IACC

INSTITUTIONAL ADAPTATIONS TO CLIMATE CHANGE PROJECT

INTEGRATION REPORT

THE CASE OF THE SOUTH SASKATCHEWAN RIVER BASIN, CANADA

ACKNOWLEDGEMENTS

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INSTITUTIONAL ADAPTATION TO CLIMATE CHANGE PROJECT

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ABOUT THE INSTITUTIONAL ADAPTATIONS TO CLIMATE CHANGE (IACC) PROJECT

The International Adaptations to Climate Change project is a collaborative, multidisciplinary research initiative that integrates scientists, government and non-government organizations, communities and other stakeholders in the research process. The goal of the project is to develop a systematic and comprehensive understanding of ❶ the capacities of institutions to formulate and implement effective adaptation strategies to manage climate change risks; and ❷ the impacts of climate change on the supply and management of water resources in the South Saskatchewan River Basin in Canada and the Elqui River Basin in Chile. This comparative study aims to influence policy by generating concrete recommendations as to how institutions can reduce climate change risks and maximize opportunities in rural communities that are simultaneously experiencing changing social and economic conditions.

IACC

EXECUTIVE SUMMARY

Expected changes in climate will create new risks for rural communities in the South Saskatchewan River Basin (SSRB).

▲ Storm approaching a wheat field in Saskatchewan. © Željko Radojko —*Fotolia.com*

These risks are largely due to increasing shifts between drought and periods of wetness on a year-to-year basis, as well as from social conditions in the communities that affect their ability to adapt to these changes. The IACC project gauges the abilities of institutions to create and implement effective strategies to address these risks in the SSRB in Western Canada and the Elqui River Basin (ERB) in Northern Chile. This document reports the main findings of the studies done by the IACC researchers in the SSRB.

Vulnerability assessments conducted in several of the basin's rural communities revealed that they are sensitive to a variety of climate events that could have negative impacts on their livelihoods. This vulnerability is compounded by sensitivities to global market changes and shifts in policy. Communities have developed various strategies to deal with these stresses, but the existing adaptive capacity and the degrees of exposure and sensitivity experienced in the region have been shaped considerably by the strengths and weaknesses of governance networks.

Climate change scenarios for the SSRB predict increases in temperatures and precipitation. Although the overall change in temperature would create a longer growing season, cold winters that kill off many pests and diseases and store water as snow would be lost. As the climate warms, most of the extra precipitation is expected in winter and spring and increasingly in the form of rain. While a shift to warmer, wetter winters and drier summers is almost certain, most of the risk from climate change will be related to an increase in the year-to-year variability, alternating between prolonged and frequent periods of drought and occasionally extreme wet conditions.

The existing adaptive capacity of communities and governance networks has several challenges that need attention before they can deal with these future climatic conditions. More robust, integrated, and anticipatory approaches are needed to reduce climate risks and maximize opportunities.

INSTITUTIONS CAN HELP BUILD ADAPTIVE CAPACITY TO CLIMATE-INDUCED STRESS BY UNDERTAKING THESE RECOMMENDATIONS

- Develop anticipatory, long-term (10–20 year) climate and water plans that build resilience to climate change
- Integrate government and community adaptation activities
- Use participatory planning and empower stakeholders and citizens in water management decision-making
- Improve the dialogue between government and communities, particularly rural communities, to build local resilience and seek new opportunities
- Focus efforts on improving local and regional coping capacities
- Prepare for water conflicts: resolve issues using adaptive conflict resolution methods
- Obtain and share more and better water data
- Seek solutions with interdisciplinary teams using social and physical sciences approaches and coordinating with stakeholders and policymakers
- Simplify water governance arrangements for efficient and effective adaptation decisions

INSTITUTIONAL ADAPTATIONS TO CLIMATE CHANGE PROJECT

INTEGRATION REPORT—THE CASE OF THE SOUTH SASKATCHEWAN RIVER BASIN, CANADA

The near-term inevitability of climate change has become part of both the scientific consensus and the political mainstream.

◂ A faint rainbow peaks through menacing clouds during an afternoon of sunshine and thunderstorms on the plains of Saskatchewan, Canada. —*iStockphoto*

Climate data and models show that the Canadian Prairies have warmed even more quickly than the rest of the globe, and projections for the future strongly suggest warmer, wetter winters and hotter, drier summers. Although the overall change in temperature will create a longer growing season, cold winters that kill off many pests and diseases and store water as snow will be lost. The warming climate will cause some extra precipitation in the late winter and spring, but the summers will be drier, with much of the rainfall coming in fewer and more intense storms. Most of the risk posed by these future scenarios is due to an increase in climate variability (i.e., generally warming trends with shifts between extended droughts and unusual wet periods on a year-to-year basis) and from social considerations, such as people's sensitivity to heat and water extremes, their dependence on specific features of heat and water supplies for their livelihoods, and the resources available to them. Institutional adaptation to these changing conditions will be crucial in facing future risks and opportunities.

The Institutional Adaptations to Climate Change (IACC) project, funded by the Social Sciences and Humanities Research Council of Canada, addresses the abilities of institutions to create and implement effective adaptation strategies in the face of these expected climate change risks. Specifically, the project examines the impacts that climate change will have on the supply and management of water resources in the South Saskatchewan River Basin (SSRB) in Canada and the Elqui River Basin (ERB) in Chile. The main objectives of the project are to identify the vulnerabilities to climate change and water scarcity in a group of rural communities in these regions, and to gauge the ability of governmental institutions to address them. These objectives are based on the idea that governance networks are as important as local resources for adaptation, because they are in charge of the use and distribution of natural resources such as water. Several research projects were undertaken to achieve these objectives:

- a group of community vulnerability assessments;
- studies of institutional roles in the resolution of water-scarcity conflicts;
- historical studies of past institutional adaptation;
- analyses of environmental vulnerabilities as identified by stakeholders and other sources;
- studies about the capacities of water governance institutions to reduce the vulnerabilities of rural communities;
- assessments of future climate scenarios and their potential impacts for the basins.

This document provides an explanation of the project where the SSRB is concerned, bringing the main results of the Canadian studies together into a single, comprehensive report.

The project's research activities have been organized around the concept of "vulnerability." For the purposes of this project, vulnerability refers to the sensitivity of a system (a rural community) to an external stimulus (changing climate and its impact), the degree of exposure to that stimulus, and the capacity of the system to adapt to the external stimulus—its adaptive capacity.

With this definition in mind, the project developed a model for assessing vulnerability that highlights the need to understand it within the context of past and present—as well as future—climate and other conditions. The model makes use of three sets of interrelated activities to achieve this: (a) coming to an understanding of the current degree of vulnerability in a system; (b) constructing future climate projections for the area where the system occurs; and (c) bringing (a) and (b) together by assessing future vulnerabilities based on how the current vulnerabilities will be affected by expected future conditions.

The structure of this report closely follows the vulnerability assessment model (see Figure 1). The first section describes what researchers learned about the past and present exposure-sensitivities and adaptive capacities of rural communities in the SSRB, particularly those provided by governance institutions. The second section discusses some expected climate changes and their impacts, while the third section discusses the potential vulnerabilities of the future and presents a list of recommendations to deal with them.

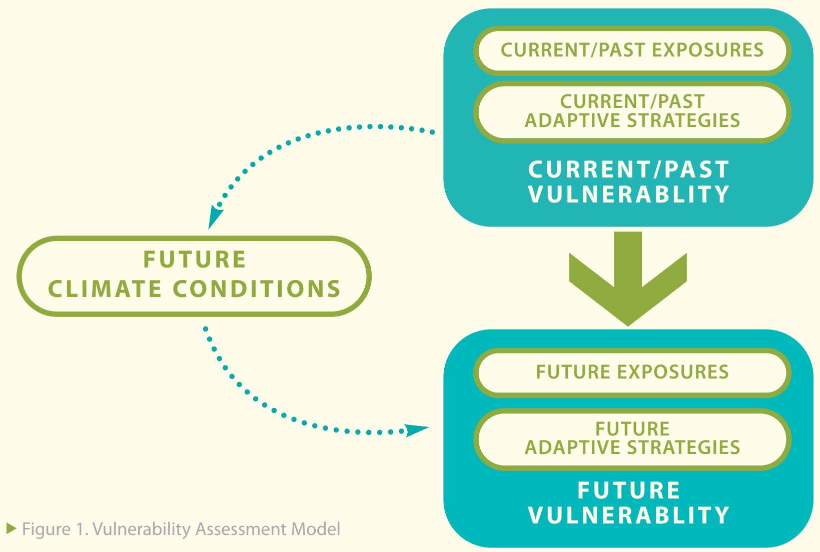


Figure 1. Vulnerability Assessment Model

Castle River basin, southwest Alberta. —D. Sauchyn

PAST/PRESENT DROUGHT AND OTHER CLIMATE-RELATED EXPOSURES AND SENSITIVITIES

Covering about 166,000 square kilometres across three provinces, the SSRB's climate is influenced by its location.

With the Rocky Mountains blocking the moderating influence of the Pacific Ocean in the west, most of the basin has a "continental" climate, meaning that it has short, hot summers, long, cold winters, and generally low levels of precipitation with high summer evapotranspiration (the combined processes of evaporation, sublimation, and transpiration of the water from the earth's surface into the atmosphere) accelerated by high winds. As a result, the region is dependent on the runoff of melted snow from the eastern slopes of the Rockies to feed its rivers and streams. The Palliser Triangle is the driest part of the Canadian Prairies and is characterized by large average water deficits on a yearly basis. The amount of precipitation that falls

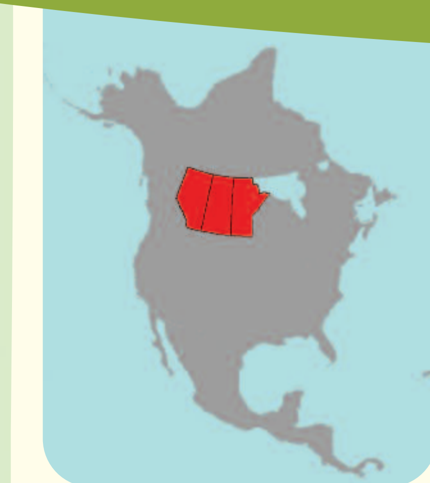
Map 1. South Saskatchewan River Basin study communities and the Palliser Triangle.
— Map by J. Pittman

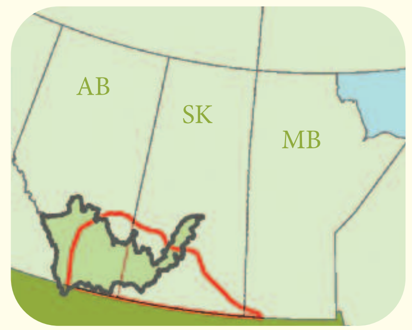
is generally much lower than the potential for evapotranspiration.

The six rural communities chosen for the community vulnerability assessment—Kainai Blood Indian Reserve, Taber, and Hanna in Alberta; and Cabri, Stewart Valley, and Outlook in Saskatchewan—all lie within the Palliser Triangle (see Map 1). Although they all share an economic base in agriculture, they are diverse in important ways. Taber and Outlook are heavily reliant on irrigation, while Cabri and Stewart Valley are surrounded by agricultural dryland and require the right amount of precipitation at the right time of the year. Hanna is also in a dryland area, largely used by ranchers, while the Kainai Blood Indian Reserve shares many of the unique challenges that First Nations communities face.

Some of the exposures and sensitivities identified in the community vulnerability assessments are:

- Chinook winds can raise winter temperatures in a short time. These thawing cycles cause problems for managing moisture in both livestock and crop farming.
- Winter cold snaps control insect infestations. For ranchers, low temperatures in late winter and early spring can result in pneumonia among newborn calves.
- Temperatures during a snow melt is an issue for farmers and ranchers: if the melt is slow and gradual, soil moisture will build up, but if it is coupled with low snow accumulation, it may increase the risk of insufficient replenishment of stock water ponds reliant on snowmelt.
- Sufficient warmth and adequate moisture is necessary for crops to be successful. After seeding, if it is cold and dry the seed will lay dormant, and if it is cold and wet the seed might become incapable of any growth at all.





- Too much heat can also be a problem, particularly for dryland farmers. Temperatures above 30°C dramatically increase the moisture requirement of crops. Also, hot summer days leading to thunderstorms that bring hail can affect all agricultural producers, while high winds can damage crops and property.
- Crops and pastures need moisture throughout the growing season at different times. Ranchers need moisture early in the season for the production of hay, while crop producers need moisture throughout the growing season.
- Early fall frosts can be problematic for both dryland and irrigated farmers because it can damage vegetables and affect the quality of the crop.
- Water scarcities always pose a significant problem but the effects are more dramatic during periods of drought. Droughts affect water supply to the regional population and may cause harmful effects on soil and ecosystems.
- Too much precipitation can cause serious problems for rural people as well. For farmers, too much rain can lead to crop losses and other damage. Intense rain or rapid snowmelt can cause flooding and become a major hazard.
- Surface and groundwater quality and quantity is problematic for rural people. Chemicals from agricultural and industrial activity, as well as sewage, storm water runoff and other biological contaminants can affect water resources and aquatic ecosystems.
- Two stressors present globally—the international market and extreme climate events (primarily drought), along with government measures—are the greatest contributors to the vulnerability of rural people. The interplay between these large-scale global stressors and local climate and weather is an important determinant of their vulnerabilities (See "The Exposures/Sensitivities of Rural Communities," page 28).

Vanguard, Saskatchewan.—*D. Sauchyn.*

PAST/PRESENT INSTITUTIONAL ADAPTATIONS

Throughout history, the rural people of the SSRB have constantly had to adapt to sources of risk, and climate is one of them. A variety of practices, processes, systems, and infrastructure have been attempted and taken on by communities to reduce climate-related risk and to create new opportunities. Accumulating assets, relocating human resources, diversifying income sources and crops, redefining land use, using new crop varieties, harvesting water, adopting new technologies, building irrigation and flood control infrastructure, and using kinship and local community social networks are some of the innovations that the IACC project has identified (See "Past and Present Institutional Adaptations," section 1, page 31).

The local adaptive capacity has been shaped to a large degree by wider decision-making frameworks, especially governance networks at different levels. Processes for dealing with adaptation have been continuous since the dawn of the twentieth century, and have been characterized by steady improvement in the management policies and practices that have shaped the capability of rural people to adapt. The processes have at times been slow and in many cases they have simply reacted to

Wheel move irrigation system in the Frenchman River Valley, southwest Saskatchewan.—*D. Sauchyn*

crises (e.g., major droughts), but their increasing effect has facilitated the development of institutional capacities to deal with the expected variability in climate. The IACC studies demonstrate the impacts of these processes, with their own strengths and weaknesses, on the ability to deal with climate conditions such as drought.

The study of water-related conflicts and the role that institutions have played in their resolution provided an opportunity to assess how the impacts of these conflicts can increase or decrease the exposure and vulnerability of affected groups. The adaptive capacity of communities and water governance institutions can be enhanced when the lessons learned in these studies are acted upon effectively and meaningfully.

The historical studies do the double duty of exposing weaknesses in the institutional framework and helping to develop innovations that address them. Two early-twentieth-century drought crises in the SSRB illustrate this lesson: 1) the drought in south-eastern Alberta that preceded the Great Depression; and 2) the drought after 1927 that covered almost all of the Palliser Triangle.

Starting in 1917, the Dry Belt (see Map 1) suffered through ten consecutive years of drought, heavily damaging the large specialized wheat growers. This first crisis revealed the weaknesses of the settlement pattern in the Prairie Provinces, including the federal government's encouragement of grain farming in the driest locations of the SSRB after 1909. It also exposed the weak and divided structure of local government. The major institutional innovation that came out of this crisis was the establishment of the Special Areas Board in Alberta, which sought a shift to a system of land tenure capable of dealing with the risks of severe and recurrent drought. The change in land tenure was complemented with the establishment of a larger administrative authority, which has advantages over small, fragmented municipalities in terms of assisting the adjustment to drought, particularly where an overall shift in land tenure was needed. The creation of the Special Areas Board remains a popular decision to this day—the people of the region recently voted to keep the Board structure rather than switch to a democratically elected rural government, despite the fact that a major drought like the one that hit in the interwar years has never recurred.

The second major water scarcity crisis—the prolonged drought that covered most of the Palliser Triangle from 1928 until 1939—revealed the critical vulnerability of the small, fragmented government structures found throughout the SSRB. It also exposed the potential weakness of provincial governments acting in isolation from each other and from the federal government. Relief was the most common and expensive institutional response to the disaster. Despite many difficulties, collaboration between the federal and provincial governments in distributing relief likely prevented wholesale starvation in the SSRB, illustrating the importance of inter-governmental and inter-agency co-operation. Numerous institutional measures have been developed in the intervening decades to ensure secure and reliable access to water in periods of scarcity:

- The *Prairie Farm Rehabilitation Act* was passed in 1935, and the activities outlined in the Act were organized under the Prairie Farm Rehabilitation Administration (PFRA) in 1937. From its inception PFRA provided technical support, research and funding for soil and water conservation, land use practices, and on-farm and rural water development projects.

- There has been significant investment in irrigation infrastructure and technology, which has always been perceived as a significant adaptation of agriculture in drier regions such as the SSRB. At the present time, Saskatchewan has about 11% and Alberta well over 60% of Canada's irrigated land.

- The Prairie Provinces Water Board (PPWB) was created in 1948. The PPWB operates under a formal relationship between Manitoba Environment, Saskatchewan Watershed Authority, Alberta Environment and the federal government represented by Environment Canada and the former PFRA. The PPWB oversees the sharing agreement on river water flow among the Prairie Provinces. Overall, the agreement provides some security on both the quality and the equitable sharing of surface water.

- Federal and provincial governments have established safety net programs that reduce the negative impacts of unpredictable weather conditions on farmers and ranchers. By 2002 there were several federal programs to help lessen drought impacts; however, the limitations of these programs were demonstrated in high costs and stakeholder dissatisfaction during the 2001 – 2002 droughts.

- Recently the region has seen the development of new institutional water governance systems aimed at improving the management of water resources. In Saskatchewan the new system was organized around the *Safe Drinking Water Strategy* of 2002. In Alberta the new institutional development was organized around the *Water for Life Strategy,* created in 2001.

- The integration of civil society into the governance of water resources was linked with the creation of new institutional systems in Alberta and Saskatchewan. In both provinces local organizations and members of the community are participating in watershed councils or committees, and engaging in the development of water plans (e.g., protection of water supplies).

- Finally, there has been a significant increase in institutional research in water resource and climate change areas within the SSRB. This increasing production of knowledge is fundamental to understanding vulnerabilities and impacts and for developing capacities to deal with them, but it still needs to be integrated into governance policies, management, programs, and practices. (See "Past/Present Institutional Adaptations," section 2, page 32).

These institutional developments have helped rural communities, farmers and ranchers by strengthening their necessary adaptive capacity to deal with past and present climate variability and to some extent with the extremes of that variability. However, several institutional challenges need to be addressed to improve this adaptive capacity and build more resilience to deal with future climate changes. Some of these challenges were identified in the assessment of rural communities and water governance networks of Saskatchewan and Alberta. Existing challenges include:

1. *Distribution of adaptive capacity:* The community vulnerability assessments demonstrate that resources are unevenly distributed. The Kainai Blood Indian Reserve is the most vulnerable, due to the particular conditions often found in First Nation communities, but other communities such as Cabri and Stewart Valley are also very sensitive to extreme climate events such as drought, due to their lack of access to irrigation and to their small, aging populations. Those communities that are most resilient have well-established water infrastructure (storage reservoirs and distribution networks) and utilize irrigation to supplement periods of low precipitation that do not meet crop water requirements. Targeted policy responses to rural communities need to consider climate impacts on several relevant areas, particularly as these relate to water, the environment, and vulnerable economic activities such as agriculture.

2. *The scope of most policy analysis and development in these communities:* Community vulnerability assessments reveal a broad array of potential harms that climate change and inappropriate institutional activity can cause or perpetuate. These include: harms to communal identities and stability; to people's sense of heritage; to cultural integrity; to informal governance systems such as First Nations clan systems; and especially to trust-based relationships. The research reports on conflict and value studies point to the need to protect "social capital," or connections between and within social networks, through such activities as allocating resources to augment community-government relations, a practice utilized by the former PFRA. The vulnerability assessments point to the need for policy and programs to consider different styles of sustainable development and new ways to relate to ecosystems and preserve the environment. New methods of program delivery should incorporate future climate scenario planning to anticipate future climate conditions and impacts on regional water supplies, with a balanced view of environmental, social and economic impacts, and ways to build local resilience.

3. *Water data availability:* The research identified gaps in water data (water quality, quantity and actual use patterns; groundwater supplies; climate data). This gap has also been emphasized in much of the relevant scientific and water management literature. Knowledge of water sources and climate impacts on surface and groundwater supplies is critical for effective water management and planning. If the status of available water resources is uncertain, it is increasingly difficult to make projections about future resilience in the face of climate change. For example, at present Saskatchewan lacks a detailed groundwater resource map. There is uncertainty about what data are available, what can be readily accessed and who is responsible for making sure that data are collected and shared. This, in theory, is a manageable problem that can be taken care of with the proper application of time, people, and money.

4. *The need for long-term planning:* While much effort has been directed towards mitigation issues, governments are still in the early stages of developing climate change adaptation plans. Many current forms of government activity assist in reducing vulnerabilities or enhancing adaptive capacity; activities could easily be reoriented to assist with improving that adaptive capacity. However, without a more intensive and collaborative strategic effort, it is hard to achieve the highest returns for climate adaptation work. This is especially important where drought is concerned. While many Saskatchewan agencies involved in water governance mentioned preliminary efforts to plan around drought, nothing of significance currently exists. A number of case-specific responses do not constitute a comprehensive plan. Not only is there a lack of planning related to the negative impacts of drought, there is little planning around the potential opportunities and benefits that drought in other regions might offer Saskatchewan residents. The lack of a drought plan is related to the absence of sufficient data, noted above. Alberta has a formal "Agriculture

▸ Barn north of Veregin, Saskatchewan. —D. McLennan

▲▲ Grain against blue sky with clouds. —D. McLennan

▲ Trail closed. —D. McLennan

▲ Livingstone Range, Oldman River basin, Alberta.
—D. Sauchyn

Drought Risk Management Plan," which is primarily concerned with short-term coping strategies at the producer level. The 2001–2002 drought, however, highlighted the need to address the larger picture of water allocation during times of surface water shortage. Long-term planning also needs to extend beyond provincial boundaries, and should consider regional approaches to achieve effective adaptation.

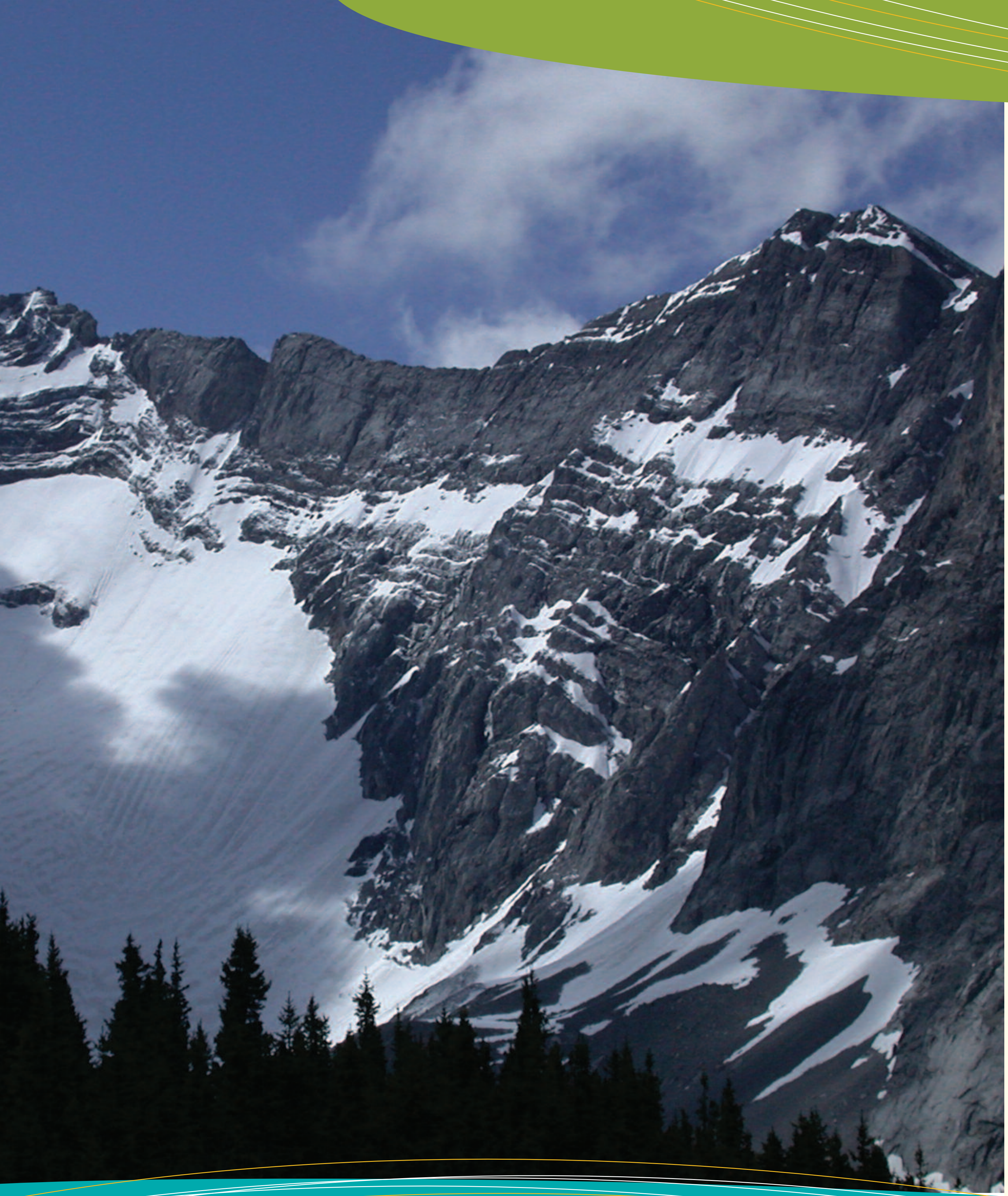
5 *The effectiveness of watershed advisory groups:* Watershed groups play an important role in increasing adaptive capacity in both provinces. They reflect the widely recognized principle that water problems and climate impacts are always local. If impacts are to be dealt with effectively, information must be gathered at the local level, and local stakeholders need to be included in the policy development and management process, as well as in the implementation of actions plans to build resilience. While the voluntary process of stakeholders may be admirable and necessary, the advisory group process is unlikely to be sustainable under the existing model. The endurance of the advisory groups is threatened by their lack of predictable funding. While there is disagreement about whether the groups should be given a regulatory and taxing capacity, their advice-giving role could nonetheless become official. Ensuring that local input is given proper consideration would provide the watershed advisory groups an assurance that their efforts are not wasted—that they represent something that goes well beyond the "appearance" of local involvement and achieves a degree of citizen and stakeholder engagement that leads to adopting best adaptation practices.

6 *Interagency coordination:* Saskatchewan's water governance and climate monitoring system suffers from duplication and a lack of coordination. Alberta is attempting to address a similar situation with the creation of a Policy Coordination Office, although little evidence of this was seen during the interviews. Lack of coordination often results in failures to identify areas needing attention because it is assumed that other agencies are looking after specific issues. Such complexity often creates confusion among government officials themselves, let alone the stakeholders and the general public.

7 *Operational challenges:* The effectiveness of water governance in Alberta and Saskatchewan is frustrated by the complexity of the water governance arrangements. Saskatchewan's rural communities and their residents are often frustrated by the need to deal with a large number of agencies and are often unsure which agencies are responsible for which aspects of water policy. Although unlikely and possibly impractical, the "one-stop shopping" or single-desk approach was suggested as a solution by a number of respondents. Water governance and management are also frustrated by the levels of funding available for delivering services to rural communities. Funding programs are sporadic, and funding availability and eligibility rules often change along with the election cycle. Rural residents and municipalities in Alberta are further constrained by the first-in-time licensing arrangements.

8 *Central resources for solving climate change problems:* Most water supply and infrastructure challenges in Saskatchewan are met by municipal governments and individual farm operators. Presently the federal Department of Agriculture's Agri-Environment Services Branch (AESB, formerly the PFRA) and SaskWater are the only senior government agencies with the experience and capacity to deliver rural water programming solutions to water-stressed communities and farmsteads. However, both face uncertain futures due to institutional rearrangements. There are questions being asked in water governance circles about the current mandates and future of these agencies. If they were to disappear or lose their capacity to provide infrastructure solutions to water problems, there would be no similar bodies in existence that could pick up the slack should a major drought occur in Saskatchewan. Their loss would represent a major reduction in the adaptive capacity of the province in the face of climate change. In Alberta, the *Water Act* provides several mechanisms for surface water shortages to be managed at the regional scale. For example, the *Water Act* includes provisions for temporary water transfers. However, past effective solutions have relied heavily on the ability of particular Alberta Environment and Alberta Agriculture employees to generate and implement solutions. Alberta's adaptive capacity to water shortages therefore rests in part on the shoulders of particular individuals, without whom the *Water Act* is unlikely to be used to its full potential.

These institutional challenges are not simply endemic to the SSRB. Rather, many of them are representative of challenges that characterize other Canadian water governance networks, as evidenced by a large number of publications that address the complexities of managing water resources in a diversified political and geographical setting.



Late lying snow on Mt. Rae, Bow River basin
—*D. Sauchyn*

Scientists have developed sophisticated global climate models (GCMs) to simulate the complex interactions that take place in the Earth's environment between the oceans, atmosphere, ice cover and land surface.

Even with the most complex models, scientists cannot precisely know the climate of the future. Rather, the models calculate the probable response of the entire system to forces such as increasing concentrations of greenhouse gases. We can put a high level of confidence in what GCMs produce because they are 1) based on the fundamental laws of physics; 2) able to simulate important aspects of the current climate; and 3) able to reproduce features of past climates and climate changes.

GCM experiments reproduce the warming experienced over the past century only when they include as input observed increases in greenhouse gases *in addition* to natural climate factors.

Of course, future greenhouse gas levels cannot be known for certain, and have to be estimated based on trends involving socio-economic activities that will diminish or accelerate their production. Minor differences in the initial conditions of the models send the simulations down different paths; therefore GCMs produce a range of plausible scenarios for climate change. The Intergovernmental Panel on Climate Change (IPCC) published 40 different scenarios that provide a broad range of possible future greenhouse gas emissions. These socio-economic scenarios, labelled SRES (Special Report on Emissions Scenarios), represent different demographic, social, economic, technological, environmental and policy prospects as emission drivers.

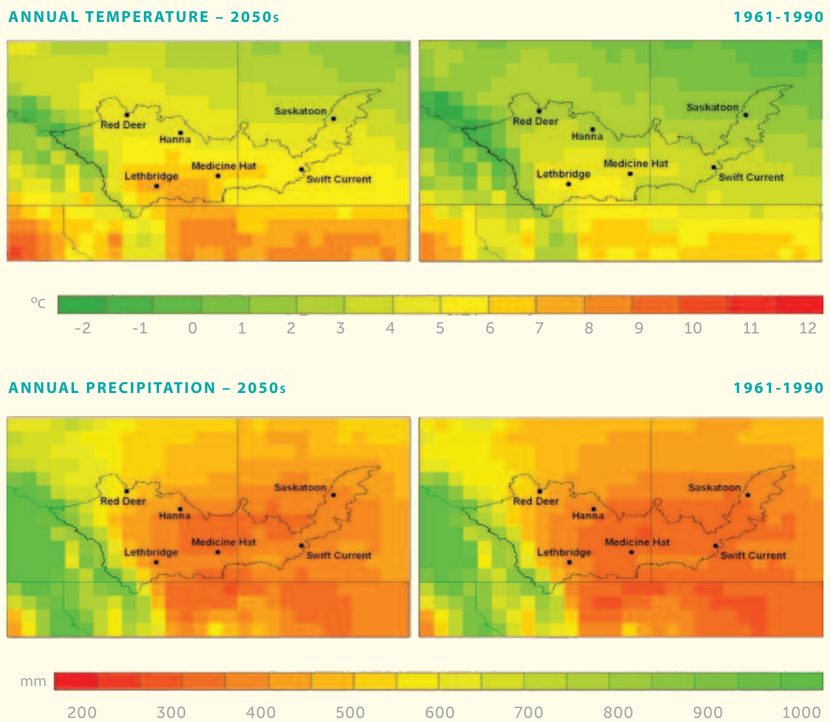


Figure 2. Annual temperature (top) and precipitation (bottom) for the SSRB. The baseline (1961–90) conditions are mapped on the right. These median scenarios were derived from the Canadian Global Climate Model (CGCM) version 3.1/T47 and greenhouse gas emission scenario B1(2).

Climate change scenarios are typically expressed as a change in average precipitation and temperature between a baseline of 1961-90 and future 30-year periods, most commonly 2010–39, 2040–69, and 2070–99. The expected difference is expressed in absolute terms by applying the differences or ratios to the 1961–90 baselines. All of the climate change scenarios for the mid-21st century suggest increased temperature and variable precipitation for the SSRB, illustrated in Figure 2. These climate changes actually favour most human activities in the basin, but the net result depends on the distribution and timing of the extra heat and water. One of the most certain outcomes of global warming for the SSRB is shorter, wetter winters and longer and for the most part drier summers. However, the surplus water that comes in late winter and spring will be lost during more days of evapotranspiration during the longer frost-free growing season.

The net result is demonstrated in Figure 3 where the difference between precipitation and potential evapotranspiration during May to July is mapped for 1961–90 as well as the three 30-year intervals in this century. The moisture deficit that naturally characterizes the SSRB expands geographically such that there is an annual moisture deficit of 150–200 mm from southern Saskatchewan across the SSRB. Five precipitation and temperature scenarios for the cities of Lethbridge, Alberta and Swift Current, Saskatchewan (used due to data availability) are presented by season and time period in Figures 4 and 5 . These plots clearly show the larger increases in minimum winter temperatures and the much more consistent increase in winter and spring precipitation as compared to the large range of possibilities in summer.

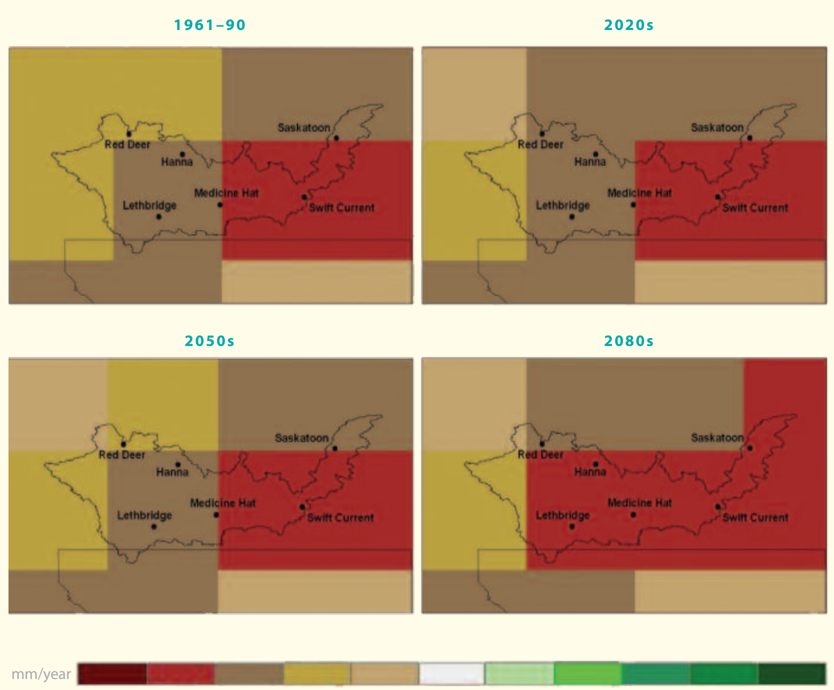


Figure 3. Median scenarios of May-June-July, Climate Moisture Index (P-PET) for 1961–90, the 2020s, 2050s and 2080s, from CGCM3.1/T47 B1(2).

The frost-free growing season is becoming longer and warmer, which could be advantageous to growing diversified, higher-value crops. On the other hand, winter is getting shorter and that means that some advantages of a cold winter will be lost. The ability of frigid temperatures to control pests and diseases will be lessened and snow accumulation, which is the most abundant, predictable, and reliable source of water, will drop off, as most of the extra precipitation expected with the warming climate will fall as rain. Most of the water in the SSRB originates as snowmelt runoff from the Rocky Mountains, and decreased runoff and a shift in timing of the flow from summer to spring will cause lower river flows in summer, which is the season of highest demand.

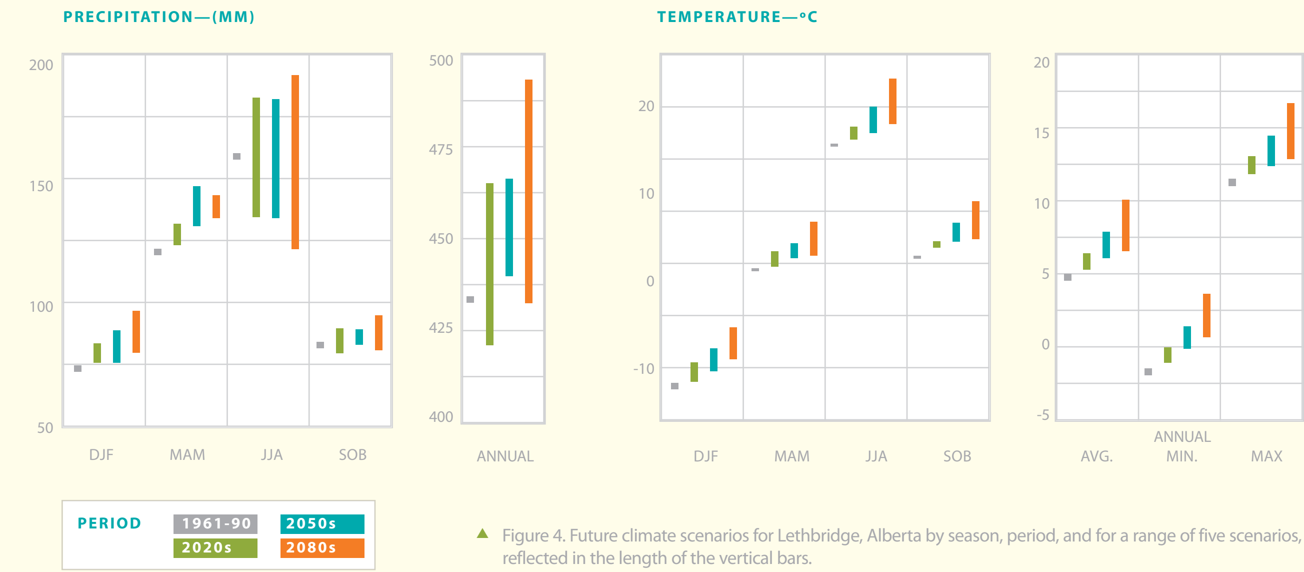


Figure 4. Future climate scenarios for Lethbridge, Alberta by season, period, and for a range of five scenarios, reflected in the length of the vertical bars.

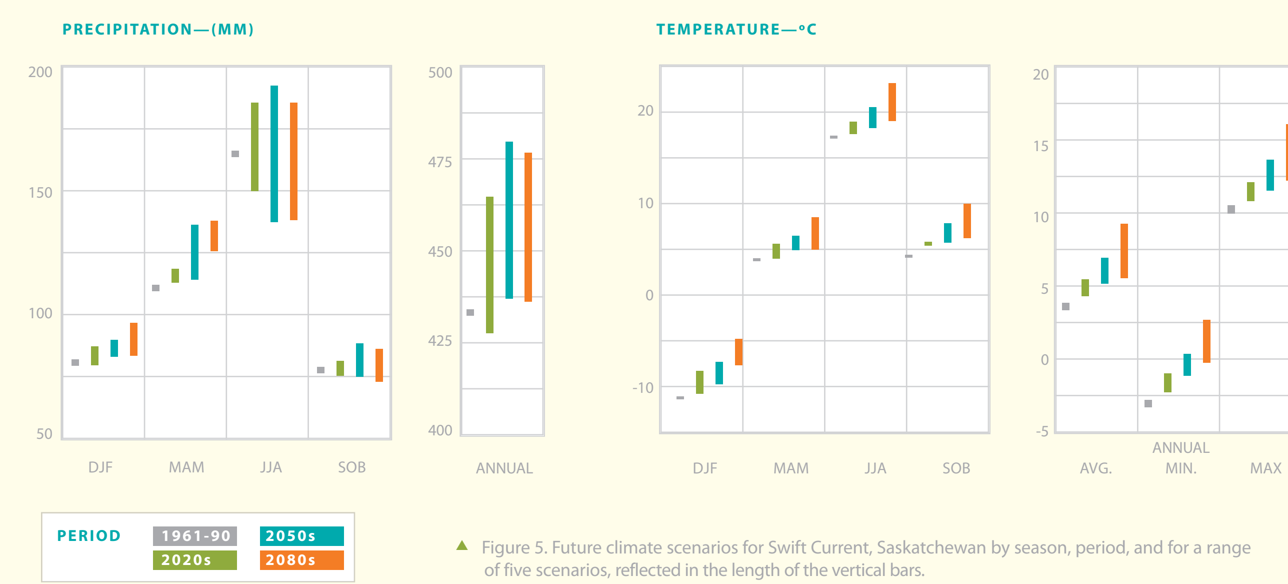


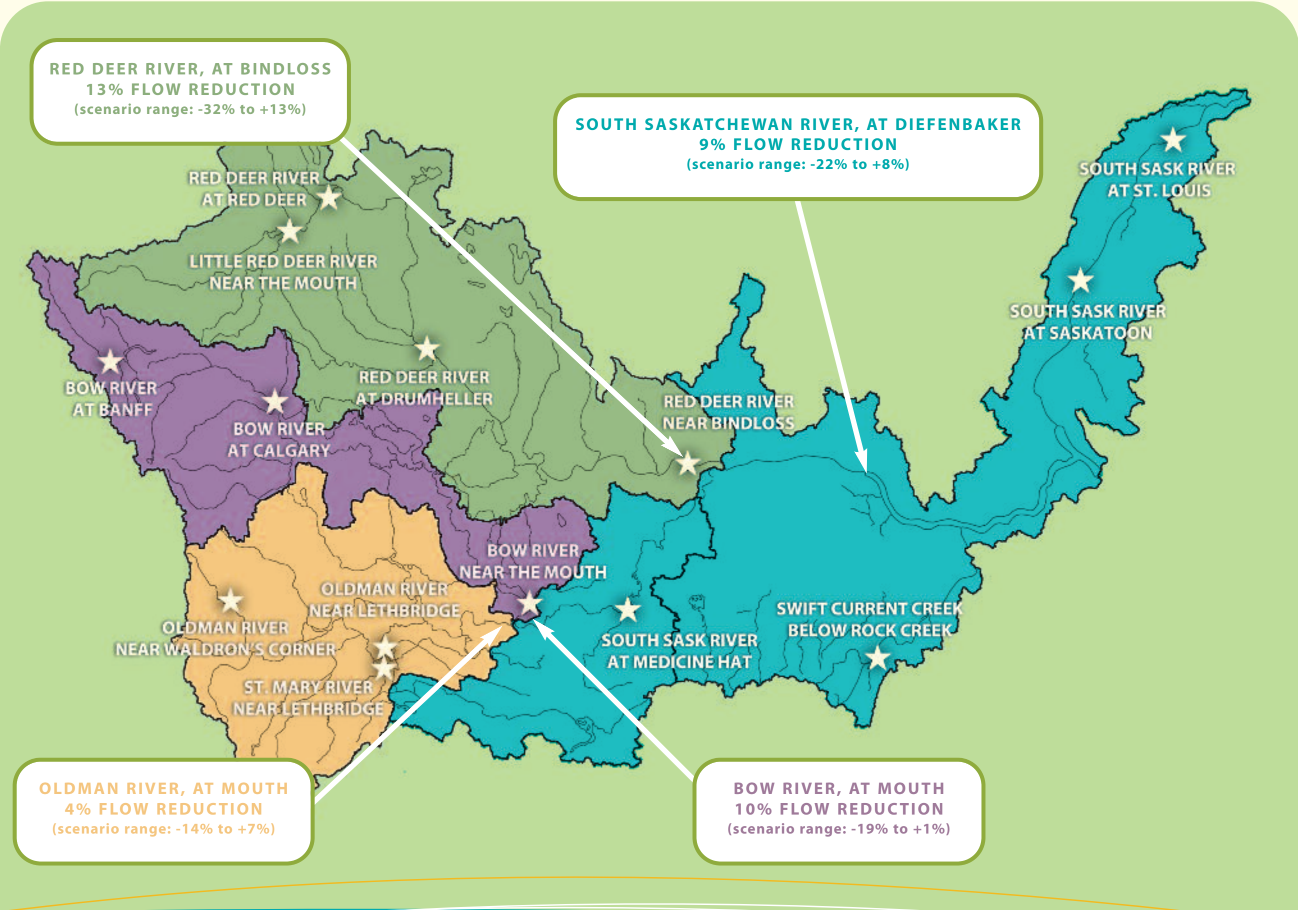
Figure 5. Future climate scenarios for Swift Current, Saskatchewan by season, period, and for a range of five scenarios, reflected in the length of the vertical bars.

Climate scenarios show flow reductions for the SSRB (see Map 2). This will result in generally drier conditions, bringing also the increased risk for long and severe droughts. Unusually wet years are also expected occasionally. While this seasonal shift to warmer, wetter winters and drier, hotter summers is almost certain, the greatest risk posed by climate change is the increase in year-to-year precipitation variability. Unusually wet years and drought years will alternate with greater severity and frequency than what occurred in the 20th century.

This variability predicted for future climate will be a result of natural climate patterns altered by greenhouse gas-related warming. Historical weather data contain detailed information on the variability of the climate on an almost daily scale; however these records are relatively short for western Canada. Records that predate the thermometer (paleoclimatologic data) can be gleaned from climate-sensitive artefacts such as trees, stones and sediment. These data suggest that drought was generally more severe prior to widespread European colonization. The perception that the Prairies contain an abundant and fixed supply of water resources has influenced water use and management in the Canadian west for a long time. While this is partly a misconception, reconstructions of past climate show that since the beginning of the last century, Canadians have indeed enjoyed relatively stable and secure water supplies and an absence of drought in relation to centuries past. But this is about to change, if it has not already begun to do so. Communities in the SSRB can expect severe and prolonged drought simply because it is a natural characteristic of the long-term climate variability for the region, and man-made global warming could make it worse.

▼Map 2. Climate scenarios (years 2039-70) show a 4 to 13% reduction in the SSRB river flows (Martz et al. 2007).—*Map by Diane Perrick & Duncan Campbell, CPRC.*

★Starred locations represent "Streamflow locations modelled for natural flow."



As we have demonstrated, expected climate change in the SSRB involves increasing temperatures, changes in snow and rainfall patterns, reduction in the flow of rivers, increases in the frequency and the severity of extreme climate events such as drought, and a growing geographic area that will experience an increasing annual moisture deficit. These are changes that are outside the range of natural variability for the SSRB, and they provide a range of opportunities and risks to rural communities and producers.

▲ R.R. 724, 12 km east of Maple Creek, Saskatchewan, looking north. —*D. McLennan*

FUTURE EXPOSURES

The new climate does offer some benefits. A longer, warmer, frost-free growing season, warmer winters, and the possibility to diversify production by introducing new crops represent some of them. However, the risks are potentially significant and cannot be ignored. Warmer temperatures in the summer can increase the possibility of heavy rains leading to flooding, but the most significant trend associated with the warmth is an increase in water scarcity. A water deficit is already a characteristic of the area, and the expected climate changes —higher evapotranspiration, decreased snowmelt runoff

▼ Snow-covered dugout at Agventure Farms in Kyle, Saskatchewan.— *M. Hadarits*

and a shift in the timing of the dominant flow from summer to spring—will have a significant impact on surface and ground-water supplies and water quality, especially during the summer months. The deficit becomes more serious since the population in the SSRB is expected to grow from 1.3 million in 1996 to over 3 million by 2046.

Extreme events bring greater risks than a shift in average climate. Drier conditions with droughts of greater length and severity will most likely happen. The likelihood of multi-year drought occurrence is not assumed solely based on projections for the future climate. Paleoclimatologic evidence shows that multiple-year droughts were common before 1900 and that the conditions that existed back then could easily recur. Droughts are a serious risk for obvious reasons, such as their effect on the water supply and negative impacts to economic activities reliant on water such as agriculture, but they also degrade ecosystems, reduce agricultural productivity, increase risk of fires, affect people's health, negatively impact soil moisture, and create potential for social conflict resulting from competing water needs.

Water resources in the SSRB will be seriously constrained, both in terms of quality and quantity. Increasing levels of water stress may result in negative consequences for the process of regional development. Although everyone in the basin will be affected to different extents, it is likely that rural people will be the most affected because of their heavy reliance on natural resources. Because of this, it is important to understand the degree to which the different agricultural sub-sectors—dryland grain farming, irrigated crop farming, and ranching—will be exposed and sensitive to reduced water supplies.

Dryland farmers will face serious challenges because of reduced soil moisture caused by less summer precipitation and increased evapotranspiration. Dryland farming is very sensitive to heat and dryness during the growing season, being dependent on adequate soil moisture, especially earlier in the season. The expected climate conditions may facilitate an earlier growing season and could perhaps even allow for greater use of winter crops or for the use of new crop varieties. On the other hand, farmers also have to face the possibility of too many hot days in a dry summer, which could stunt crop growth. It is obvious that dryland agriculture is highly sensitive to drought, and a severe, multi-year drought could cause a disaster in this sector.

Ranchers need precipitation for grass growth and reliable water supplies for stock. Tame grasses need enough rain during the spring and summer, which makes them more sensitive than native grasses, which also need rain but are not as sensitive to drought. Ranchers also need a secure source of water for their animals. Dugouts that catch snowmelt during the spring currently satisfy this need, but with warmer winters this strategy could become problematic, especially in the case of sustained drought periods. The alternatives are either to build extra dugouts in order to have a larger stock of water, or to install shallow pipelines for dugout recharge, a process which requires access to more reliable streams or canals and sufficient runoff. Options may also exist to utilize groundwater supplies for livestock water in years where surface water is not adequate, provided that the necessary infrastructure (wells) and water treatment is available for utilizing mineralized groundwater.

Irrigated crop farmers are better equipped to deal with drying soil. Precipitation is still very important to them in the growing season, although not as much as on dryland. They are also susceptible to the impact of too much heat on the crops. Two big challenges exist for irrigators. During droughts, water scarcity means irrigators will not receive full water allocations and will suffer shortages. The second challenge may be water consumption and the increased demand for water from non-irrigation uses, which could double by 2021. There will likely be pressure to expand water infrastructure and distribution networks. This situation could lead to significant conflicts if coupled with periods of drought. As a highly successful adaptation, irrigation expansion will need to be considered where water availability exists. Saskatch-ewan has significant irrigation expansion potential to help build agricultural resilience. However, such expansion requires significant planning and investment and would require concerted effort of all stakeholders, citizens and all orders of government to balance economic, social and environmental benefits and impacts.

Sensitivities to new climatic conditions could also be high in rural communities, particularly since their primary economic driver is most commonly the agriculture industry. Most community businesses are affected either directly or indirectly by the state of agriculture, so periods of drought are a problem for residents as well. Communities are also sensitive to changes in water quality, and so they need to have the money to build modern water treatment plants. Small communities are limited in their capacity to raise the necessary funds, and unless governments are willing to invest in these communities, they will be facing problems meeting provincial water quality standards.

▲ Modern irrigation methods conserve water and energy by applying water closer to the plant and soil, reducing evaporation losses.—*D. Corkal*

FUTURE INSTITUTIONAL RESPONSE/ADAPTATION

The question we face is whether the existing adaptive capacity is enough to address the challenges of the future. The IACC research findings indicate that we currently have sufficient adaptive capacity to deal with the existing range of climate variability. The future conditions outlined by the climate change scenarios fall outside this range, however, so more efforts are needed to develop a robust, co-ordinated, more anticipatory approach to reduce the risks and optimize the opportunities. People in the communities, too, recognize the need to strengthen adaptive capacity. They recognize the benefits of the past and present adaptation strategies, but they also say that these strategies will not be sufficient under future climate scenarios. They argue for overall long-term planning in terms of conservation, financial management, education and learning, social capital, improved agricultural practices and diversification, and active participation in watershed management decisions. People said they had to be "more prepared for more extremes," which can be accomplished by understanding the risks involved and by identifying risk-reducers such as

▸ Glorious Evening II.— *Joss Photography / fotolia*

more efficient equipment, the ability to change crops, the ability to reduce farm expenses, improve storage and distribution of water and feed and have access to "slush funds" from good years and for use in poor or drought years.

KEY IACC RECOMMENDATIONS

As in the past, institutional support is fundamental to building adaptive capacity. Without this support, communities and agricultural producers will be unable to access all the resources necessary to deal with the new climate conditions. Governance networks could contribute to adaptive capacity through the following:

- *Develop anticipatory, long-term (10–20 year) climate and water plans that build resilience to climate change:* The IACC studies demonstrate the need to develop and strengthen a policy process aimed at building resilience to climate change impacts on rural communities. It requires a more comprehensive strategy that combines both mitigation and adaptation activities. Long-term strategies need to adopt an anticipatory approach based on knowledge and scenario-planning rather than relying only on reactive, ad hoc, or "crisis management" approaches. Strategies also need to integrate climate policy into several policy fields, especially as they relate to water, the environment, and highly vulnerable economic activities such as agriculture.
- *Integrate government and community adaptation activities:* Climate interacts with many other stressors, and there is the need for an inclusive policy framework across branches and orders of government that emphasizes the link between adaptation and sustainable economic development priorities, while also specifically targeting communities which currently have weak adaptive capacities. The interrelations between climate change and economic and social vulnerabilities require an approach that is able to strengthen the general sustainability of the community, and this will involve a great deal of coordination among government agencies. We need to plan and act across traditional sectors and issues, and bring together environmental management, disaster reduction, and social and economic development measures.
- *Use participatory planning and empower stakeholders and citizens in water management decision-making:* Efforts should be made to strengthen civil society organizations that participate in the process of water governance, such as irrigation associations, watershed groups, and other stakeholders, as they are crucial to fostering and increasing adaptive capacity in both Saskatchewan and Alberta. Their participation in water governance widens the range of interest that is included in the adaptive process, helps to legitimize decisions, and enhances goal achievement. It is important to support these groups with enough operational and project funding to ensure their ability to function. No less important is to properly define their role, so they are more than simply advisory groups to government agencies, and so that they can play a central role in a large range of adaptations to water shortages and in the resolution of conflicts.
- *Improve the dialogue between government and communities, particularly rural communities, to build local resilience and seek new opportunities:* In the same vein, managing the risks and opportunities created by climate change requires a structure of governance that improves communication between communities and government agencies. Appropriate and locally relevant solutions to community sustainability problems require a proper understanding of local vulnerabilities. At the same time, mobilizing and coordinating external resources to alleviate local vulnerabilities requires a comprehensive knowledge of programs available within government. Both are required to develop the necessary knowledge and build the incentives required to strengthen communities.
- *Focus efforts on improving local and regional coping capacities:* A special joint effort between communities and government should be directed toward improving capacities on both a local and a regional level. Local training and capacity building could enhance the skills and knowledge available in the SSRB, aiding the management of risks and opportunities. Water conservation and management is one of the areas in which local knowledge and resources could be improved and supported by an institutional framework, particularly one that supports and trains individuals as to how to implement local water conservation strategies and secure water quality. Existing federal institutions such as PFRA need to be reinforced to assist this process. Programs oriented to developing or strengthening the networking of communities could foster community organization and mobilization to reduce vulnerability. Furthermore, improving inter-community (and inter-provincial) coordination around common issues, such as committees for watershed planning, could help bring communities together to resolve regional problems. All these measures would not only provide rural communities with the instruments to become more sustainable, but they would also contribute to a more effective strategy to reduce the risks of climate change.
- *Prepare for water conflicts: resolve issues using adaptive conflict resolution methods:* Water scarcities could easily lead to water conflicts among water users. In order for governments to truly represent the public good, they must be proactive, making sure that their responses include a highly transparent and accountable decision-making process, which will in turn enhance the legitimacy of government action in the eyes of stakeholders. This will also encourage stakeholders to be more open to accepting water management strategies in

times of scarcity. In these terms we recommend that governments make use of the adaptive conflict resolution approach, which will create a dynamic among stakeholders that can often transform conflict into a learning opportunity and uncover possible institutional adaptations that may have been unthinkable prior to the conflict. Although all stakeholders can contribute to the implementation of this approach, the role of government in creating the conditions for their implementation is essential.

- *Obtain and share more and better water data:* There is a need to improve the processes of gathering and sharing water data within each province's water governance network and between federal and provincial agencies. The research identified gaps in water data (e.g., the climate and hydrology of the upper part of the basin; groundwater data; water quality, quantity and usage information) required to monitor and predict future water supplies and the impact of climate change on water resources. In addition, it is essential to maximize the coordination and use of data. This need could be met by an umbrella water data portal used for effective water management and planning.

- *Seek solutions with interdisciplinary teams using social and physical sciences approaches and coordinating with stakeholders and policymakers:* Climate change and vulnerability are issues that cut across several domains, from philosophy to climatology, from social sciences to engineering. Therefore, comprehensive responses to climate change will need to be based on solid interdisciplinary teams that are able to collaborate with a variety of stakeholders and policy makers to develop appropriate responses to the challenges and impacts of climate change. A more intensive effort to bring together governments and universities to organize an interdisciplinary research agenda around climate change would be a great step in reducing the vulnerability of prairie people. A further step would be to incorporate industry and target research towards sustainable adaptation practices.

- *Simplify water governance arrangements for efficient and effective adaptation decisions:* The effectiveness of water governance is stunted by the complexity of water governance arrangements, especially the lack of interagency coordination.

Water governance and climate monitoring systems suffer from duplication and a lack of coordination, creating confusion among government officials and stakeholders. It is important to reduce this inefficiency and lack of coordination between federal and provincial agencies, as well as within provincial networks, to ensure a comprehensive and systematic approach to the development of a stronger adaptive capacity. In this perspective, the initiative taken in May 2008 by the Western Canadian Premiers is a step forward in addressing the needs identified above. The formation of the Western Water Stewardship Council illustrates the need for stronger federal leadership in water and climate change issues and associated vulnerabilities in the SSRB and across Canada. The Premiers' plans to develop a drought preparedness plan for the west and a climate change policy framework are laudable. While natural resource management is a mandate of provincial governments, this current provincial initiative demonstrates that there is clearly a need for regional approaches. The federal government could play a significant role in supporting such provincial initiatives in order to enhance regional adaptation. It would be advantageous to develop climate and water strategies that span 10 to 20 years with built-in performance measurement requirements. Such strategies should allow for flexible and incremental improvements as knowledge is improved. If implemented, this type of approach would provide unique adoption opportunities and adaptive resilience for regional and local needs.

▲ Winter wheat.— *Lorraine Swanson / Fotolia*

◄ Cattle. — *Doug Olson / Fotolia*

In closing, the vulnerability of communities is not defined solely by the severity of the climate events that they experience, but also by a variety of social and economic conditions that characterize the daily life of rural people. A reduction in vulnerability will require a synchronized institutional effort across all levels of government, an interdisciplinary perspective that integrates both the natural and social sciences, and strengthened stakeholder and citizen engagement. This collaborative effort will help us manage the risks and explore the opportunities presented by the new climatic conditions.

THE EXPOSURES/SENSITIVITIES OF RURAL COMMUNITIES

Rural communities like those chosen for the vulnerability assessment are exposed to a variety of events that can be induced or worsened by climate variability. Changing temperature such as heat waves, early or late frost, general temperature fluctuations, or other climate-related products such as hail, high winds, erosion, or grasshopper infestation can impact the livelihoods of people in these communities, sometimes dramatically so.

Chinook winds can significantly raise temperatures in the western portion of the SSRB over the course of just a few hours. These thawing cycles can melt snow, which then refreezes as ice and causes health problems for cattle. Indeed, Chinooks cause particular problems for managing moisture in both livestock and crop farming. Vegetable producers in Taber have reported that the temperature changes brought by Chinooks can damage the quality of crops in long-term, non-climate-controlled storage by reducing sugar content. Complete snow cover in the winter months means that the soil beneath is protected from the drying effect of the winds, but if warm winds melt the snow down to the bare ground, evaporation will resume and soil moisture will be lost. A snow melt off by Chinooks is inferior to a gradual spring melt because rapid warming causes the water to run off the still-frozen soil where it may be inaccessible for usage, unless it can be captured in a surface storage facility such as a dugout, reservoir or lake.

Low temperatures in winter is also an important exposure-sensitivity. The southern Prairies have regularly experienced extreme cold snaps during the winter, which provide the benefit of controlling insect infestations from year to year. The absence of these periods of extreme cold means that these pests can survive and ultimately damage crop yields. On the other hand, cattle producers face a significant increase (30–50%) in feed requirements when the mercury dips below -20°C. The calving season occurs between approximately January and May, and as such ranching operations are particularly sensitive to extreme cold in the late winter and early spring. Low temperatures can affect both the cow and her calf, with one common unfortunate effect being an increase in pneumonia among newborns.

The temperature during a snow melt also presents exposure-sensitivities for farmers and ranchers: if the melt is slow and gradual, soil moisture will build up and contribute to better crops and better grass growth throughout the season. However, if the slow and gradual melt is coupled with low snow accumulation, be it from a lack of snowfall or as a result of repeated "Chinooking off," it may mean that the ranchers' dugouts do not fill, increasing the risk of insufficient replenishment of stock water ponds reliant on snowmelt.

All producers need enough heat for crop germination and growth in the spring, but in order for a crop to be successful a certain balance has to be struck between sufficient warmth and adequate moisture. After seeding, farmers would like it to be mild and wet because if it is cold and dry the seed will lay dormant, and if it is cold and wet the seed might become incapable of any growth at all. If the plants do not get enough moisture after they germinate they will fail as well. Late frosts can be a serious problem for crops if they happen after the plant has sprouted. These issues are at stake for both field crops and tame pastures, although native pastures are more resilient generally.

Too much heat can also be a problem, particularly for dryland farmers. Temperatures above 30°C dramatically increase the moisture requirement of the crops. This is particularly problematic when the heat is coupled with drought. Even when irrigation is available to meet the moisture requirements of the crops, excessive heat will hasten the ripening. Early ripening means that the crops mature early, and yields decrease.

Crops and pastures need moisture throughout the growing season, although the amount that they need and when they need it varies with enterprise type. Ranchers need moisture early in the season for the production of hay, and after haying in mid-summer they are far less sensitive to low moisture than crop producers, who need moisture all the way throughout the growing season. Ranches that rely on native grasses are less sensitive to drying than those who seed tame grasses, as native grasses retain their protein value even after they have dried on the stalk.

Hot summer days often lead to the formation of severe thunderstorms, and when these bring hail all agricultural producers can be affected. Hail is particularly devastating to pre-harvest field crops, but localized hail can do serious damage to pasture areas as well. High winds, whether brought with thunderstorms or on their own, can also damage crops and property for irrigators and contribute to drying. When frosts begin before September 15, they can be problematic for both dryland and irrigated farmers because they can damage vegetables and affect the quality of the crop. Irrigated farmers are at a greater risk because their crops tend to have a longer growing season, and frost is more likely to hit before they are harvested.

The SSRB can also be subject to many extreme weather events, the most significant of which is prolonged and severe drought. Water scarcities always pose a significant problem but the effects become more dramatic during periods of drought, and drought is a common characteristic of the western Prairies. Droughts affect the water supply to the regional population, but they also increase the harmful effects of dryness on soil and ecosystems. A troubling recent trend is that droughts seem to have migrated northward from more traditional sites in southwestern Saskatchewan. The impacts on these newly-hit communities can be particularly harsh because the communities that are affected are not accustomed to dealing with drought and its impact.

Studies within the IACC project reaffirmed that the impact of drought on the Prairies over the past century has been dramatic, with the most significant case being the drought that accompanied the Great Depression, which affected millions of acres of land and forced the migration of thousands of people. Much more recently, significant droughts shortly after the turn of the century had serious impacts on the Prairies—in 2001 and 2002 net income was negative for Saskatchewan farmers and zero for Albertan farmers, and overall agricultural production losses totalled over $2 billion in the two provinces. The extent and severity of water shortages in the six communities selected for the vulnerability assessment varied, but all of them suffered economic woes and water supply shortages during this period.



Large hailstones. —*AlesVeluscek / iStock Photo*

Frosted wheat. —*JenD / iStock Photo*

Daytime flash. —*AlesVeluscek / iStock Photo*

Although the SSRB is naturally susceptible to drought, too much precipitation can cause serious problems for rural people. For both dryland and irrigated farmers, too much rain can lead to crop losses and other damage. Ranchers are far less vulnerable to heavy rains throughout the growing season, because grass is less likely to be damaged. When rainfall events or snowmelt turn into flooding, as they often do, it can become a major hazard. Floods can damage housing, equipment and infrastructure and can place a major strain on emergency services. Taber, Kainai Blood Indian Reserve, and to a lesser extent, Outlook, have experienced serious flooding during the growing season, with notable floods taking place in 1995, 2002 and 2005.

The quality and quantity of surface and groundwater can also come into question for rural people. Chemicals from agricultural and industrial activity, as well as sewage, storm water runoff, and other biological contaminants can affect the water resources and the aquatic ecosystem of the SSRB. Potential increases in water demand could pose yet another problem for the local population.

The rural communities of the SSRB are all heavily dependent on agriculture, and so they all face the problems of having a mostly undiversified economy. People in these communities face first-hand the stresses of changes in the global markets and global/national policy changes. Market woes at home and abroad have contributed to economic instability, financial hardship, major changes to long-term family agriculture, high family stress, rural out-migration, and significant changes to rural infrastructure, health care, and education. Farming and ranching operations in the SSRB are sensitive to a "cost-price squeeze," meaning that low prices and high input costs are reducing the profitability of the farm.

▲ Saskatchewan rain storm. —*Lightguard / iStock Photo*

▲ Straw bales in the sun. —*Ricofan / iStock Photo*

PAST AND PRESENT INSTITUTIONAL ADAPTATIONS

1 Agricultural producers have adopted a range of strategies to deal with climate-related sensitivities. They have relied on altering the timing of their operations based on conditions and diversifying them to include more drought resistant crops and livestock adapted to prairie climate Alberta. Some producers have even completely replaced crop farming with livestock. For their part, cattle producers rely on management strategies such as building more or larger dugouts, fencing off existing ones, and using pumps to maintain water quality when supplies run low. In some areas, producers have started digging shallow pipelines to recharge their dugouts from more secure water sources such as pipeline tap-offs or good wells. In extreme cases, ranchers have resorted to hauling water in tanker trucks. Farmers and ranchers have both diversified their sources of income in order to deal with the economic risks created by globalization and sought work off of the farm. Luckily, adaptation to insecure agriculture industries has been aided by the presence of the oil and gas industry in portions of the SSRB. For example, oil and gas industries compensate farmers and ranchers for access to both owned and leased land, and the rigs are a source of high-paying work.

There is adaptive capacity to varying climates at the local level, as these examples show, but these capacities are unevenly distributed across the SSRB and among social sectors. The project's community vulnerability assessments have shown that rural communities differ in terms of their access to resources, types of agriculture, institutional capacities and so forth. For example, the Blood Tribe is perhaps the most vulnerable of the selected communities because of its lack of resources.

In 1936 an Agricultural Improvement Association demonstrates "listing." This was one of many experimental adaptation soil tillage practices to deal with severe soil drifting. No longer used, these experiments tried to reclaim land by ploughing deep ridges to resist wind erosion, often prior to seeding of grass.—*PFRA*

2

The prolonged drought that covered most of the Palliser Triangle from 1928 until 1939 revealed the critical vulnerability of the small, fragmented government structures found throughout the SSRB and the potential weakness of provincial governments acting in isolation from each other and from the federal government. Relief was the most common and expensive institutional response to the disaster. Despite many difficulties, collaboration between the federal and provincial governments in distributing relief likely prevented wholesale starvation in the SSRB, illustrating the importance of inter-governmental and inter-agency co-operation. Overall, Saskatchewan was more vulnerable to the severe drought and accompanying water shortages than Alberta. Alberta's agriculture consisted largely of ranchers and irrigated crop farmers, and policy interventions had been set up to restrict wheat farming in order to shore up a weak municipal structure in the eastern part of the province. Because of this, Saskatchewan became the centre of gravity for the federal government's major initiative to rehabilitate the stricken Palliser Triangle—the Prairie Farm Rehabilitation Administration (PFRA).

The *Prairie Farm Rehabilitation Act* was passed in 1935. The Act set out that the federal Department of Agriculture would administer small dam building, and grass and tree planting, as well as conduct extensive soil surveys. Demonstration farms would be established to address the most pressing needs of farmers in the hardest-hit parts of the Palliser Triangle. In 1937 the activities outlined in the Act were organized under the PFRA, adding the creation of community pastures out of the worst areas of soil drifting. These pastures were federally owned and managed, and were made available to the surrounding farmers to supplement their own livestock feed. Because of the distribution of powers outlined by the constitution, the project could not have been undertaken without some collaboration from the provincial government. Saskatchewan's government turned out to be an enthusiastic supporter of the program, which allowed for a remarkable rehabilitation of the southern part of the province. In Alberta, on the other hand, the PFRA received only grudging support from the provincial government, but it was enough to initiate most of the PFRA's programs within the province. The exception was the community pasture program, which was not a significant problem because of the pre-existing program that existed in the Special Areas.

Since its inception PFRA has provided technical support and funding for soil and water conservation projects and on-farm and rural water development projects, including farm dugouts, rural water pipelines, and rural water infrastructure ranging from irrigation works to rural water treatment facilities, increasing access to water supplies for the agricultural sector and rural communities in the process. These programs were delivered in close partnership with rural communities, where technical support and government programs were delivered by staff located in rural communities. To a large extent, PFRA is responsible for the considerable drought resilience in the agricultural industry of the Prairies. It also developed climate monitoring and forecasting capabilities designed to aid decisions and planning related to extreme climate events like droughts, which is an important step in developing an adaptive strategy for future climate change. With all this experience the PFRA is well ahead of other governmental agencies on this front, but in recent years some of its activities have been curtailed (e.g., reduced water infrastructure programming). The organization remains a branch of the federal department of Agriculture and Agri-Food Canada, and has been re-named Agri-Environment Services Branch (AESB). AESB now delivers national agri-environmental programming and considers water and climate as key priority issues.

Other institutional measures have been developed to ensure secure and reliable access to water in periods of scarcity. One of them has been a significant investment in irrigation infrastructure and technology, which has always been perceived as the primary adaptation of agriculture in drier regions such as the SSRB. At the present time, Saskatchewan has about 11% and Alberta well over 60% of Canada's irrigated land. While irrigation is only practiced on 5% of the land in the SSRB, it accounts for nearly 20% of agricultural Gross Domestic Product in the region. However, the benefits of irrigation, such as favourable conditions for diversification and additional income, are only available to those farmers and ranchers located in irrigated areas. Irrigation expansion is still possible as an adaptation to water scarcity, particularly in the Saskatchewan portion of the basin.

Another institutional contribution to secure water on the Prairies was the creation of the

Modern dryland cropping uses less soil disturbance to protect soil from erosion and conserve soil moisture. This photo shows "direct seeding"—the new crop is seeded into the previous year's stubble. —*Saskatchewan Soil Conservation Association*

Prairie Provinces Water Board (PPWB) in 1948. The PPWB operates under a formal relationship between Manitoba Environment, Saskatchewan Watershed Authority, Alberta Environment and the federal government represented by Environment Canada and PFRA. The PPWB oversees the sharing agreement on river water flow among the prairie provinces, which requires that 50% of the natural water flow from Alberta be allowed to pass into Saskatchewan, which then has to pass half of the natural flow into Manitoba—both what it receives from Alberta and what is added in Saskatchewan. The PPWB also monitors the quality of water as it flows between each of the provinces. Overall, the agreement provides some security on both the quality and the equitable sharing of surface water flowing across the three prairie provinces.

Coulee south of Bengough, Saskatchewan.—*D. McLennan*

Institutional support has increasingly been thrown behind the effort to reduce the risks involved with unpredictable weather conditions. Federal and provincial governments have established safety net programs that reduce the negative impacts of these conditions on farmers and ranchers. By 2002 there were several federal programs to help lessen drought impacts. Alberta and Saskatchewan are partnered with the federal government in several programs. They also maintain their own crop insurance, livestock drought insurance, farm management, and conservation programs. These programs have limitations, however, as was demonstrated in the high costs they racked up during the 2001–2002 drought and the dissatisfaction expressed by many farmers. This drought caused a drop of $5.8 billion in Canada's GDP, a drop of $3.6 billion in Canada's agricultural production, and 41,000 job losses in Canada. The impact of the 2001–02 drought to the Prairies was estimated to be $4.5 billion, nearly 80% of the entire Canadian impact. However, these serious socio-economic impacts were not accompanied by significant ecological impacts as had occurred in the 1930s. This was largely due to the successful adaptations (better land use, water management, and agricultural practices) and the fact that the 2-year drought was not as severe as the decadal droughts.

Research Team, Institutional Adaptations to Climate Change Project.

Significant developments have contributed to this growing capacity over the last decade. The first was the development of a new institutional water governance system aimed at improving the management of water resources. In Saskatchewan the new system was organized around the *Safe Drinking Water Strategy* of 2002, which came to be partly as a response to drinking water disease outbreaks in Walkerton in 2000, and North Battleford in 2001. The strategy involved a rearrangement of water governance in the province and the development of a wide-ranging water monitoring and regulatory system for municipal drinking water. The system required that municipalities had to meet standards for water quality and have qualified water treatment technicians. While the institutional approach has its challenges, it provides reliable drinking water to communities and nearby farm households. In Alberta the new institutional development was organized around the *Water for Life Strategy*, created in 2001. Its goal was to achieve more sustainable management of water resources after Alberta recognized that it was facing significant pressure on its water supplies.

More recently, the integration of civil society into the governance of water resources was linked with the creation of new institutional systems in Alberta and Saskatchewan. In both provinces local organizations and members of the community are now participating in watershed councils or committees, and engaging in the development of water plans. Integrating local people into watershed decision-making processes is a central theme of integrated water management, and is consistent with standards set by the World Water Council. When this approach is fully realized it should contribute to better management of the risks associated with climate change, as well as more sound water management.

Finally, there has been a significant increase in institutional research in water resources and climate change areas within the SSRB. Climate change research programs have been developed in regional universities, such as the Prairie Adaptation Research Collaborative (PARC) at the University of Regina, the Water Institute for Semi-arid Ecosystems based at the University of Lethbridge, the Alberta and Saskatchewan Research Councils, and other government agencies. This increasing production of knowledge is fundamental to understanding vulnerabilities and impacts and for developing capacities to deal with them, but it still needs to be integrated into governance policies, management, programs, and practices.

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USEFUL LINKS

IACC—Institutional Adaptations to Climate Change: www.parc.ca/mcri/

IACC—Insitutional Adaptations to Climate Change, Assessment of Formal Institutions: www.parc.ca/mcri/unit1e.php

IACC—Insitutional Adaptations to Climate Change, Assessment of Vulnerabilities of Rural Communities: www.parc.ca/mcri/unit1a.php

IACC—Insitutional Adaptations to Climate Change, The Historical Study of Institutional Adaptation: www.parc.ca/mcri/unit1c.php

NRCAN—Natural Resources Canada, Climate Change Impacts and Adaptation Division: http://adaptation.nrcan.gc.ca/index_e.php

PARC—Prairie Adaptation Research Collaborative: www.parc.ca