with input from Conservation Districts, to prepare five-year water management plans that promote water conservation. These plans could be integrated into existing planning processes;
    - Developing coordinated land-use and watershed management plans to protect and monitor water sources and riparian areas;
    - Promoting regionalization of water management services and technology development; and

  - Integrate adaptation considerations into existing operations, such as flood control (particularly the Red River Floodway), shoreline protection and infrastructure management.

- *Reducing water demand.* To mitigate the potential for water shortages in the future, current efforts to help municipal governments encourage efficient water usage by residents, industry and agricultural producers could be increased through targeted education, awareness, incentive and subsidy programs.
- *Increasing water supply.* To minimize climate change impacts on water supply and food security, greater understanding is needed of the potential options for increasing water availability in Manitoba. Additional research, building on the Assiniboine River water supply and demand studies completed as part of the PRAC, could be undertaken.
- *Strengthening drought management capacity.* Given projected increases in the frequency of drought on the Prairies, Manitoba's draft Drought Management Plan could be finalized and implemented to monitor and mitigate drought impacts or water supply shortages in the future.
- *Further promoting the Water Soft Paths approach.* The PRAC's exploration of WSP approach demonstrated its usefulness and potential applicability in future planning at the municipal and conservation district level throughout the province. Continued effort could be made to train municipal planners and build a community of practitioners actively engaged in its use. The WSP pilot also highlighted municipalities' greater need for specific information if they are to effectively use the WSP, generate recommendations and initiate next steps.
- *Undertaking additional research to support decision-making.* Additional research could be undertaken to better inform current and future water management in the Assiniboine River Basin. Specifically, there is a need to: quantify in-stream water needs along the river; and determine a safe level of peak usage in months when the streamflow is low.
- *Strengthening understanding of the potential hydrologic impacts of climate change.* The province could undertake additional modelling runs using different water demand and hydrological models (building on those developed as part of the PRAC) to better assess potential changes in water supply and water demand. MCWS could also support the development of new hydrological models for other high risk, high impact areas of the province to facilitate adaptation planning.
- *Ensuring consultations.* Experience gained through the PRAC demonstrated the value of combining climate modelling and risk assessment process with community consultations to gain insight on water supply concerns. To identify conflicting priorities, clarify appropriate approaches and build consensus for action in the water sector, continued consultation with various stakeholders, including municipal governments, industry and consumers, could be emphasized.

4.5 Agriculture and Grasslands

Through projects completed under the Terrestrial and DEM Themes of the PRAC, insights were obtained regarding the vulnerability of Manitoba's agricultural sector to the impacts of climate change and potential adaptation options. **Key findings** from the different PRAC activities targeting the grasslands sector and agriculture in general included:

- A northward shift in vegetation zones is likely to occur even under the coolest/wettest of climate scenarios, with conditions on the Canadian Prairies expected to become more conducive to the growth of grassland ecosystems presently found in the United States. As the movement of grassland and forest species will depend on factors such as the degree of climatic change, species dispersal strategies and soil conditions, there is uncertainty regarding the future composition of Prairie grassland ecosystems (Thorpe, 2012a).
- Average production of grasslands is projected to moderately decline even in warm, dry climate scenarios. Changes in average productivity are likely to be of lesser concern than the potential for greater variability in productivity, in part due to changes in the frequency, intensity and duration of extreme weather events (Thorpe, 2012a).
- A deeper understanding is needed of the extent to which current policies and programs are helping to build adaptive capacity in the agricultural sector. A number of current policies support efforts to resist and build resilience in the short- and medium-term, but few address the long-term need to proactively adapt to climate change (Thorpe, 2012b). Use of IISD's Adaptive Policies Analysis Tool can provide an initial assessment of whether a suite of existing programs collectively contain the elements needed to support planned and autonomous adaptation. Deeper analysis, however, is required to determine the extent to which these policies and programs are achieving their stated objectives.
- Conservation of existing grassland ecosystems and promotion of ecological diversity are likely to be important options for reducing the long-term vulnerability of the rangelands sector to the impacts of climate change. Supportive policies and programs are those that promote sustainable grazing practices, control invasive species, establish migration corridors for grassland ecosystems, and retain and/or expand wetlands (Thorpe, 2012a).
- Insurance and financial compensation programs may need to be reviewed to assess their long-term suitability and sustainability given the potential for climate change to bring about more frequent and more intense extreme weather events. For example, the current AgriInsurance program was found to be potentially vulnerable to greater demand on its services in the future. More generally, insurance and compensation mechanisms are currently tailored to meeting one-off events and therefore are not designed to address multiple/repeated/regular extreme weather events. Greater flexibility in funding mechanisms to support the regular occurrence of adverse impacts on the agricultural sector may be required (MMM, 2012).
- Improved monitoring of grassland ecosystems is needed to detect directional changes in their composition and to develop appropriate adaptive management practices in response (Thorpe, 2012b).
- The ASRD Adaptation Framework is not ideal for Manitoba's adaptation planning purposes. It is technically complex, does not provide quantitative results, and difficult to relate the process to the departmental objectives and timeline using this framework.[11]

[11] Personal communication, MAFRI representative, December 2011.

Overall, strengthening climate risk management capacity in the agriculture and grasslands sectors is hindered by uncertainty regarding how Manitoba's climate will change in the future, what the impacts will be on water resources, and how different grassland species will respond to this change. The absence of policies that support long-term adaptive planning, such as the creation of corridors that link together currently fragmented habitats, is also a barrier.

MAFRI recognizes adaptation as a priority and is currently preparing an internal adaptation strategy. As part of this ongoing effort, MAFRI may consider the following **options for promoting adaptation in the agriculture sector**:

- Identify and apply a new framework, rather than the one developed for ASRD, for assessing the vulnerability of its operations to climate change, such as: a simplified sector based risk assessment following ISO 31000; or a survey based assessment of major issues and gaps in programming from MAFRI experts and stakeholders.
- Undertake an in-depth review of existing agriculture policies, programs and initiatives to assess their "adaptive fitness," taking into consideration: the degree to which they enable producers to engage in planned and autonomous adaptation; whether or not current existing programs and policies support the implementation of identified measures for reducing vulnerability; if gaps in policies and programs might be filled by modifying existing programs or through the establishment of new programs; and whether existing measures promote practices that undermine or prevent actions that reduce vulnerability. Particular attention could be given to:
    - Ensuring the long-term sustainability of current funding programs given the potential for DEM conditions to become more frequent and intense in the future;
    - Enhancing monitoring and evaluation systems to ensure that best practices are followed and new programs/policies do not duplicate existing efforts; and
    - Promoting movement towards coordinated, multi-year approaches in which stakeholders are regularly consulted, and away from reactive, event-based policy and program development.
- Build on and expand current policies and programs that promote ecosystem conservation and the maintenance of ecosystem services as a strategy for increasing the resilience of producers in the near- and long-terms. Emphasis could be placed on the maintenance and expansion of wetlands and linking fragmented native prairie ecosystems. Complementarily, attention could be given to enhancing agricultural extension services and maintaining community pastures and Crown lands.

4.6 Municipalities

Activities undertaken as part of the PRAC and LIRA studies in Brandon, the City of Winnipeg, and Basswood found a range of interest levels in adaptation to climate change among municipal officials. Some municipalities are beginning to act, including the cities of Brandon and Winnipeg. Specific interest was expressed in the use of climate projections to inform the development of current and future public

works infrastructure. Through the work undertaken in partnership with Brandon and the TransCanada West Planning District, the *Risk-based Guide for Local Governments* was found to be user-friendly, flexible and therefore to have "the potential for being a highly effective tool for helping Manitoba municipalities and conservation districts to integrate climate change considerations into their day-to-day planning, operations and decision making" (GENIVAR, 2012a: v). In contrast, the LIRA process was found to require resources and expertise that exceeds that which is presently available within Manitoba municipalities and needs streamlining if it is to be effectively used by municipal staff. It therefore was recommended that it not be applied on a pilot basis led by a municipality at this time.

Work at the municipal level also revealed several challenges that will need to be overcome if local level capacity to adapt to climate change is to be built. In particular, municipal officials have limited financial and staff resources to devote to complex planning processes. Existing demands on their time raises concerns about continued participation and ongoing commitment. They also may be reluctant to take on something new, and may focus on individual issues rather than seeing the whole landscape. Experience with the PRAC suggests that municipal staff members will need greater awareness of the potential implications of climate change (impacts and vulnerabilities) if risk-based adaptation planning is to move forward. They also will require access to new financial resources to overcome the additional cost of adaptation and improved access to guidance on adaptation planning. Municipal officials expressed the need for climate modelling information at a scale sufficient to be effectively used in adaptation planning. Lower resolution forecasts are felt to be needed to improve the accuracy of municipal risk assessments.

Along with these barriers, opportunities for promoting the integration of adaptation into decision-making emerged. Namely, municipal officials would like to see adaptation integrated into on-going development and sustainability planning processes, but require assistance with this process. Complementary frameworks into which adaptation could be integrated include land-use planning frameworks, development plans and secondary plans. The need to address climate change is also already incorporated into Provincial Planning Regulations. Another strong entry point for local level adaptation planning was found to be conservation districts and Planning Districts given the diverse nature of climate change impacts and need for integrated, holistic watershed level planning.

In light of these findings, **options for promoting municipal adaptation** to climate change include:

- In partnership with an enthusiastic municipality, undertaking a comprehensive pilot of the *Risk-based Guide for Local Governments* in order to gain a clear understanding of its strengths, weaknesses and how it might be effectively tailored to the Manitoba context (e.g. economic activities, availability of information, existing municipal planning processes, and time and resource constraints) (GENIVAR, 2012a).
- Encouraging integration of adaptation planning (such as through use of the *Risk-based Guide*) into other, established planning processes, such as land-use planning frameworks, development plans and secondary plans (Bizikova and Medeiros, 2011; GENIVAR, 2012a).

- Encouraging more municipalities to join conservation districts and Planning Districts as they provide a strong entry point for adaptation planning (GENIVAR, 2012a).
- Strengthening collaboration between municipalities and other levels of government and research institutes so that they have greater access to the information needed to inform decision-making in a changing climate.
- Making use of innovative tools like online training videos to provide municipal officials, particularly planners, with information about climate change in a cost-effective manner. Draw upon lessons learned through the current development and roll-out of a training video on climate change impacts by the City of Winnipeg.
- Increasing municipal officials' access to climate modelling information at a resolution sufficient to be effectively used in municipal risk assessments and adaptation planning.

5.0 Recommendations for Moving Forward

Through the PRAC, the Manitoba Government has strengthened understanding of its potential vulnerability to the impacts of climate change and tools that might help government departments and municipalities manage these risks. It has also identified a number of options for strengthening adaptive capacity in the water, agriculture and municipal sectors. These insights will be of value in any future efforts to complete a provincial vulnerability assessment and develop a provincial adaptation plan.

Engagement in the PRAC has also clarified the government's need to put in place the basic building blocks required to engage in more comprehensive and longer term adaptation planning. These foundational steps include:

- Strengthening governance capacity by establishing clear objectives for managing the impacts of climate change and an effective mechanism for coordinating adaptation action across government.
- Gaining the commitment of senior government leaders in efforts to prepare for the adverse impacts of climate change and take advantage of emerging opportunities.
- Improving access to the knowledge and tools required by different levels of government and civil society to engage in adaptation planning and action.
- Establishing mechanisms for ensuring the involvement of stakeholder groups in adaptation planning.
- Putting in place processes for monitoring, evaluating and improving the effectiveness of current policies and programs with respect to their capacity to reduce the adverse impacts of climate change and take advantage of emerging opportunities.

To establish these building blocks for climate change adaptation, it is recommended that Manitoba:

1. *Fully integrate adaptation into Manitoba's next climate change plan.* The Manitoba Government is presently in the process of developing a successor to the Beyond Kyoto Climate Change Strategy. This successor strategy could give equitable attention to mitigation and adaptation, and strive to fully integrate adaptation considerations throughout its sector based recommendations. Development of an integrated plan would not only advance adaptation efforts in Manitoba but also facilitate the identification of potential synergies and conflicts between mitigation and adaptation actions, and improve efficiency of implementation.

2. *Raise awareness among senior government officials regarding the need to adapt.* Preparing for the impacts of climate change will require additional investments and a commitment to long-term planning. Leadership within government is needed to fulfill these requirements. A first step towards achieving this objective could be communicating to departmental executive management committees the lessons drawn from the PRAC process, adaptation co-benefits that meet current needs (e.g. actions that reduce flood risk and cost in the near future), and the importance of adapting to climate change for the province's long-term economic and social well-being.

3. *Establish an inter-provincial adaptation working group*. Effective adaptation planning and implementation requires inter-disciplinary collaboration and coordination across government. Establishing an active inter-provincial adaptation working group (as called for under an August 2011 Cabinet decision) that builds on relationships established through the PRAC—but also expands these by bring in other departments—would improve the capacity of Manitoba to act in a coordinated fashion. It could also assist with knowledge sharing, peer review, building of expertise, and minimizing the potential emergence of conflicting policies.

4. *Establish a Provincial Climate Data Centre.* The purpose of this centre should be to: collect, standardize, manage and share historic and projected climate data for Manitoba; support the development of climate projections; and create communication products such as maps, graphs, guidance documents and training materials. As a first step towards this objective, capacity requirements for the centre should be established and a feasibility assessment undertaken that aims in part to assess the potential cost of establishing the centre and where it should be housed (e.g., within a university or a government department). In time, the role of the centre could be expanded to provide a database of vulnerability and integrated risk assessments undertaken in the province; and tools to support cost analysis of proposed actions.

5. *Establish a provincial roundtable on adaptation.* Expertise on adaptation to climate change resides in a number of different individuals and organizations within Manitoba, but communication between these experts is relatively limited. To foster the creation of an adaptation community of practice in the province, it is recommended that a provincial roundtable on adaptation be established. This roundtable could provide a venue through which information on adaptation action in the province is shared, research gaps are identified, and input on emerging policies, strategies and plans that support adaptation is provided.

6. *Ensure continued engagement with stakeholders.* Through the PRAC, increased awareness, interest and cooperation among stakeholders in southern Manitoba has been achieved. The process has also

highlighted the importance of consulting local stakeholders, such as industry, farmers, academia and community leaders, in the identification, design and implementation of adaptation actions. Going forward, efforts should be made by the province to continuously create opportunities for engagement by local stakeholders in adaptation planning processes. This practice should help ensure the development and implementation of effective policies, and minimize the occurrence of unexpected outcomes.

7. *Act now and build on existing programs.* Although significant gaps in understanding persist regarding how Manitoba's climate will change in the future and the implications of these changes, efforts can be made today to strengthen resilience. Integrating the outcomes of the PRAC into existing programs that enhance capacity to manage current, known climate risks is one opportunity. Examples include: strengthening existing resource management, land use and watershed protection policies; expanding native grasslands and wetlands; facilitating the integration of adaptation into municipal planning processes as required under the Provincial Planning Regulations; enhancing flood forecasting and drought monitoring capacity; strengthening ecological goods and services programs; and modifying insurance and compensation mechanisms to strengthen their capacity to respond to multi-year drought and excessive moisture events.
8. *Take advantage of emerging opportunities.* In seeking to develop and implement its efforts to prepare for and adapt to the impacts of climate change, the Manitoba Government should continue its efforts to establish partnerships with others within and outside of the province. Ongoing dialogue with Natural Resources Canada, Alberta and Saskatchewan in particular is likely to facilitate more efficient, cost-shared efforts to facilitate adaptation.
9. *Establish systems for monitoring, evaluating and adjusting programs to build adaptive capacity.* Monitoring and evaluating adaptation efforts plays a dual role of providing insight into which policies and practices are helping to build adaptive capacity and enabling the modification of strategies over time as climatic conditions change (Spearman & McGray, 2011). An outcome of the PRAC was recognition of the need to better understand the efficacy of existing programs and policies in the context of climate change—to assess the extent to which they already or could enhance capacity to adapt to changing circumstances. Outcomes of MAFRI's analysis of the adaptive fitness of its programs/policies should inform similar efforts lead by other departments. More generally, adaptation concerns could be integrated into existing enterprise risk management systems.

Acting on many of these recommendations will require transitioning from short-term, reactive actions to a longer-term proactive approach to policy development and planning. It will also require the commitment of additional time and financial resources. The potential adverse consequences of climate change for Manitoba, however, means that informed, proactive planning today could avoid significant economic and social costs in the future.

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Appendix 1: Summary of Activity under Theme 1 – Water Resources Management

Changes in water quantity in Manitoba are predicted with varying degrees of certainty by climate by running hydrologic models with climate change predictions. Under the PRAC project, Manitoba Conservation sought to develop existing knowledge about water supply and demand by creating a pilot hydrological model and demand study for the Assiniboine River Basin, and by piloting and testing the Water Soft Paths planning tool in the Pembina Valley Conservation District.

A1.1 Assiniboine River Basin Hydrologic Supply Study

To better assess the vulnerability of the Assiniboine River basin to climate change, a hydrologic modelling study was completed by Stantec Consultants under the direction of MCWS. The study aimed to establish a hydrological model for the Assiniboine River Basin and examine changes in key basin parameters (such as soil moisture and stream flows) over the current century under different climate projections. To support implementation of the study, a Project Steering Committee composed of experts from government and the research and consulting communities was established.

Main activities:

The project began with the development of a model for the water basin using the integrated catchment modelling software MIKE-SHE developed by the Danish Hydrologic Institute, which is able to simulate groundwater, surface water, recharge and evapotranspiration. The model was built to encompass the Assiniboine River Basin upstream of Winnipeg, including the Qu'Appelle and Souris sub-basins. To build it, meteorological, land use, soil, topographic, streamflow and climate projection data was gathered. Calibration of the model was done iteratively and in collaboration with members of the Project Steering Committee. Monthly flow duration curves produced by the model were compared to actual flow records from Brandon, Welby, Russell and Wawanesa during the reference period of 1961 to 1990 climate parameters, and the model then systematically adjusted[12] to complete the calibration. The model was then tested using 1991 to 2003 climate parameters compared to recorded streamflows at the reference stations. The model was found to be representative of stream flow and soil moisture conditions within the Assiniboine River based (Stantec, 2012).

The calibrated and verified model was then run using climate change projection data supplied to MCWS by Manitoba Hydro. The data originally was produced by the OURANOS Consortium, and was for the following time periods: 1960 to 2000; 2011 to 2040; 2041 to 2070; and 2071 to 2099. Use of this data was challenging as descriptors or background information regarding its creation was not provided. Despite this limitation, based on a detailed analysis of the data received, the Canadian Regional Climate Model (CRCM) AET run (CRCM4.2.3 run using CGCM3 GCM input) was selected for use in the analysis as

[12] Parameters adjusted included snowmelt, soil characteristics, land use patterns, overland flow coefficients, base flow assumptions, and river hydraulics.

its results were relatively close to historical monthly mean temperatures and precipitation.[13] To correct for bias, the delta method[14] applied (Stantec, 2012).

To assess changes in stream flow under changing climatic conditions, Headingly was selected as the study site. Historical stream flows for three periods (1913 to 1944; 1945 to 1976; and 1977 to 2009) were assessed, and then compared to projected flows generated by the MIKE-SHE model for the periods of 2011 to 2040, 2041 to 2070 and 2071 to 2099. Results from this single run were then examined.

Key findings:

- The model developed through the project was found to reasonably represent the hydrology of the Assiniboine River basin. However, the CRCM data was found to be biased when compared to historical records and bias correction techniques needed to be applied (Stantec, 2012).
- As the modelling undertaken relied on a single run of the CRCM with input from a single GCM, the results from the study are insufficient for decision-making. Additional runs using a wider range of different climate data sets must be undertaken to capture the breadth of hydrologic changes that might occur in the basin due to climate change (Stantec, 2012; McCandless, 2012).
- Soil moisture levels were found to be an important driver of runoff (Stantec, 2012).
- Historically the Assiniboine River basin has experienced large variations in flow volumes from year to year and decade to decade. In the future, flow variation is also expected to be large and to increase, but to not be significantly different than in the past. Greater variability may be observed if additional runs of the model were undertaken (Stantec, 2012).
- The single run completed during the PRAC suggests (with some uncertainty) that:
    - Soil moisture conditions might be lower in the late summer and fall in the latter third of the current century due to higher summer temperatures and lowered summer rainfall. Lower soil moisture in the later summer and fall would lower the risk of high stream flows in the spring. Projections suggest that spring soil moisture levels will be similar to those found today.
    - Annual average stream flow in the future will be within the range experienced historically, as higher rates of evapotranspiration will be offset by higher levels of annual precipitation (which will be greater in the fall, winter and spring, and lower in the summer); and
    - No trends was observed with respect to average monthly stream flows.

  However, as only a single run was undertaken, "strong conclusions cannot be drawn with respect to monthly soil moisture and stream flows" (Stantec, 2012: E.4)
- Reliable, user-friendly, and easily accessible climate change projections for developing hydrological models are scarce. Facilitating better access to and processing of climate projections would have

[13] The CRCM projects that temperatures will continue to rise over this century, and that precipitation will increase in the fall, winter and spring but decline in the summer (Stantec, 2012).
[14] The delta method involves quantifying the difference between the projection data's baseline and several future scenarios, and applying that difference to measured data (McCandless, 2012).

significant benefits for researching impacts of climate change in Manitoba for applications such as hydrological model development and water conservation planning (McCandless, 2012).

Recommendations:

- To gain a more reliable picture of the potential for water supply in the Assiniboine River basin to change in the future, continued development of the MIKE-SHE model is recommended and additional modelling runs using different climate change scenarios is necessary. The analysis should give attention to potential changes precipitation and temperature, and their implications for changes in monthly and seasonal stream flow and soil moisture (Stantec, 2012).
- Review the adequacy of the current meteorological station network in the province for its suitability in hydrological planning (Stantec, 2012).
- As well, further analysis will be required to assess the extent to temperatures will become variable and the impact of anticipated changes in land use and cropping patterns (Stantec, 2012).

A1.2 Assiniboine River Basin Water Demand Study

Along the Manitoba portion of the Assiniboine River, a study was undertaken to assess current water use and demand, and to project future water demands considering population expansion, economic growth and climate change. Under the direction of MCWS, this work was completed by GENIVAR in conjunction with Stantec and Associates Engineering.

Main activities:

The analysis of current and future water demand in the Assiniboine River Basin took into consideration the river's three reaches in Manitoba: Reach 1 from the Shellmouth Dam to the City of Brandon; Reach 2 from Brandon to the Portage Diversion; and Reach 3 from the Portage control structure to the Forks in Winnipeg. To assess demand for water within each of these reaches, the following are the activities undertaken during the study (GENIVAR, 2011):

1. A literature review was conducted to determine the current state of knowledge of the study region. An array of background quantitative materials was collected, such as relevant data records and projections.
2. A water consumption baseline was created by reviewing and analysing current water demand conditions in the Assiniboine River region.
3. A "visioning process" was undertaken in August 2011 with affected users and stakeholders. The water consumption baseline information was used to develop criteria for the visioning process, which gained input regarding stakeholders' expectations of future use of the river, current strategies for managing climate extremes, and ways of responding to potential climate change impacts. Information gathered through this process was used to develop projected demand scenarios for the region.

4. Socio-economic projections were created. Based on the work of the visioning process, projections of population, agricultural and economic growth were created for several future timelines. In predicting demand, the consultants assumed that no new agricultural licences would be distributed, there would be only one new industrial project, and only one recreation site would be using water from the basin.
5. The socio-economic projections were converted into projected future water demand. Future water demand was assessed with and without taking into account the effect of climate change on future demand (e.g. with and without taking into consideration the potential for greater demand for water for irrigation in future drier summer climate). The results were used to identify vulnerabilities for future demand for water from the River due to climate variability and change.

The projections were conducted by Study Team by using the Canadian Regional Climate Model 4.2.3, which is based from the CGCM and ECHAM5 global climatic models. Data sets were used from the Canadian Climate Change Scenarios Networks, and the climate model output was used to determine future changes in temperature and precipitation for the years 2011 to 2040, 2041 to 2070 and 2071 to 2099. Projections were developed for potential changes in mean annual temperature and for a change in the ratio of precipitation levels between current conditions and future scenarios. The results of this analysis were then compared to North American IPCC Reports and the Institute for Catastrophic Loss Reduction's report on climatic projections for Southern Manitoba (GENIVAR, 2011).

Key findings:

- Water is abstracted from the Assiniboine River for the following uses: municipal, agricultural, industrial, irrigation, the La Salle diversion, and recreation. Municipal and irrigation water supply creates the largest demand.
- Results from the analysis suggest that: the Assiniboine River region will continue to have few industries with high water demand and high sensitivity to climate change; irrigation demand will grow modestly without climate change, but increase more if higher temperatures due to climate change allows for the production of higher value crops such as corn.
- Water demand from the Assiniboine River will continue to increase over the study period, even in the absence of climate change, and may exceed the firm annual yield estimate toward the 2080s as calculated according to current allocation policies (Harrison & Kashem, 2012). Meeting growing water demand by the City of Brandon will require issuing of an additional water withdrawal allocation. While demand for irrigation is expected to increase significantly, no additional growth in agricultural or recreational licences is anticipated (GENIVAR et al., 2012).
- Climate change is predicted to strongly affect water demand from the river. In scenarios run without climate change, water demand exceeds available yield by 2080. Under the climate change scenarios examined, irrigation demand will be dramatically higher than planning accounts for by 2050 (GENIVAR et al., 2012; Harrison & Kashem, 2012).

- The results of the study need to be verified through additional research using different water demand and hydrological models. This additional research is needed in part because there is an inadequate meteorological data network for model calibration and bias correction (Harrison & Kashem, 2012).
- The absence of a standardized classification system for inter-provincial soil and land use data impedes the development of models for basins such as the Assiniboine River that crosses jurisdictional boundaries (Harrison & Kashem, 2012).

Recommendations:

- Additional research is required to better understand the potential implications of climate change for water demand in the Manitoba portion of the Assiniboine River Basin. Specifically:
  - More study is needed to determine when peak water demand might occur to enable better assessment of the potential for peak usage to occur in months when river flows are low (GENIVAR et al., 2012).
  - Greater knowledge is required regarding the in-stream ecological needs of the river as these are not well quantified and account for a substantial allocation of water (GENIVAR et al., 2012).
- Improved access to easy to use climate projection data specifically for Manitoba is needed if the province is to strengthen its understanding of the potential implications of climate change on its water supply. A region-specific climate projection data inventory that is accessible to the public would be a very important resource for assessors and in drought risk assessment and adaptation planning efforts. A standardize methodology for correcting bias within climate data is also needed by the province (Harrison & Kashem, 2012).
- Additional runs of the model developed for the water demand study under different climate projections is required for greater confidence in the trends suggested by this initial study undertaken as part of the PRAC.

A1.3 Water Soft Paths

Between 2009 and 2011, MCWS, in partnership with Friend of the Earth Canada, worked to develop a community of practitioners for Water Soft Paths (WSP) in the Pembina Valley Conservation District. The goals of this community of practice were to encourage incorporation of the WSP approach into municipal and conservation district planning, and to increase decision-makers' capacity to move forward with climate change adaptation. The WSP approach focuses on reducing demand for water through innovation, conservation, reallocation, re-use, and changing use. It focuses beyond quantitative water supply. Water supply and planning is viewed as a service that provides security and prosperity to its consumers, protects watersheds and reduces water demand. The cornerstone of the WSP approach is ecological sustainability, where ecological integrity and protection take a leading role in water management planning. In turn, water management planning ensures that the quality of the water

supply matches the needs of consumers now and in the future. Strategic planning is undertaken using a backcasting process that considers various socio-economic factors (e.g. education, pricing, use of technology). The output is an actionable plan that includes policy development and implementation (e.g. bylaws, incentives, regulations). Finally, the WSP encourages stakeholders to be involved by taking part of the implementation process. The WSP approach is an important element of MCWS's mandate due to is potential to assist decision makers in adaptation planning and to be adapted to locally developed Integrated Watershed Management Plans (MCWS, 2011).

Main activities:

As a preliminary step towards this project, municipal level workshops were held in 2009 in the Pembina Valley Conservation District (PVCD), which includes the municipalities of Stanley, Morden and Winkler. The PVCD was chosen for the pilot on the basis of its existing progressive water management system and pre-existing concerns related to water quality and quantity. The purpose of the workshop was to demonstrate the applicability of the method, and to train planners in the methodology (McCandless, 2012). Some key results from the workshop included: development of municipal water conservation goals, objectives, and tools for 2040 through the use of real-life data; and a unanimous agreement among participants to expand the project to other municipalities and communities in the area (FoE-Canada, 2010).

Following the success of its initial phase, the project continued working in the PVCD, and expanded to six rural municipalities and several small communities in the region. Data collected from the different areas was analysed, and individual scenarios and recommendations were provided to each municipality for future water conservation planning. Over the course of the project the *Guidebook for Developing Water Soft Paths in Canadian Municipalities* was used and improved. The intent of this guide is to expand the lessons learned to other jurisdictions across Canada (MCWS, 2011).

Key findings (FoE-Canada, 2010, cited in McCandless, 2012: 16)*:*

- "Agriculture in the Pembina Valley Conservation District (PVCD) relies mainly on natural precipitation and surface water (including irrigation). Two of the major challenges in adapting to climate change in the PVCD are drought and population growth."
- "Targets for water use reduction were developed, and measures for maintaining water use at the present level of demand were discussed during the workshops. Some of these include: changes to water pricing; grey water and sump pump recycling; city subsidies for use of high-efficiency appliances and fixtures; education and training of citizens; and limiting the amount of water that is available for lawn care."

A1.4 Workshop on Climate Data, Modelling and Applications for Planning

On February 17, 2012, a workshop on *Climate Data, Modelling and Applications for Planning* brought together the central groups of climate data end-users in Manitoba to address three areas of focus:

1. Understanding the current climate data and climate projection data needs and applications for stakeholders active in climate impact assessment in Manitoba.
2. Defining the conditions necessary for getting climate projection data "right" in terms of management, format, quality and guidance on limitations for use in Manitoba adaptation assessments.
3. Collaborating and communicating climate data for Manitoba regions and relevant impact assessment findings.

Stakeholder groups invited to discuss their climate data needs included: planning level climate data users; detailed modelling and analysis climate data users; and research and academic climate data users.

Main activities:

The climate data workshop consisted of a series of presentations from Manitoba Conservation (on current activities and workshop context), the University of Winnipeg (on the current state of climate data), Stantec (on the Assiniboine River Water Demand Study), MMM Group (on the Interlake Excess Moisture Modelling Study), Manitoba Water Stewardship (on modelling and climate data needs), PARC/University of Regina (on modelling work completed as part of the PRAC in Alberta and Saskatchewan) and Manitoba Hydro (on an overview of Manitoba Hydro's climate change impact studies). These presentations were followed by breakout group discussion of data needs. Breakout group discussion led to the identification of some of the climate data needs and concerns of the stakeholder groups invited. In addition to expressing data needs, participants sought to develop solutions. The data users assembled identified a number of data needs broken down by the stakeholder groups and presented recommendations to be included in a workshop report.[15]

Key findings:

- Planning level climate data users indicated a need for probabilistic data on climate events, particularly with regard to weather variability and extremes in climate. They also indicated a need for the ability to track differences between historical data and future projected data. Finally, planning level users felt there was a need for dedicated capital and operational investment in climate data by government.
- Detailed modelling and analysis climate data users identified several needs, including:
  - Data sets pertaining to key areas of focus for their work (e.g. community planning, infrastructure/asset management, flood planning, transportation networks, forest management, permafrost conditions);
  - A need to establish understanding of trends differences between historical data and future projections;
  - Guidance on protocols or best practices on handling data;

[15] Roger Rempel, FEC, P.Eng. *Manitoba Climate Data Modelling Workshop*. Stantec, February 2, 2012

  - GCM/RCM datasets to be provided for a variety of climate variables covering appropriate time scales for adaptation planning and of high enough resolution as to be regionally representative; and
  - Background information accompanying projection data with sufficient details for understanding of internal characteristics and potential bias of models as well as limitations and appropriate context of data projections.

- Research and academic climate data users indicated needs for improving the quality of the Manitoba monitoring station network and better systems for climate data exchange. Data exchange was a priority as datasets are not easy to assemble and must be collected from a variety of sources. Re-assessing climate data requirements to meet current adaptation planning needs was also identified by this group.
- A lack of direction and official coordination of Manitoba climate data holdings was identified, and there was no known initiative to develop a regional inventory of climate data for Manitoba. This problem creates low coverage of Manitoba regions and constrains communities looking to act on adaptation. Crown corporations (i.e. Manitoba Hydro) are not suitable to meet this need given their own corporate mandates.
- Several cross-cutting climate data issues were identified:
- Existing monitoring networks are not robust enough to meet needs;
- Networks are degrading due to a lack of, or withdrawal of, financial resources (an issue of high concern);
- There is a need in Manitoba for coordination and management around climate data sharing (a "government desk") as the current void in this area impairs the ability of users to make progress in vulnerability assessments and adaptation planning. "SaskAdapt" offers a productive model for user-friendly data portals.
- Many communities are prepared to act on adaptation but lack the technical guidance and data resources.

Recommendations:

- The Manitoba Government has a role and interest in creating effective products to simplify key climate adaptation concepts and to promote the use of proven, accepted methods for using climate projections and conducting climate resiliency assessments for populations in all regions of Manitoba.
- A strong effort to simplify climate data information for end users and promote accepted assessment protocols is required. The creation of a "central government desk" for climate data and guidance on best practices would improve Manitoba's adaptation planning efforts. A Manitoba based "public climate data portal" (PCDP) would include:
  - communication of data trends and results, mapping products, communicable graphics;

- synthesis reports on envelopes of predicted changes, limitations for using data, and references to additional data support;
- training materials, procedural guidance, adaptation assessments, and case studies.

- In establishing a PCDP, it was noted that an emphasis must be placed on quality control and assurance. While Manitoba could learn from the experiences in other jurisdictions, it should develop an independent portal that meets its specific needs.
- Manitoba should undertake a shift from a traditional emphasis on greenhouse gas mitigation to a new outreach initiative on adaptation and climate risk management by Manitoba communities.

A1.5 Water Policy Guidance

To bring together the outcomes of the previously described projects, IISD was commissioned by MCWS to provide an assessment of the implication of the activities completed under the PRAC's Water Resource Management Theme for climate change policy decisions in Manitoba over the short, medium and long-term. The report, "Adaptation in the Water Sector in Manitoba: A policy discussion following activities of the Manitoba PRAC Water Theme" (McCandless, 2012) begins by providing an overview of the current characteristics, capacity, bias and limitations of GCMs and RCMs, and of the projected changes in Manitoba's climate. Summaries of the activities and outcomes of the Assiniboine Basin water supply and water demand studies, as well as the WSP project, are then provided. Based upon this analysis, recommendations regarding policy initiatives to support adaptation to climate change within Manitoba's water sector are then provided.

Key findings:

- As previously suggested, the most significant challenge for additional policy related action in Manitoba's water sector was found to be access to climate change projection data. Access to sufficient, easy-to-use climate data was identified as a problem by those engaged in the Assiniboine River basin water demand and water supply studies, leading in part to the recommendation to establish a Provincial Climate Data Centre at the January 2012 climate data workshop.
- Water availability in the Assiniboine River basin is inherently highly variable, and this natural variability could mask changing patterns caused by climate change. It is also strongly affected by evapotranspiration rates—a fact that should be considered in future modelling.
- The outcomes of the water supply and demand studies are not comparable. Additional runs of the models with a wider range of climate projections are required before accurate estimates of future allowable annual yields can be made. Refinement of the ecological flow requirement is also advisable.
- The Water Soft Paths approach could promote water conservation in the province, and potentially offset a projected rise in water demand. To achieve its potential, however, municipalities require

additional information to support implementation of the WSP approach and further analysis is needed to quantify water saved through its application.

Recommendations:

- Improve access to reliable and standardized climate data by establishing a Provincial Climate Data Centre housed either at one of the universities or within the provincial government.
- To further promote use of the Water Soft Paths approach within Manitoba, it should be integrated into water use planning at the municipal and Conservation District level throughout the province. To support this measure, municipalities and Conservation Districts will need greater access to the specific information (e.g., water usage levels, the effectiveness of current water conservation efforts, restrictions imposed by provincial regulations).
- Deepen understanding of projected water supply and demand by (1) quantifying in-stream needs along the Assiniboine Basin, incorporating municipal and industrial return flows and refining environmental flow calculations; (2) undertaking additional runs of the models created within the PRAC project using a wider range of future climate projections; (3) studying land use change over time for their impact on run-off; and (4) determine a safe level of peak usage in the Assiniboine Basin.
- Develop hydrological models for other high risk, high impact areas of the province.
- Continue and enhance efforts to promote water conservation at the household level through educational, incentive and subsidy programs, and potentially increasing the cost of consumption. Improved efficiency by industry and agriculturalists should also be promoted.
- Refine water legislation in partnership with municipalities and Conservation Districts to strengthen efforts to reduce water consumption.
- Develop coordinated land-use and watershed management plans to protect and monitor water sources and riparian areas.
- Promote regionalization of water management services and technology development.

Appendix 2: Summary of Activity under Theme 2 – Drought and Excessive Moisture Planning

Increased incidents of drought and excess moisture due to climate change have the potential to pose a serious threat to Manitoba's agricultural sector and municipalities. Under the PRAC, Manitoba Conservation's Climate Change Branch worked primarily with MAFRI and MLG to begin to address these challenges.

A2.1 Municipal Adaptation Planning – Brandon and TransCanada West Planning District

The goal of the Municipal Adaptation Planning component of the DEM Theme of the PRAC was to increase the capacity of municipal decision makers to integrate climate adaptation planning into local planning decisions. Efforts to achieve this goal were led by MCWS in partnership with Manitoba Local Government (MLG). Through the Municipal Adaptation Planning component, activities were undertaken in two locations:

- Brandon and the TransCanada West Planning District, as described below; and
- City of Winnipeg, as described in section A2.2.

Main activities:

To support adaptation by Manitoba, MCWS initiated a process to identify, review and test a tool that would assist municipalities in understanding their vulnerability to the impacts of climate change and develop appropriate adaptation strategies and plans. The City of Brandon and the TransCanada West Planning District (composed of the Town of Virden, the Village of Elkhorn, and the Rural Municipalities of Archie and Wallace) agreed to partner with MCWS and MLG in this process.

Work was initiated in late 2010, beginning with a review of different municipal adaptation planning guides to assess which would be most appropriate for application in Manitoba.[16] Based upon this review, it was decided to explore use of *Adapting to Climate Change: A Risk-based Guide for Local Governments* (Black et al., 2010). Originally developed by NRCan, this guide has been adapted by Alberta,[17] British Columbia[18] and Ontario[19] for use within each province. British Columbia's version of the guide was selected by Manitoba as it contains an accompanying workbook and case studies.

[16] Guides reviewed during this process included: "Preparing for Climate Change: A guidebook for local, regional and state governments" prepared by ICLEI; "The Climate Change Adaptation Framework" developed for Alberta Sustainable Resource Development; the SaskAdapt Self-Assessment Tool; and the Public Infrastructure Engineering Vulnerability Committee's Engineering Protocol for Climate Change Infrastructure Vulnerability Assessment. Case studies prepared by the Clean Air Partnership, C-CIARN and the Heinz Centre, among others, were also reviewed. These case studies describe the application of different tools by municipal governments and local communities, and noted lessons learned and good practices.

17 A draft guide was produced for municipalities in Alberta. Available at: http://www.nrcan.gc.ca/earth-sciences/projdb/pdf/176b_e.pdf

18 Available at: http://www.nrcan.gc.ca/earth-sciences/projdb/pdf/213_e.pdf

To support design of a process for strengthening adaptation planning capacity in southwestern Manitoba, MCWS commissioned IISD to undertake a brief survey of municipal officials. Between December 2010 and January 2011, 34 policy-makers based in municipal offices and conservation districts completed the survey. Its specific objectives were to better understand municipal officials' experiences with climate-related events, concerns about future climate change, capacity to deal with adaptation, current adaptation planning efforts, and appropriate ways of supporting adaptation planning in Manitoba (Bizikova and Medeiros, 2011). The survey found that nearly 80 percent of communities surveyed had not yet initiated planning for adaptation and/or mitigation of climate change. It also found a high level of interest in adaptation to climate change, with concern being expressed in particular regarding the impacts of climate change on flooding, excessive moisture, storm water management, and changes in lake and river water levels.

Building on the results of the survey, two workshops were undertaken to explore application of the *Risk-based Guide for Local Governments* in Manitoba, increase awareness of the need for adaptive planning, and identify planning and operational vulnerabilities to climate change. The guide lays out a six steps process through which vulnerabilities and risk can be identified and adaptation options developed: (1) setting the context; (2) preliminary assessment; (3) risk estimation; (4) risk evaluation; (5) adaption measures or risk controls; and (6) implementation and monitoring. The first two steps of this process were completed during a workshop held in November, 2011. Steps 3 to 5 were completed during a workshop held in March 2012. Participants in the March workshop focused their discussion on identifying, assessing and evaluating the risks associated with too much and too little water—a priority area identified during the first workshop. Both workshops were held in Brandon, and were attended by representatives of the City of Brandon, the Town of Virden, the Village of Elkhorn and the RMs of Archie and Wallace. The March 2012 workshop was designed and facilitated by GENIVAR, which also produced a final evaluation report on the appropriateness of future application of the *Risk-based Guide* in Manitoba.

Key findings:

- Key challenges for making progress on adaptation are perceived by municipal officials as being a lack of financial resources, limited staff time, and the lack of clear direction from provincial/federal agencies (Bizikova and Medeiros, 2011).
- Municipal officials expressed a desire for adaptation to be integrated into on-going development and sustainability planning processes, and for the provision of assistance to support this process (Bizikova and Medeiros, 2011).
- The *Risk-based Guide for Local Governments* was found to be user-friendly, flexible and therefore to have "the potential for being a highly effective tool for helping Manitoba municipalities and conservation districts to integrate climate change considerations into their day-to-day planning,

19 Available at: http://www.nrcan.gc.ca/earth-sciences/projdb/pdf/176a_e.pdf

operations and decision making" (GENIVAR, 2012a: v). It strengths were identified as being (GENIVAR, 2012a; Walsh, 2012):

  - its capacity to be tailored to the available financial and administrative capacity within a municipality and it does not need to be an overly time consuming process;
  - its encouragement of consultation with multiple stakeholders in a structured manner, which opportunity it creates for discussing climate change, sharing of information, and forging of partnerships needed to implement adaptation actions;
  - the control it provides to users to identify their priority areas for action based on an understanding of their own needs;
  - its lack of reliance on detailed prior knowledge of climate change or risk assessment processes;
  - its capacity for repetition and regular update, which should increase the sustainability of the adaptation planning process.

- A challenge in using the guide was the terminology used, which participants sometimes found unclear. Should the guide be adopted by Manitoba, it could be improved by clarifying the terminology that it uses.
- Municipal officials expressed desire for more detailed information regarding current and future climate risks, and existing programs that could mitigate these risks.

Recommendations:

- Consider adapting the *Risk-based Guide for Local Governments* for use by Manitoba municipalities, conservation districts and planning authorities. It is advised that this recommendation be facilitated by: designating a provincial department to coordinate application of the *Risk-based Guide* or another tool; promoting collaboration, resource sharing and partnerships at the local level; and assessing the potential benefits and drawback to making it mandatory for municipalities and planning districts to incorporate climate risk assessment and adaptation and/or mitigation planning into their planning proceses (GENIVAR, 2012a).
- Inform local governments and authorities about the *Risk-based Guide for Local Governments* and "provided with links to various web-sites where copies of the manual and its derivatives can be down-loaded" (GENIVAR, 2012a: v).
- Consider having MCWS and MLG partner with a willing municipality to pilot a comprehensive application of the *Risk-based Guide for Local Governments* process (GENIVAR, 2012a).
- Facilitate the establishment of relationships between municipalities, the Association of Manitoba Municipalities, the Manitoba Conservation Districts Association and others to foster collaboration and increase the efficiency of efforts to integrate adaptation into decision making.[20]

[20] Personal communication, MLG representative, December 2011.

A2.2 Municipal Planning – City of Winnipeg

The City of Winnipeg expressed interest to MCWS in participating in the PRAC's Municipal Adaptation Planning component. Some departments within the city have begun to consider the implication of climate change on municipal planning and operations (e.g. emergency preparedness, engineering). However, a coordinated response across departments has not yet been developed, and few staff members have a complete picture of the potential climate change impacts and the city's vulnerabilities. With the support of the PRAC, the City of Winnipeg has initiated efforts to build its employees' understanding of climate change adaptation needs and potential actions.

Main activities:

With the support of the PRAC, the City of Winnipeg held a Climate Change Adaptation workshop in March 2011. The purpose of this workshop was to train key members of the City's administration (staff, managers and directors) on climate impacts, adaptation needs and implementation strategies. Use of ICLEI's *Changing Climate, Changing Communities* milestone approach was suggested as a potential framework for adaptation planning by the city. An agreed outcome was to develop a corporate education video that will provide information about climate change to all parts of the municipal government in a cost effective manner. When completed, all staff members will be required to view the video. It will provide expert research and perspectives on forecasted impacts, highlight likely implications for city operations, and will have broad appeal to all service areas and seniority levels. This awareness raising campaign is anticipated to help facilitate development of a corporate adaptation plan (Madden, 2012).

Key findings:

- Participants in the March 2011 workshop were eager to incorporate climate change considerations into planning. They were particularly interested in using climate projections to inform current and future public works infrastructure engineering considerations.
- There is a need to disseminate climate information more broadly throughout the City of Winnipeg organization. As such, the initial goal of adaptation planning should be to develop tools that enable a shared understanding of the projected climate impacts facing Winnipeg. This would facilitate risk-based adaptation planning.
- The best way to achieve wide-scale awareness of climate change impacts and adaptation options is an online climate change adaptation video or videos which can be made available to all City of Winnipeg employees.

A2.3 Land and Infrastructure Resilience Assessment (LIRA) Tool

In parallel with but separate from the PRAC, Manitoba undertook an assessment of the LIRA Tool, with a focus on the Little Saskatchewan River watershed. The LIRA Tool was designed by Agriculture and Agri-Food Canada (Agri-Environment Services Branch). Largely a cost-benefit assessment tool, LIRA is designed to help local governments determine: the socio-economic vulnerability of a watershed region's infrastructure, economy and environment to extreme precipitation events (including floods); and the comparative potential financial cost and socio-economic benefits of different adaptation options. Vulnerability is assessed against a baseline of the socio-economic cost of an extreme event today in comparison to projected damage in the future, initially assuming that no adaptation measures are introduced. This assessment is undertaken through a five-step process:

- Mapping of the landscape using GIS;
- Collecting historical and projected climate date, with particular attention to frequency and intensity of extreme precipitation events;
- Predicting the impact of extreme precipitation events on infrastructure, economy and environment;
- Developing and prioritizing adaptation options (e.g., improved drainage, changing land use regulations); and
- Reaching informed decisions regarding which actions to take to reduce vulnerability.

Completion of these steps provides decision-makers with an understanding at the watershed or sub-watershed level of where flooding and damage will occur, areas of high risk and/or value, and prioritized adaptation options. The expected outcomes of its application include a stronger regional understanding of the impact of extreme precipitation events and associated mitigation measures, and increased resilience to climate change. The LIRA Tool is being piloted in locations in Saskatchewan and Nova Scotia (GENIVAR, 2012b).

Main activities:

With separate funding from NRCan, Manitoba undertook a scoping study to assess the potential for applying the LIRA Tool in Manitoba. A consultant, GENIVAR, was engaged to assess the LIRA process, hold an introductory workshop, and provide an assessment of the value and practicality of implementing the LIRA Tool in Manitoba. The LIRA Process Workshop was held in Basswood, Manitoba, in February 2012. The objective of this workshop was to introduce the LIRA Tool to key government officials and interested administrators and others from the Saskatchewan River Conservation District. The workshop provided participants with: an introduction to LIRA's history, rationale and current applications; an overview of LIRA's objectives, benefits and five step process; a more detailed review of the LIRA process, with an emphasis on its stages related to economic valuation and cost-benefit analysis; and an opportunity to develop questions regarding LIRA and its potential for application in Manitoba. A final report summarizing the outcomes of the workshop and assessment of the feasibility of applying the tool in Manitoba was subsequently completed by GENIVAR.

Key findings:

- Potential benefits of using the LIRA Tool identified by workshop participants included the collection of an inventory of municipal infrastructure and various data in a GIS format that could then be used in other planning processes (GENIVAR, 2012b).
- However, participants identified a number of concerns, including: the demand LIRA could place on the limited time and financial resources of municipal staff; and limited technical capacity at the municipal level to undertake the process, and therefore a need for external assistance to complete the analysis. In particular, assistance would be needed to complete the data collection and mapping, climate modelling, flood modelling, and socio-economic assessment, cost-benefit analysis and probability analysis (GENIVAR, 2012b).
- LIRA requires access to topographic data that most rural municipalities cannot afford; includes socio-economic analysis that is complicated and labour intensive; relies on detailed probability analysis; and may not support the identification of adaptation options more robustly than what is presently being undertaken based on historically experience.

Recommendations:

- As the LIRA process requires resources and expertise that exceeds that which is presently available within Manitoba municipalities, and requires streamlining to be used effectively, it should not be applied on a pilot basis within Manitoba.

A2.4 Interprovincial Drought Communication Framework

A project supported jointly Alberta, Saskatchewan and Manitoba sought to strengthen inter-provincial communications related to drought. To this end, Rescan Environmental Services Ltd. was commissioned by the PRAC (through Saskatchewan Watershed Authority) to prepare a draft Interprovincial Drought Communication Framework.

Main activities:

To support development of the draft framework, Rescan interviewed six key informants from Alberta Agriculture and Rural Development, Saskatchewan Watershed Authority, Saskatchewan Ministry of Agriculture, and MCWS. Insight was also gained through break-out group session work undertaken during the PRAC Joint Drought and Excessive Moisture and Water Theme Forum held in September 2011 in Winnipeg. Information gathered through these two processes was used to inform development of a draft Framework that identifies existing gaps and needs, and potential ways of addressing these concerns (Rescan, 2011).

Key findings:

- Communication related to drought is already occurring within and between the Prairie Provinces. Informal exchange of information between individuals has emerged in part from relationships

established during joint participating in existing committees and programs. Conferences and workshops were indicated by key informants as being particularly valuable in facilitating learning and knowledge sharing related to drought. Communication is also fostered through drought management committees established in each province and a number of federal and/or inter-provincial committees whose mandates also include drought (Rescan, 2011).

- Support was expressed for greater use of two scenario-based tools developed by AAFC to foster drought communications: the Drought Preparedness Partnership Table-top Exercise and Invitational Drought Tournament Simulation Exercise (Rescan, 2011).
- Of the existing committees, the WSC is well-placed to host inter-provincial drought communication efforts on the Prairies due to its existing inter-jurisdictional and interdisciplinary mandate. However, a sub-committee may need to be established given the WSC's Canada-wide mandate (Rescan, 2011).
- Prominent barriers to improving interprovincial drought communication include the absence of sufficient funding, inadequate staff resources, and the need for champions (Rescan, 2011).

Recommendations:

- Establish a framework for communications that builds upon existing institutional structures, is supported by legally binding and firm commitments between jurisdictions,[21] and involves civil society stakeholders. A framework that includes these components is more likely to be able to maintain the momentum needed for success.
- "Coordinate interprovincial drought communication through an existing interprovincial group, such as the WSC, and ensure representation from key federal departments" (Rescan, 2011: 4-1). Given the mandate of the WSC and its relationship to the Council of the Federation, it is recommended that the WSC have a led role in efforts to strength interprovincial communication related to drought. It is suggested that a Prairie Interprovincial Drought Working Group be established under the WSC to bring together relevant experts from the provincial and federal levels. A proposed framework for the interaction of these bodies with existing provincial bodies and external stakeholders is presented (Rescan, 2011).
- "Develop a Prairie Drought Community of Practice" (Rescan, 2011:4-1).
- "Organize annual or biannual interprovincial forums for learning" (Rescan, 2011: 4-1).
- Use AAFC's scenario-based decision-making tools noted in the key findings section (Rescan, 2011).
- "Develop a web-site and portal to act as a 'one-stop-shop' for Prairie drought" through which all information will be shared (Rescan, 2011: 4-1).

[21] These commitments could be articulated through Memoranda of Understanding, legislation or specific mandates (Rescan, 2011).

- "Share technical tools utilized by practitioners in Prairie jurisdictions for drought characterization and preparedness" (Rescan, 2011: 4-2).
- "Develop a searchable directory and database of individuals working on drought in the Prairies" that will provide information about their expertise and how they may be contacted (Rescan, 2011: 4-2).

A2.5 Provincial Drought Plan

The purpose of the Provincial Drought Management Planning component of the PRAC was to strengthen Manitoba's capacity to reduce the effects of drought and describe recommended responses to different drought stages. When completed, the plan is expected to complement existing provincial water resources management and emergency plans and policies (Harrison & Kashem, 2012).

Main activities:

MCWS undertook a process to define (Harrison & Kashem, 2012):

- "drought severity levels and reporting frequency;"
- "action protocols and strategies for drought preparedness, reporting, monitoring, communication, data sharing and response;"
- "protocols for communication, linkages and coordination among governmental agencies, committees and stakeholders for drought management;"
- "drought mitigation and water conservation strategies;"
- "a direction for updates, research and implementation."

Based on the process undertaken, a draft Provincial Drought Management Plan has been prepared. The draft plan identifies four stages of drought as defined by proposed primary (e.g., precipitation and water flow) and secondary indicators (e.g., groundwater and soil moisture levels). The draft plan is to be reviewed by stakeholders within and outside of government. Additional research on climate change and water supply and demand may also be undertaken to further inform the content of the plan, as well as the development of lake and reservoir drought indicators (Harrison & Kashem, 2012).

Key findings:

See discussion related to water supply and water demand studies.

A2.6 Provincial Planning on Adaptation to Excessive Moisture in the Interlake Region

The aim of the PRAC project Provincial Planning on Adaptation to Excessive Moisture in the Interlake Region of Manitoba was to support the development of a provincial-level strategy to increase adaptive capacity in the agriculture sector by improved management of excessive moisture conditions (MMM Group, 2012). To achieve this goal, the project sought to: assess the risks associated with excessive moisture on farm land; identify the potential effects of excessive moisture using climate modelling scenarios; and provide recommendations to support development of a provincial strategy (Szumigalski, 2012). The study focused on the Interlake Region, an area found to have the lowest level of adaptive capacity among Manitoba's agricultural census regions (Swanson et al., 2009). The case study approach undertaken in this region was to be used to inform the excessive moisture management needs of other parts of southern Manitoba (MMM Group, 2012). MCSW oversaw implementation of this study, which was implemented by MMM Group Limited. A Steering Committee composed of representatives of MCWS, MAFRI and MLG provided guidance and feedback on the design and execution of the project. The project was initiated in the fall of 2011 and concluded in March 2012.

Main activities:

Three primary activities were completed as part of the Interlake Region Excessive Moisture study: a literature review, modelling of potential water flows in the Icelandic River Watershed and consultations with local stakeholders. As a first step, background information was completed to clarify understanding of adaptive capacity, Manitoba's agricultural policies and programs, climate change projections, and potential adaptation options. The results of this review were used in part to identify current and emerging practices for adapting to excessive moisture conditions (MMM Group, 2012).

In the second component of the project, hydrological modelling was completed for the Icelandic River Watershed to determine the possible impact of different climate scenarios on streamflow events. The Icelandic River Watershed was selected for the case study as it was judged to be representative of the wide variety of agricultural activities and land use practices in the Interlake region. In addition, data of sufficient quantity and quality was available to support the planned modelling. The main objectives of this component of the project were to "identify the timing, frequency, and causes of moisture extreme cycles, and examine the influence of climate change on the magnitude and duration of these cycles, as well as the corresponding change in water balance within the watershed" (MMM Group, 2012: 26).

The Hydrologic Engineering Centre Hydrologic Modeling System (HEC-HMS) water balance model was used for the study. To develop flood frequency curves, historical climate data from Environment Canada hydrological and hydrometric gauging stations in the watershed were used. The model was calibrated using data from 1974, 1979, 1986 and 1989 to represent 1 in 2, 1 in 15, 1 in 33 and 1 in 85 water flow events. Temperature and precipitation files for these years were used as the baseline against which to compare climate change scenarios. To develop these scenarios, climate data provided by the

Government of Manitoba was used in the CRCM4.2.3 model, which is based on the SRES A2[22] future greenhouse gas emissions scenario. Three different scenario runs of this model were used: AET and AEV driven by CGM3; and AGX driven by the ECHAM5 Global Circulation Model. This model was then used to create climate scenarios for the Interlake Region for the average of the periods of 2010 to 2039, 2040 to 2069, and 2071 to 2099. This information was then used to model potential future hydrological conditions in the region, focusing on moisture extremes in the upper and lower soil storage zones, and the duration, magnitude and statistical return period of flooding. Modified flood frequency curves were created for three different climate change scenarios (AET, AEV and AGX) for each of the three time periods (MMM Group, 2012).

Stakeholder consultations were undertaken in the third component of the Interlake Region Excessive Moisture study. These consultations were used to understand the strengths and weaknesses of the existing government agricultural policies, understand local concerns, and gain advice on future policy directions. As a first step, key informant interviews were undertaken with some agriculture producers and representatives of local municipal governments, First Nations, NGOs, Conservation Districts and the provincial government. A workshop was then held in Arborg on November 16, 2011. The goal of this workshop was to "better understand how excess moisture impacts the agricultural community" and how it could be better served by modifying current public policy (MMM Group, 2012: 44). Through the workshop, participants identified significant challenges and issues related to excessive moisture conditions. Solutions to excessive moisture conditions were discussed, as well as future opportunities for addressing excess moisture conditions.

Key findings:

- Results from the modelling showed considerable range in the projected flood frequency curves, with hydrologic response varying significantly depending on the climate change scenario used. As a result, "conclusive results with respect to expected hydrological trends can therefore not be drawn." Either an increase or a decrease in hydrological peak may occur in the future (MMM Group, 2012: 36).
- The modelling results do suggest that future hydrological conditions in the Icelandic Watershed are likely to following the general trend of currently observed hydrographs. As in the past, future peak stream flow will coincide with spring snow melt, and this melting is likely to be the greatest concern with respect to the generation of excessive moisture conditions and overland flooding. A limited expected increase in summer rainfall means that "little change in water balance and peak runoff rates" is projected for the future during the summer. As such, an excess moisture strategy will largely depend on the ability to deal with spring melt. (MMM Group, 2012: 33).
- However, the projections developed during the project should be used with care due to several limitations and uncertainties associated with the modelling. First, a limited set of Global Circulation

[22] The A2 climate scenario contained in the Intergovernmental Panel on Climate Change's Special Report on Emissions Scenarios (SRES) projects that greenhouse gas emissions will rise moderately in the short to medium term but will be high in the long term.

Models (AET, AEV and AGX) were used, along with only one SRES scenario. The research therefore does not represent a full analysis of the breadth of future climate projections. Additional concerns include difficulty modelling the cumulative impact of multiple excessive moisture events in the growing season; uncertainties related to the role of feedback mechanisms in climate projections; potential for different emission pathways; and the utilization of average precipitation and temperature and not extreme events (MMM Group, 2012).

- Key excessive moisture concerns of agricultural producers in the Interlake Region were: the saturation of soils and the resulting net loss in crop production; the need to bring together all parties to cooperatively engage in policy development and planning; replacement of the current ad hoc and current approach to water management with a coherent strategy; development of a drainage plan and improved maintenance of drains; and a move away from the current reactive approach to individual extreme moisture events to one that addresses the need for financial assistance for successive rain events (MMM Group, 2012).
- Local stakeholders expressed a need for:
    - An integrated approach to drainage issues that involves all levels of government, streamlines response measures, and "accepts that flooding may be a regular, rather than sporadic, event" (MMM Group, 2012: 51).
    - Reflection of actual costs on the ground in financial compensation.
    - Improvement of existing infrastructure, sustained maintenance of existing drainage infrastructure, and better understanding of natural drainage patterns.
    - More coordinated approach to the management of excess moisture conditions.
    - Review of existing water and watershed policies to assess their effectiveness, and continued monitoring of their effectiveness (MMM Group, 2012).
- Any adaptation strategy will need to be flexible enough to deal with both potential minimum and maximum stream flow events.

Recommendations:

Within its report, the MMM Group identified recommendations for implementation in the short term (defined as being in less than two years), the medium term (in two to six years) and in the long-term (in more than six years). These recommendations are presented below.

Regulatory Framework recommendations (MMM Group, 2012: 55-58):

- "Require Conservation Districts to issue permits for land use changes." (Short-term)
- "Province should undertake a drainage study to define water quality and drainage objectives in a balanced way." (Short-term)
- "Province should encourage planning authorities to use best available data to clearly designate land so that development is guided away from higher-risk areas." (Short term)

- "Coordinate excess moisture management under the *Provincial Planning Regulation* policies and Development Plans to ensure lands subject to regular flooding are not considered for development." (Short term)
- "Survey producers, agricultural organizations and supporting agencies to determine the effectiveness of the *Conservation District Act*, other relevant legislation and implementing regulations." (Medium term)
- "The Province should undertake a study to ensure that drainage practices on private land are consistent with provincial strategy and policy, and how to align drainage policies on private property with the provincial strategy." (Medium term)
- "The Province should create a high-level integrated provincial drainage strategy." (Medium term)
- "Municipalities should be required to determine a five-year water management plan, as part of longer-term planning." (Medium term)
- "The Province should initiate a review of policies, programs and initiatives supporting the agriculture industry and used in reaction to historical extreme events, including excess moisture." (Medium term)
- "The Province, in conjunction with Conservation Districts and municipalities, should monitor selected elements and update the Strategy as needed." (Long term)
- "The Province needs to be innovative in planning policy and practices that accepts regular flooding in some areas regardless of insurance/funding programs." (Long term)
- "The Province should undertake a review of water-related legislation, policy and regulations to develop consistency and determine if changes are required." (Long term)

Recommendations related to improved coordination (MMM Group, 2012: 58-60):

- "Improve shared (provincial, municipal, land owners) understanding of water flows in the region." (Short-term)
- "Accept that flooding may be a regular event, rather than sporadic or occasional events and have budgets and protocols for policy and insurance programs set on this basis." (Short-term)
- "Encourage crop diversification choices based on long-term excess moisture trends in the context of fixed physiographic conditions." (Short term)
- "Consider options for engaging private land owners in water management practices that are aligned with approved water management practices." (Medium term)
- "Improve communication of weather pattern information to farmers to assist in applying BMPs"

Recommendations related to infrastructure development (MMM Group, 2012: 59-60):

- "Improve maintenance schedule to better manage the existing drainage system." (Short term)

- "The Province should partner with municipal governments and NGOs to identify water management and drainage priority projects for funding." (Medium term)
- "Ensure that maintenance of municipal and provincial drainage infrastructure is sustainable and regulated on a watershed basis." (Medium term)
- "Explore cost-sharing models for drainage system to ensure the financial burden is not solely with the producer." (Medium term)

Recommendation related to funding (MMM Group, 2012: 60):

- Provide for flexible funding to support regular and extreme weather events." (Long-term)

A2.7 Evaluation of Existing Drought and Excessive Moisture Programs

The Manitoba Government has established a number of different programs designed to help producers cope with existing climate variability, including DEM conditions. There is uncertainty, however, regarding the degree to which these existing programs contribute to building rural producers capacity to adapt to more frequent water-related extreme conditions (as expected due to climate change). To address this uncertainty, MAFRI and MCWS engaged IISD to develop a framework for evaluating DEM preparedness programs. The evaluation framework was to be used to assess the extent to which these programs are enhancing the adaptive capacity of agriculture producers, business and communities at a watershed level, and provide the basis for making recommendations for program improvement and how to fill potential programming gaps (Swanson, 2011). The first phase of this work was co-financed by the SWA. In Manitoba, the analysis focused on evaluating adaptive capacity in the East Interlake Conservation District.

Main activities:

In collaboration with MAFRI, MCWS and SWA, IISD developed a simple yet comprehensive, qualitative evaluation framework called the Adaptive Policy Analysis Tool (APAT). The tool is designed to evaluate the extent to which a suite of public policies and programs contribute to capacity of key economic sectors to adapt to increased DEM conditions (Swanson, 2011). It defines the scope of the evaluation, supports identification of critical vulnerabilities, and enables evaluation of the extent to which existing programs support adaptation to the anticipated and unanticipated impacts of climate change. The APAT was tested in January 2011 using one program from each of Saskatchewan and Manitoba.

Based upon the positive outcome of these pilot evaluations, the APAT was subsequently used in March 2011 to evaluate a few additional programs active in the East Interlake Conservation District. To support this evaluation, a preliminary list of agriculture sub-sectors being implemented in the Conservation District (cattle, forage, cropping, forage seed and hogs) was developed by MAFRI personnel. The potential vulnerabilities and adaptive responses for each of these sub-sectors were then identified. Five DEM programs were then evaluated using APAT: Environmental Farm Plans, Manitoba Agricultural

Services Corporation's AgriInsurance, AgriStability, the Agri-Food Research and Development Initiative, and the Manitoba Sustainable Agriculture Practices Program. The analysis undertaken was not comprehensive; rather it was intended to assess the utility of the tool for further application.

Key findings:

- The pilot analysis demonstrated the potential of the APAT to help the province understand the degree to which its existing programs could enhance the capacity of producers to cope with greater DEM stress in the future. It is flexible and does not require detailed climate projections or vulnerability assessments in order to be applied.
- The Manitoba Sustainable Agriculture Practices Program and the Environmental Farm Plans program were found to positively contribute to both planned and autonomous adaptive capacity. Of these two programs, the Environment Farm Plans program is best designed to support adaptation to unplanned events as it promotes networking between producers, MAFRI and agricultural specialists.
- AgriInsurance could be vulnerable to the greater demand imposed on it by the impacts of climate change. As well, none of the programs reviewed help to build the infrastructure needed to reduce vulnerability.
- While the programs contained a good mixture of policy instruments and were partially decentralized to facilitate adaptation, there was a lack of coordination between programs that would enable the sharing of best practices and innovations.

Recommendations:

- Consider use of the Adaptive Policy Analysis Tool in assessing the contribution of a broader array of provincial policies and programs to building adaptive capacity.
- Undertake more detailed analysis of the adaptation-relevant actions identified in each program assessed to better understand their effectiveness. While the APAT is able to highlight which components of a program are supportive of planned and autonomous adaptation, it is not designed to assess the degree to which these components are being effectively delivered (Swanson, 2011).
- Use a scenario analysis approach to better understand the potential vulnerability of Manitoba's crop insurance program to climate change and identify potential strategies for increasing its robustness (Swanson, 2011).
- Strengthen producer associations and extensions services in order to better facilitate the sharing of best practices and innovations—thereby enhancing adaptation decision making (Swanson, 2011).

- Examine the potential benefits associated with further decentralizing delivery of the AgriStability program given its potential positive contribution of this devolution of responsibility to enhancing adaptive capacity (Swanson, 2011).
- Assess existing formal review processes within the different programs examined to better understand their capacity to consider and react to the challenges and opportunities arising from future increases in the occurrence of DEM events (Swanson, 2011).

Appendix 3: Summary of Activities under Theme 3 – Terrestrial Workshops

Climate change is likely to stress Manitoba's forests and grasslands, with negative effects for the timber, forage and agriculture sectors. Through the PRAC, Manitoba Conservation and Water Stewardship's Climate Change branch worked with the Forestry branch and MAFRI to begin to address these challenges.

A3.1 Vulnerability Assessment of the Sandilands Provincial Forest

To strengthen understanding of the vulnerability of Manitoba forests to climate change, the Forestry Branch of MCWS, in conjunction with the SRC, conducted a pilot vulnerability assessment of the Sandilands Provincial Forest. The assessment aims to detect sensitivities and identify vulnerabilities to climate change, as well as develop potential adaptation options. A key component of the study is the development of climatic scenarios by SRC that are being used to assess current and future sensitivities and adaptive capacity.

Main activities:

In the first phase of this project, the SRC developed and summarized climate scenarios for the Sandilands region. The data include maximum, mean and minimum temperature and precipitation, and was categorised both seasonally and annually. The study looked at four time periods, ranging from the latter part of the twentieth century to the end of the twenty-first century (e.g. 1971 to 2000, 2010 to 2039, 2040 to 2069 and 2070 to 2099).

In the current phase, using the Canadian Council of Forests Minister's *Guidebook for Assessing Vulnerability* (2011) as a framework, the pilot will explore potential adaptation options, and develop tools and processes for conducting future vulnerability assessments of other forests in Manitoba. The assessment is near completion, and a report will be released identifying adaptation options for the area, as well as recommendations for future assessments in the province. Current plans are also underway for the Manitoba Model Forest to conduct a vulnerability assessment in eastern Manitoba using the same protocol with the participation of local First Nations Communities.

Key Findings:

- A full vulnerability analysis has not yet been conducted, but results to date suggest that the forest is likely to be increasingly vulnerable to drought, forest fires and insect outbreaks due to climate change. This could have a negative impact on the commercial, ecological and recreational uses of the forest.
- The CCFM Guidebook has thus far proved to be a useful tool for structuring the vulnerability assessment process. The Forestry Branch is likely to continue to use this tool for future vulnerability assessments of Manitoba forests.

A3.2 Vulnerability and Adaptation Options for Grasslands Management

To find effective adaptation strategies for grasslands and rangelands, MAFRI led the implementation of two PRAC activities:

- Assessments of the vulnerability of Manitoba to climate change and potential options for reducing this vulnerability, as described below, and
- Engagement of MAFRI and other partner departments in efforts to determine how best to integrate adaptation considerations into its planning processes, as described in section A3.3.

To better understand the vulnerability and adaptation options of Manitoba's grasslands to the impacts of climate change, MAFRI engaged the Saskatchewan Research Council (SRC) to undertake two studies:

- An assessment of the vulnerability of Manitoba's grasslands to the impacts of climate change; and
- Identify options for adapting to climate change within the agricultural sector.

The first of these studies was completed in 2010-2011, and implemented in partnership with Alberta and Saskatchewan. The second project was undertaken in 2011-12 specifically for MAFRI.

Main activities:

The **vulnerability study** undertaken by SRC sought to understand the vulnerability of native grasslands in Alberta, Saskatchewan and Manitoba's Prairie Ecozone to the impacts of climate change. The study included a review of relevant literature, and the development of ecoclimatic models for the Prairie Ecozone to project potential shifts in native grassland zonation. For the modelling component, the project built upon and refined previously developed models for projecting the impact of climate change on Prairie grasslands and the zonation of grassland types under different climatic conditions (Archibald, 2011). Refinements included recalibration of the different models to use a common set of data derived from Canada and the United States, the use of finer-resolution data surfaces, and the latest available GCMs (Archibald, 2011; Thorpe, 2012a). Through this process, a model was created that provided guidance on how grassland production might be altered by climate change, and therefore the future availability of forage (Thorpe, 2012a).

In the **review of adaptation options** study, SRC provided an overview of current understanding of climate change adaptation, highlighting the difference between: "resistance" to climate change, in which short-term actions are undertaken at the local level in response to adverse climate events; "resilience" to climate change, in which actions are taken in the medium-term to return a disturbed system to its previous state; and "responding" to climate change, in which actions are taken in anticipation of the likely impacts of climate change, rather than resisting the change. Potential types of adaptation options in the agricultural sector were then identified, including technological approaches, changes in management, financial measures and integrated actions. Options for range management

were also noted, including those that resist change (e.g. changing feeding practices), those that build resilience to change (e.g., rangeland management practices), and those that respond to change (e.g., increasing management flexibility). SRC's work continues by examining adaptations related to wetland (e.g. integration into wetlands planning; greater conservation and restoration; and improved information management) and biodiversity (e.g., integration into biodiversity planning; enhancing protected areas; reducing threats such as pollution, fragmentation and invasive species; better information management; improving landscape connectivity; and assisted migration) (Thorpe, 2012b).

Based on this literature, a summary of adaptation options for grasslands management were identified and characterized in terms of whether they were short-term (resistant), medium-term (resilience) or long-term (responding) actions, and whether they were undertaken by producers and/or government. Examples include:

- *Short-term options*: reducing the size of the herd by either culling or the sale of yearlings (by producers) and forage insurance programs (by government);
- *Medium-term options*: sustainable grazing management to increase the health and productivity of the rangeland (by producers); provision of reserve grazing through community pasture programs; and protecting stockpiled feed from wildlife (by producers and government).
- *Long-term options:* producers and government can increase their awareness of climate change risks; promote improved health of rangeland resources in order to keep future options open; and ensure conservation of native prairies.

Public policies in the United States and the Canadian Prairies related to climate change and grasslands were then briefly described.

Key findings:

Key findings from the **vulnerability assessment** of native grasslands in the Prairie Ecozone revealed:

- Even in the coolest climate scenarios, some changes in the distribution of native grasslands are likely to occur. A northward shift in vegetation zones is expected to occur, with climatic conditions in Canada becoming suitable for the establishment of grassland ecosystems presently found in the United States. However, a lag in the migration of species into these vegetation zones is expected. As a result, there is uncertainty regarding the future composition of grassland ecosystems within the Great Plains and Prairies (Archibald, 2011).
- The zonation modelling does suggest that climatic conditions will become suitable for the following events to occur should other enabling factors (e.g. soil conditions) be present:
    - Fewer trees in areas current classified as aspen parkland and southern boreal forest, and reduced encroachment by woody species into grasslands (potentially opening up new rangelands);
    - Growth in species that depend on grassland and reduction in those that depend on forest cover, including migration of species up from the United States;

  - An increase in short grasses and a reduction in mid grasses;
  - Greater presence of warm-season (C4) species and few cool-season (C3) species;
  - Creation of new communities as species migrate at different rates (Archibald, 2011).

- Average grassland productivity is projected to decrease. However, even in warm, dry climate scenarios, a decrease in production is projected to be moderate (Archibald, 2011; Thorpe, 2012b).
- Changes in average production will likely be of less concern that the potential for changes in the frequency and duration of extreme weather events, particularly drought. Should the frequency of drought increase, a greater number of years of low productivity could occur along with a shift in the composition of the grasslands towards shorter and earlier-growing species (Archibald, 2011; Thorpe, 2012b).
- Climate change is likely to lead to the loss of wetlands, and therefore to habitat for waterfowl and other species (Archibald, 2011; Thorpe, 2012b).

Key findings from the **review of adaptation options** study include:

- Many current policies support efforts to resist and build resilience to climatic risks in the short- and medium-term, but few address the long-term need to proactively adapt to the impacts of climate change (Thorpe, 2012b).
- Measures that increase adaptability over the long-term to climate change can be mainstreamed into current programs and policies, such as: maintaining the health of grassland systems through promotion of sustainable grazing practices and control of invasive species; and greater conservation of existing grassland ecosystems and wetlands (Thorpe, 2012b).
- As considerable uncertainty remains regarding how climate change will manifest itself and, in turn, its impacts on grassland ecosystems, it is important to have monitoring systems in place to detect directional changes. Adaptive management practices that respond to the information gather through monitoring efforts are also required (Thorpe, 2012b).
- There will eventually need to be the introduction of efforts to help southern species to move northwards, either through the creation of corridors by linking together currently fragmented habitats or by "assisted migration" (Thorpe, 2012b).
- Ongoing research is needed regarding projected climate change and its potential impacts (Thorpe, 2012b).

Recommendations:

- Use the list of adaptation options identified by SRC to assess whether existing programs and policies support their implementation, could be expanded to better support adaptation efforts, identify critical gaps in current actions, and develop plans for filling these gaps (Thorpe, 2012b).

- Mainstreaming climate change considerations into existing programs is likely the way that progress on preparing for climate change will occur, but there will also need to be the launching of new initiatives to support long-term adaptation (Thorpe, 2012b).
- To ensure adaptive capacity over the long-term, promote ecosystem conservation efforts to ensure that remaining native prairies and wetlands are maintained, expanded and migration corridors established (Thorpe, 2012b).
- Provide incentives for actions that facilitate the building of adaptive capacity, such as the provision of Ecological Goods and Services, agriculture extension, and the maintenance of community pastures and Crownlands (Szumigalski, 2012b).

A3.3 Integration of adaptation into MAFRI's planning processes

The third initiative undertaken in Manitoba as part of the PRAC's Terrestrial Theme was an exploration of the best process for integrating adaptation considerations into MAFRI's planning processes. This component focused on testing the applicability of the Adaptation Framework, a risk-based climate change action planning framework developed for Alberta Sustainable Resource Development (ASRD) by Deloitte. A series of workshops was initiated by MAFRI to test the utility of the ASRD framework for future application. Feedback on experience with use of the tool was collected to better align the vulnerability assessment process and planning framework with the Manitoba context.

Main activities:

MAFRI conducted three workshops to: raise awareness about the potential impacts of climate change on the forage and beef sections; demonstrate and apply the ASRD Adaptation Framework; and better understand existing and potential adaptation options. Each of these workshops took place in Winnipeg and was developed in partnership with Deloitte. The workshop series built upon the outcomes of an initial inter-departmental workshop held in November 2010, "Workshop on Climate Change Adaptation." Bringing together representatives of MAFRI, MCWS and MLG, the workshop's purpose was to demonstrate the ASRD Adaptation Framework decision-making tool and provide a preliminary assessment of its potential application in Manitoba. This assessment focused on its applicability for adaptation of grasslands and forests in Manitoba's Parkland Region (MAFRI, 2012b).

The first of MAFRI's workshops, "Agricultural Climate Change Adaptation Workshop," was held on November 30 and December 1, 2011. The workshop was designed to: "(1) create awareness regarding climate change and the potential impacts on agriculture, and more specifically the forage and grassland sectors; (2) demonstrate and apply a risk-based climate change adaptation planning framework; and (3) allow participants to assess the use of the framework for applications within MAFRI" (MAFRI, 2012a: 38). During the workshop, information was presented on projected temperature and precipitation trends in Manitoba and the potential impact of these trends on forage, grasslands and crop production. An overview of the Adaptation Framework developed for ASRD was also given by Deloitte. Workshop participants were then given an opportunity to pilot use of the Adaptation Framework in order to better

understand MAFRI's organizational vulnerability to climate change, and to identify potential adaptation options for the forage and beef sectors (MAFRI, 2012a).

On February 1, 2012, two half-day workshops were held to further the outcomes of the first workshop. In the morning session, representatives of MAFRI, producer groups, academia and conservation groups came together to build on the feedback received during the November 2011 workshop. The " Exploring Options for Manitoba's Forage and Beef Sectors to Adapt to Climate Change" workshop sought to: "(1) create awareness among stakeholders in the forage and beef sectors regarding impacts that may result from climate change; (2) obtain feedback from stakeholders on additional climate impacts they are currently observing in the forage and beef sectors; (3) allow stakeholders to share ideas on the risks faced by the forage and beef sectors resulting from climate change; (4) communicate and discuss potential adaptation options to minimize these risks; and (5) provide stakeholders with the opportunity to identify additional adaptation options and discuss how MAFRI could support these adaptation options" (MAFRI, 2012b: 66). It began with presentations on projected future changes in Manitoba's climate, potential impacts on the province's forage and grasslands sectors, and possible adaptation options. Participants then discussed current climate impacts and risks in the forage and beef sectors, and risk management strategies that they are currently using. Outputs of the workshop included a list of current climate impacts, potential risks, and potential climate risk management options (MAFRI, 2012b).

In the afternoon session, MAFRI and MCWS staff involved in adaptation planning met to discuss to summarize the outcomes of the previous workshops. During the meeting, participants were introduced to the different type of adaptation strategies governments have developed in different countries and provinces; informed of the steps through which an adaptation strategy might be developed; reviewed the progress MAFRI had made on the development of its internal Climate Change Adaptation Strategy; and identified next steps for MAFRI's and Manitoba's climate change adaptation strategies (MAFRI, 2012c).

Key findings:

- Adaptation is recognized as being a priority for MAFRI, and an action that needs to be undertaken in collaboration with other provincial departments (Szumigalski, 2012b).
- Adaptation options for the forage and beef sectors identified by participants during the November 2011 workshop focused primarily on water management and the identification of long-term adaptation options that will minimize the use of Business Risk Management" programs (MAFRI, 2012b).
- To inform decision-making, further research is needed regarding projected climatic changes and potential impacts, including impacts on water resources (Szumigalski, 2012b).
- Further research is needed into MAFRI's existing policies and programs, to discover their adaptive potential, identify gaps in service provision in the context of climate change, and ensure the absence of unintended consequences and barriers (Szumigalski, 2012b).

- The Alberta SRD framework is not ideal for Manitoba's adaptation planning purposes. The framework is too technically intense, does not provide quantitative results, and it is difficult to relate the process to the departmental objectives and timeline using this framework. In addition, the vulnerability and risk assessments developing using the SRD framework did not build off each other. As such, the risk statements that were developed did not appear to capture all the issues of the various sectors being evaluated.[23]
- A barrier to effective adaptation is the current emphasis on short-term decision making and the limited support for proactive, long-term planning (Szumigalski, 2012b).

Recommendations:

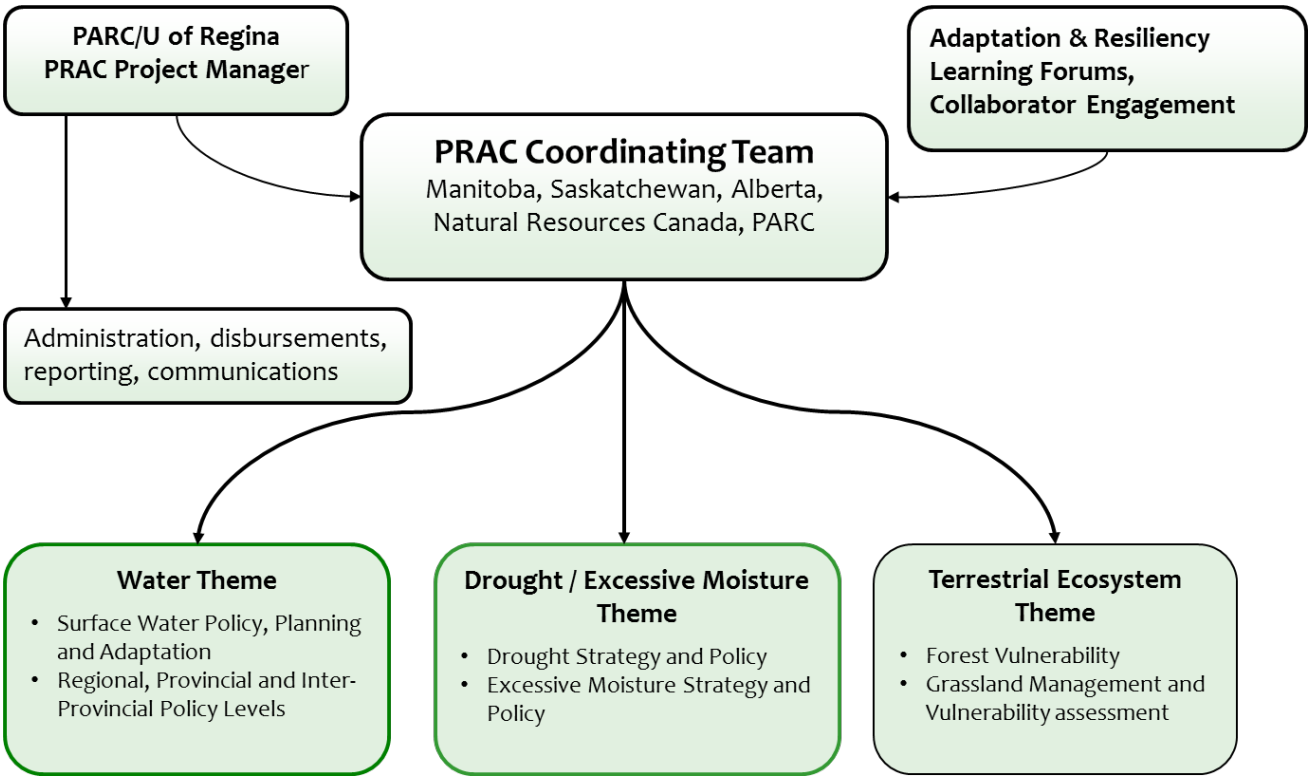
- MAFRI (along with other provincial departments) may decide to engage in adaptation planning using a tool more suited to its needs than the one developed for ASRD.[24]
- Establish an inter-departmental adaptation working group to ensure coordination, collaboration and knowledge sharing across departments (MAFRI, 2012c).
- Consider establishing a provincial adaptation framework into which adaptation strategies developed by individual departments will be integrated in a coordinated manner (MAFRI, 2012c).
- Communicate to departmental executive management committees the need to make adaptation to climate change a provincial priority, and secure sufficient funding to continue work in this area (MAFRI, 2012c).

[23] Personal communication, MAFRI representative, December 2011.
[24] Personal communication, MAFRI representative, December 2011.

Appendix 4: Governance Structure for the PRAC

The PRAC's Governance Structure is presented in Figure 1 below.

Figure 1: Governance structure of the Prairies Regional Adaptation Collaborative



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