Institutional Adaptations to Climate Change (IACC) Project

Unit 1A: Assessments of Vulnerabilities of Rural Communities
The Case of the South Saskatchewan River Basin (SSRB), Canada
November, 2009

INTRODUCTION

The Institutional Adaptations to Climate Change (IACC) project is a multi-disciplinary research project funded by the Social Sciences and Humanities Research Council of Canada under the Major Collaborative Research Initiatives program. The project is a comparative study between two dryland river basins—the South Saskatchewan River Basin (SSRB) in Canada and the Elqui River Basin (ERB) in Chile. The objective of one of the research teams involved conducting vulnerability assessments in the study communities in each basin. This report summarizes the Canadian community vulnerability assessment findings, and also incorporates the findings from the stakeholder workshops held in Lethbridge (2006) and Hanna (2007), Alberta, and in Outlook (2007), Saskatchewan. The communities chosen for the assessments in Canada are: Hanna, Taber and the Blood Tribe in Alberta, and Outlook, Cabri and Stewart Valley in Saskatchewan (Figure 1).

The project adopted a vulnerability approach, which guided the research process as well as analysis and ensured consistency in the results from the various research teams (Figure 2). Vulnerability is conceptualized as a function of *exposure-sensitivity* and *adaptive capacity*. *Exposure-sensitivities* are properties of a system (or community) and refer to the interaction of both the characteristics of the system and a stimulus. They reflect the manner in which a system experiences conditions to which it is sensitive (Smit and Wandel, 2006). The actions taken to ameliorate the negative effects and capitalize on opportunities are considered *adaptive strategies*. The system's ability to employ adaptive strategies reflects its *adaptive capacity*. This report is organized according to the vulnerability approach (Figure 2). It begins with a brief description of each community, followed by the key findings of the community vulnerability assessments.

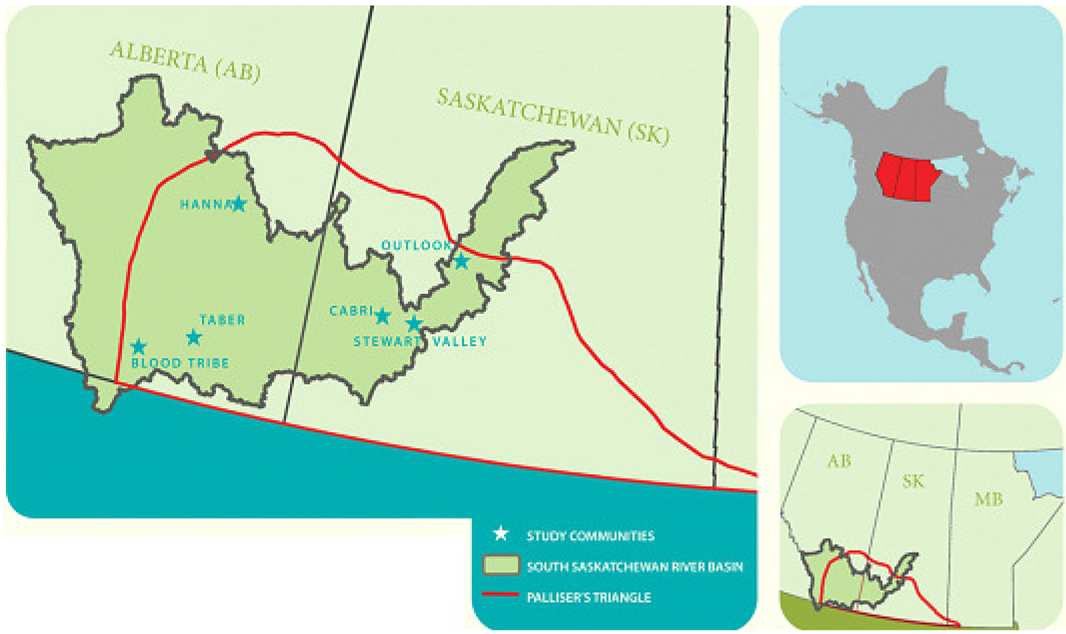

Figure 1. Map of IACC Study Communities

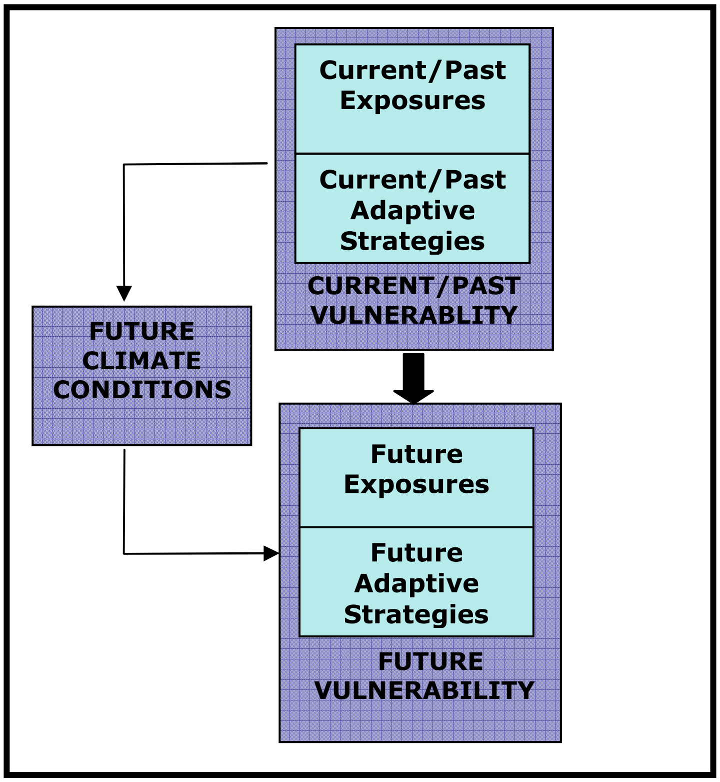

Figure 2. Conceptual Model of Vulnerability

COMMUNITY DESCRIPTIONS

Town of Hanna and Alberta's Special Areas

The Town of Hanna (population 2,847) is surrounded by Alberta's Special Area No. 2 (population 2,074). Alberta's Special Areas comprise a tract of just over two million hectares north of the Red Deer River. This region of Alberta is part of the dry mixedgrass natural grasslands, characterized by treeless prairie with shrubs and trees only in relatively moist areas such as coulees and river valleys. Most of the area receives less than 250 mm precipitation per annum. Evaporation generally exceeds precipitation throughout the study area, and consequently solonetzic soil groupings are common in parts of the study area, including 30% or more of all land in the western portion.

Hanna and the Special Areas represent a unique institutional situation in the SSRB. The Special Areas were established as a direct result of drought and poor harvests in the 1920s and 1930s (Marchildon, 2007). The area was settled at the beginning of the 20th Century and reached an all-time population high of 29,689 in 1921. In accordance with the Dominion Lands Act, settlers broke the native shortgrass prairie sod and established a wheat farming culture based on relatively small (65 ha) parcels.

Poor harvests and wind erosion during the 1920s and 1930s meant that many settlers were unable to meet tax obligations. The title of land in tax arrears reverts to the Crown. Tax recovery through loss of title and out-migration was so widespread in non-irrigated south-eastern Alberta at this time that the provincial government replaced regional government in this region with a crown agency which manages the remaining crown (never claimed) and tax recovery lands under the Special Areas Act of 1938. Unlike the remainder of Alberta's counties and municipal districts, regional government falls directly under the authority of the Province and administered by a provincially appointed Special Areas Board.

Despite depopulation and out-migration in the last century, the Special Areas remain a predominantly agricultural landscape. The Special Areas administration oversees agricultural land with a view to drought via grazing and farming leases and community pastures. The governance framework established by the Special Areas Act and the Agricultural Service Board Act (1945) allows the Special Areas Board to devote resources to prevent and mitigate some of the impacts of drought. For example, the Special Areas Agricultural Service Board has undertaken extensive research into and promotion of zero tillage initiatives to decrease wind erosion during dry periods and recommended particular mixes of native grasses for reseeding grazing leases. To generate research and extension with particular relevance to the drought-prone special Areas, the Agricultural Service Board established the Dryland Applied Research Association (now known as the Chinook Applied Research Association, CARA).

Primary industries remain as the dominant source of employment within the Special Areas, with agriculture as the largest source of employment in the rural areas of the region. Over the past several decades, ranching has increased in importance at the expense of dryland (non-irrigated) farming. Furthermore, there is one very small irrigation project managed by the Special Areas (~30 irrigators, most of whom only irrigate a small proportion of their operations) on Berry and Deadfish Creeks in Special Area 2. The entire area was hard hit by the recent droughts, as severe moisture stress meant poor crop growth and grasshopper outbreaks decimated much of what did grow. In addition, the area's increasing orientation toward ranching meant that climatic exposure-sensitivities were compounded by the difficulty beef producers faced in shipping to the United States as a result of Bovine Spongiform Encephalopathy (BSE) outbreaks beginning in 2003.

Although dryland farmers and most ranchers rely primarily on spring runoff and precipitation, surface water from the Red Deer River plays a key role in the area. The irrigation project's water is supplied via a raw water pipeline and surface water canal operated by Alberta Environment and Sheerness Generating Station. In addition, potable water for the Town of Hanna, surrounding villages, some rural water co-operatives and bulk tank filling stations is provided by the Henry Kroeger Water Commission in Hanna. The Henry Kroeger Commission receives raw water via the Alberta Environment/

Sheerness pipeline. Most rural residents have wells, but overall water quality in many of these is poor due to sodium and sulfate loads that exceed Canadian drinking water guidelines.

Primary research in Hanna and Special Area 2 consisted of 47 semi-structured interviews with producers, industry, community residents and local institutional representatives in the fall of 2006 (see Hadarits, 2007; Wittrock et al., 2007; Young and Wandel, 2007).

Town of Taber and Taber Municipal District

The Town of Taber (population 7,591) is located 50km east of Lethbridge, just south of the Oldman River. The Taber Municipal District (population 6,280) straddles the Oldman River and borders the Bow River on the northeast. Taber is representative of the 5.1% of the SSRB which is irrigated land, and the Municipal District includes three of Alberta's large Irrigation Districts (IDs): the Taber ID, St. Mary's River ID and Bow River ID. Collectively, these three IDs account for over 250,000 hectares of irrigated land.

Irrigation development in the Taber Municipal District dates back to 1915, with the establishment of the first Irrigation District, the Taber ID, under the Alberta Irrigation Districts Act. The Oldman and Bow Rivers have experienced insufficient water supply to meet Alberta's needs in recent history and in particular during the drought of 2001-2002, prompting innovative water sharing arrangements among license holders in parts of the Oldman River Basin (Rush et al., 2004; McGee, 2007).

The regional economy of Taber relies heavily on agriculture, which accounts for the largest share of employment in the Town and Municipal District. The combination of a favourable climate and availability of irrigation has meant that Taber produces a range of diversified specialty crops, notably corn, sugar beets, vegetables and potatoes. Local processing of these crops accounts for further employment in local potato, sugar beets and vegetable processing plants.

Water allocation in Alberta is administered through water licenses, and the date associated with a particular license determines its priority in times of water shortage. While the established irrigation districts have very early dates (i.e. high priority numbers), it is not possible to "hoard" water as allocated volumes must be used in order to be maintained. Consequently, even established IDs may have portions of their licenses with very junior priorities. In dry years (arguably the times when irrigation is most crucial to producers), junior license holders have no entitlement for any water. This situation can be expected frequently for junior license holders, as both the Bow and Oldman Rivers are fully (if not over) allocated and the Province of Alberta placed a moratorium on new water licenses on these basins in 2006. Furthermore, in the case of Taber, some of the processing industries which agricultural producers rely on have much more junior license priority than the Irrigation Districts. The combination of junior and senior licenses within IDs and the reliance on more junior processing license holders led to some innovative adaptation strategies in this area during the recent 2001-2002 drought.

Research in Taber consisted of 31 semi-structured interviews which represented agricultural producers, local authorities, business and service industries and retired residents in both the Town and the Municipal District during the summer of 2006 (see Wittrock et al., 2007; Prado, 2008).

Kainai Blood Tribe First Nation Reservation

The Blood Tribe (9,782 members, 3,852 living on-reserve) is located 200 kilometers south of Calgary and is currently the largest reserve in Canada. The tribe is a member of the Blackfoot Confederacy and the Treaty 7 Tribal Council. Members live in numerous communities within the reserve: Standoff, Moses Lake, Lavern, Old Agency, Fish Creek, Ft. Whoop Up and Bullhorn. The reservation borders the Belly, St. Mary's and Oldman Rivers. Agriculture is the primary industry on-reserve and is the Band's main source of income. Grain, wheat, barley, canola and alfalfa are cultivated by non-aboriginal farmers under contract. The Blood Tribe Ranch runs 500 head of cattle, which includes several square kilometers of unbroken moist mixed-grass prairie. The tribe's forage processing plant exports to countries in the Pacific Rim, primarily Japan.

The Blood Tribe Agricultural Project (BTAP) was formed in 1991. The project's irrigation system has the capacity to irrigate up to 25,000 acres. Irrigation water is obtained from the Maine Turnout of the Alberta Environment Protections Belly River Diversion Canal just upstream of the St. Mary Reservoir. Currently there are 200,000 acres cultivated—20,000 irrigated and 180,000 dryland. Plans are underway to develop another 6,000 acres adjacent to the Mokowan Ridge Canal. The project is administered by Blood Tribe personnel, and its expansion is currently being discussed.

Research in the Blood Tribe consisted of 30 semi-structured interviews with Band employees, industry representatives, Elders and youth (see Magzul and Rojas, 2007).

Town of Outlook and Saskatchewan Rural Municipality of Rudy No. 284

The Town of Outlook (population 1938 in 2006) is located southwest of Saskatoon on the South Saskatchewan River (SSR), just downstream of the Gardiner Dam and Lake Diefenbaker. Livelihoods in Outlook and the surrounding Rural Municipality (RM) of Rudy (population 434) are centered on agriculture and its related industries. Like Taber, there is some agricultural processing via a hay dehydration plant and an extraction plant for essential herb oils.

Outlook derives its potable water by treating surface water, in this case directly from Lake Diefenbaker. Similar to Hanna, treated water is pumped to rural areas through pipelines. Agricultural producers rely on a mixture of surface water and precipitation for their operations, with some supplementing supplies from wells (which are rarely of sufficient quality for potable water). There is access to irrigation water from Lake Diefenbaker, but the majority of farmers continue to "dryland" farm (i.e. crop farming without supplemental irrigation). Saskatchewan currently has no statutory scheme for water rights, and water licenses are granted at the discretion of the Saskatchewan Watershed Authority (Hurlbert, 2009). Currently, evaporation from Lake Diefenbaker accounts for the largest consumptive water use, and irrigation is underdeveloped relative to supply (Weiterman and Thauberger, 2006).

Field work in Outlook consisted of 34 semi-structured interviews with respondents representing agriculture, business, and the service industry (see Hadarits, 2007; Wittrock et al., 2007; Pittman, 2008).

Town of Cabri and Saskatchewan Rural Municipality of Riverside No. 168 & Village of Stewart Valley and Saskatchewan Rural Municipality of Saskatchewan Landing No. 167

The Town of Cabri (population 439 in 2006) and the Village of Stewart Valley (population 100 in 2006) are located northwest of Swift Current and south of the SSR. Both communities are in Palliser's triangle, a semiarid region in the Canadian Prairies characterized by high moisture deficits. The majority of community members gain their livelihood from the agricultural sector.

The SSR is the primary water source for the town of Cabri. The river water is pumped through a pipeline to a reservoir just outside the town, then from the reservoir to the treatment plant in the town, where it is distributed via another pipeline. Stewart Valley pumps water from three wells near the treatment plant, where it is heavily chlorinated and then piped to the village. Similar to Outlook, farming in Cabri and Stewart Valley is predominately dryland.

Field work consisted of 30 semi-structured interviews in Cabri and 11 in Stewart Valley with farmers, institutional representatives and seniors. These interviews were complimented with 2 focus groups in Cabri (see Matlock, 2007).

CURRENT EXPOSURE-SENSITIVITIES

Although all study communities 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 faced by First Nations communities. Despite these differences, the community vulnerability assessments found they are exposed and sensitive to similar climate conditions (Table 1). The assessments also found there is a number of compounding non-climate-related conditions that influence vulnerability (Table 2).

Climate-related Exposure-sensitivities

Table 1. Climate-related Exposure-sensitivities

Climate Exposure-sensitivities	Outlook	Cabri and Stewart Valley	Hanna	Taber	Blood Tribe
Precipitation/Water					
Lack of moisture	x	x	x	x	x
Excessive moisture		x		x	x
Hail	x	x		x	
Water quality		x	x		x
Temperature					
Excessive heat	x	x	x	x	
Extreme temperatures	x	x	x	x	x
Other					
Wind	x	x	x	x	
Disease	x	x			

Crops and pastures need moisture throughout the growing season, although the timing and the amount of moisture varies according to enterprise type. Ranchers need moisture early in the season for the production of hay, wile crop producers need moisture all the way through the growing season in order to ensure proper germination. Insufficient moisture throughout the growing season can lead to reduced yields and poor grass growth, while repeated dry years can lead to severe grasshopper infestations, which compromise yields and quality. Water scarcities are always problematic, but when coupled with drought, the effects are much more dramatic. Droughts also affect the supply of water to the regional and can be detrimental to soil and ecosystems.

Excessive moisture can cause serious problems for rural people as well. For both dryland and irrigated farmers, too much rain can lead to crop losses and other damage, particularly near the end of the growing season. Ranchers are far less vulnerable to heavy rains throughout the growing season because grass is less likely to be damaged by rain than crops. When rainfall events or snowmelt turn into flooding, it can become a major hazard. Floods damage rural peoples' dwellings and hamper water delivery systems and quality due to high turbidity. During the 2005 flood, surface water contaminated the Blood Tribe drinking water system; a "boil water" advisory was subsequently issued.

Surface and groundwater quality and quantity is also problematic for rural communities. For those connected to a water pipeline, water quality does not seem to be a major issue, unless an error is made at the water treatment plant. In 2003, a valve was left open in the Cabri water treatment plant. The basement was flooded, and there was a backlog from the filtering engine to the clean water supply. Officials were uncertain if the water had been contaminated, so a "boil water" advisory was issued. Those who have a well, haul water, or have water delivered, as is the case for many Blood Tribe residents, identified water as being of poor quality, as it often has high concentrations of sodium, iron and/or magnesium. Chemicals from agricultural and industrial activity, as well as sewage, storm water runoff and other biological contaminants can affect water resources and the aquatic ecosystem of the SSRB. Community members fear that the intensification of agricultural and industrial activities in the basin will have negative effects on water resources and ecosystems.

Chinook winds can significantly raise temperatures over the course of just a few hours. These thawing cycles can melt snow, which then re-freezes as ice, and can cause health problems for cattle. Chinooks cause particular problems for managing moisture in both livestock and crop farming. Vegetable producers in Taber 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 can melt the snow down to the bare ground, evaporation will resume and soil moisture will be lost. Also, 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. Often Chinook winds are not warm enough to thaw the soil, therefore snowmelt will not be retained in the soil as the ground is still frozen, decreasing potential soil and subsoil moisture, resulting in poor grass and/or crop growth. Low snow accumulation in the winter months also results in minimal spring runoff; producers then have difficulty filling dugouts to meet their water needs.

Excessive heat during the growing season can be problematic, particularly for dryland farmers, as temperatures above 30°C dramatically increase the moisture requirement of the crops. Crops mature early as a result of high summer temperatures, resulting in decreases in crop quality. As for livestock producers, they tend to have lighter cattle after a hot summer. Also, hot summer days often lead to the formation of severe thunderstorms, and when these bring hail all agricultural producers can be affected. Hailstorms tend to be highly localized, but can have devastating effects on crops. They reduce quality, yields, and have the ability to decimate an entire crop. High winds, whether brought by thunderstorms or on their own, can cause considerable damage to buildings, machinery and other infrastructure. Irrigation equipment, for example, is light weight when empty and can be easily damaged by high winds. Wind also causes soil moisture and topsoil losses, particularly in dry years and in summer fallow fields, and contributes to soil erosion; during the growing season, high winds can devastate grasslands and crops that are already suffering from moisture shortages. They can also blow crops over, making them very difficult if not impossible to harvest as combines are unable to pick up blown over crops.

Cold snaps during the winter provide the benefit of controlling insect infestations from year to year, but 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, and lead to an increase in pneumonia among newborns. Cattle producers also face an increase of 30 to 50% in feed requirements if temperatures are below -20˚C. However, a lack of extreme cold temperatures (-25 degrees Celsius) can affect crop farmers because it results in year-to-year survival of pests, which ultimately results in lower yields.

For dryland and irrigated farmers, frosts during seeding are problematic because seeding is delayed, while frosts prior to harvest are problematic because they can damage and even destroy crops. Frosts can also affect crop quality. Irrigated farmers tend to be more sensitive to frosts because they often plant crops that require a longer growing season and ripen later. Farmers from the Cabri/Stewart Valley area recall that during the 2005 growing season July was the only frost-free. This frequent occurrence of frosts significantly affected their yields and quality.

All producers need a certain combination of sufficient warmth and adequate moisture for a crop to be successful. 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.

Compounding Non-climatic Exposure-Sensitivities

The "cost-price squeeze" exacerbates the climate-related exposure-sensitivities that communities and agricultural producers experience. Rising inputs costs coupled with stagnant crop and livestock prices make it difficult for producers to make ends meet, while a lack of economic opportunities reduces the viability of rural communities and their residents. People have a difficult time finding work, and there are limited activities to participate in that stimulate rural economies. Dwindling resources for rural community infrastructure and the high costs for new producers to enter the agricultural sector also present significant challenges.

Global markets are a major force affecting producers. The BSE crisis that began in 2003, for example, drastically reduced cattle prices, causing producers serious financial hardships. Cattle producers in Taber noted that the United States' decision to close its borders to Canadian beef in the wake of the BSE crisis had devastating consequences for them. Ranchers, and the industry as a whole, have yet to fully recover, although prices have begun to rebound.

Producers find it difficult to find farm labour, forcing them to either do try to do the work themselves, which is often exhausting or impossible, or to mechanize, which is a costly endeavour. Rural out-migration—a consequence of a lack of economic opportunities, reduced rural funding, and many other reasons—is affecting communities, as more and more youth are migrating to the city to attend school and find employment.

As a result, communities are left with an aging population and a lack of resources to satisfy their needs. Social cohesion and networks are diminishing because people are not as actively engaged in social programs as they used to be, and because funding for rural programs is declining.

Table 2. Compounding Non-climatic Exposure-sensitivities

Non-climatic Exposure-sensitivities	Outlook	Cabri and Stewart Valley	Hanna	Taber	Blood Tribe
Economic					
Cost-price squeeze	x	x	x	x	
Lack of economic opportunities		x	x	x	x
Global markets			x	x	x
Lack of resources	x	x		x	x
Social					
Labour shortages	x			x	
Out-migration	x	x	x	x	
Fractured social networks		x		x	x
Institutional					
Inadequate/poor housing				x	x
Program removal	x	x	x		x
Bureaucracy	x	x			
Lack of funding/support	x	x	x	x	

Taber and Blood Tribe residents report that inadequate housing is an issue for their communities. Taber can barely accommodate the influx of new residents it is currently experiencing, while the Blood Tribe suffers from poor housing conditions—some people did not receive adequate relief during the 2002 and 2005 floods to properly repair homes.

Program removal negatively affects communities and producers. The removal of the crow rate (transportation subsidy offered to the Canadian Pacific Railway by the Canadian government) and spot-loss hail coverage from Saskatchewan Crop Insurance in 2002, along with the disappearance of local grain elevators, are particularly problematic.

Residents attribute the loss of both social networks and community cohesion to the loss of schools and other social programs. Too much bureaucracy leads to confusion among community members as to who is responsible for what, and a lack of communication within government leads to inefficiency. A perceived lack of funding and government support (e.g. reduced presence of the Prairie Farm Rehabilitation Administration in rural communities) leads to inadequate infrastructure in communities, higher input costs for producers, and reduces community sustainability.

Rural communities and agricultural producers in the SSRB are experiencing multiple risks simultaneously. The climate-related exposure-sensitivities described above represent significant risks for communities and producers, while the economic, social and institutional (non-climatic) risks serve to compound the climate-related ones. Rural people and agricultural producers have developed a suite of adaptation strategies that help reduce risks and increase their capacity to cope with these risks.

ADAPTATION STRATEGIES AND ADAPTIVE CAPACITY

Rural communities call on a range of management strategies to deal with climate-related exposure-sensitivities. Generally, agricultural producers rely on changing the timing of their operations, diversifying their crop and livestock mix, purchasing crop insurance, both constructing additional infrastructure and employing new farm practices to cope with altered moisture regimes, or using institutionally-supported risk reduction strategies, while community members use a variety of techniques to secure water resources (both quality and quantity).

Farmers have always adjusted the timing of their operations based on microclimatic conditions. For example, seedbed preparation requires that fields are free of snow and adequately dry to support the weight of tillage equipment without leading to excessive soil compaction. Similarly, seeding is often adjusted to weather forecasts. In situations where seeds do not germinate or germinate poorly, or if the plants are damaged or destroyed post-emergence, farmers will often re-seed. Re-seeding places additional stress on farm profitability due to the increased costs of seed, fuel, and operator time.

A common adaptation strategy among producers is to diversify the operation to include fewer moisture-sensitive or higher value crops as well as livestock or, in the case of several producers in the Hanna area, abandon crop farming altogether. Producers in Outlook have experimented with different vegetables, potatoes, mint and timothy in an attempt to capitalize on a new market niche, while livestock introduce more options to reduce losses if crops fail during the latter part of the growing season, as fields with insufficient yield or quality for harvesting can still be used for cattle feed. Furthermore, since cattle operations are less sensitive to minor fluctuations in temperature and moisture, these operations are better able to deal with extreme weather events.

Cattle producers also rely on a suite of management strategies. Ranchers require secure stockwater supplies. Traditionally, these needs are met via dugouts, and adaptation strategies involve constructing more or larger dugouts, fencing off existing ones, and using on-demand pumps to maintain water quality as supplies run low. In the Hanna area, a number of producers have started digging shallow pipelines for dugout recharge from secure sources (such as pipeline tap-offs or good wells). In the worst case scenario in both Hanna and Outlook, ranchers have resorted to hauling water using bulk tankers to bring their cattle through extreme dry periods. Dryland farmers adopt minimum or no till cropping practices such as direct seeding (where the new crop is seeded into the previous year's stubble) in order to reduce soil disturbance, protect soil from erosion, and conserve soil moisture. Dryland and irrigated farmers often let their fields lie fallow for a year so that soil moisture can build up and the land can "rest"; ranchers also let their grazing land lie fallow in order to avoid over-grazing and to facilitate regeneration.

Institutional programs such as crop and hail insurance are, in theory, designed to buffer the insured against the adverse effects of an extreme event or a poor season. However, farmers in both Saskatchewan and Alberta expressed a range of frustrations with the current arrangements, citing issues such as increasing premiums following claims and the removal of spot-loss hail insurance. In the latter case, farmers are unable to claim losses for an individual field as the loss has to be averaged over the entire operation. Given farm sizes in the hundreds and thousands of acres coupled with the extremely localized impact of hail, these losses are difficult to recoup.

Producers who have access to irrigation are better able to survive moisture variability; however, reliance on irrigation introduces greater sensitivity to late season temperature fluctuations. In addition, access to irrigation generally results in a crop mix with greater moisture requirements. In the Taber area, higher moisture crops including corn and sugar beets are common. In the event that irrigation water runs short, the loss is even greater, although producers have replaced traditional irrigation systems (e.g. flood) with more efficient ones (e.g. pivot with drop nozzles) that reduce waste water and evaporation losses, and can be more easily controlled. When there is insufficient water for irrigation, producers in Taber, for example, prioritize irrigation; they irrigate higher value crops first.

To reduce the risks associated with poor water quality and inadequate water supplies, rural people ration water supplies, install water purification systems and practice water conservation. Investment in rural water pipelines also helps ensure access to clean water supplies.

Generally, the cost-price squeeze has been heavily felt, and many agricultural producers have started to diversify incomes beyond the farm. To help cover the high costs of equipment, producers do custom work for other producers; this helps cover the costs of expensive farm equipment. Farm spouses and operators working off the farm have become increasingly common in the study area. While this pluriactivity is not generally prompted by climate change itself, income diversification leads to higher adaptive capacity to absorb stresses, including climate-related stresses, and thus represents a major adaptation strategy.

Adaptation to insecure farm economics is particularly facilitated in the SSRB by the presence of oil and gas. Producers do not own sub-surface minerals, but are compensated for oil industry access to both owned and leased land. In this way, farmers in oil and gas-rich parts of the Hanna area, for example, sometimes have far higher oil-lease revenues than gross farm receipts. This influence of oil and gas money is increasingly being felt in Saskatchewan as well. Furthermore, the oil and gas industry is a source of high paying employment, which in turn can supplement farm income.

The lure of high income non-farm jobs, however, has negative implications for rural communities in the SSRB. Agricultural producers in the study communities expressed frustration over the lack of available farm labour, with producers in Hanna and Taber resorting to hiring immigrant workers. In all cases, the average age of operators is increasing, with fewer young people entering the industry. Rural areas are declining in population, and in the case of Outlook and Cabri, this is reflected in the communities' total population. With fewer people, services such as local schools and health care become more difficult to provide.

Although social networks and community cohesion were reported as diminishing, rural people do work together to reduce climate and economic risks. Producers collectively purchase equipment in order to cut costs, and they also share their agricultural knowledge with one another; many people rely on these social dynamics to aid their decision making. These networks help enhance adaptive capacity.

FUTURE EXPOSURE-SENSITIVITIES AND ADAPTIVE CAPACITY

Climate change scenarios for the SSRB project increases in temperature and more variable precipitation. More specifically, scenarios suggest there will be 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 moisture deficit that naturally characterizes the SSRB will also expand geographically.

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 (e.g. pest and disease control), 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. 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.

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 will have a significant impact on surface and groundwater supplies and water quality, especially during the summer months.

Extreme events bring greater risks than a shift in average climate. Drier conditions with droughts of greater length and severity will most likely happen. Droughts are a serious risk as they affect water supply and the agricultural sector, and have the potential to create social conflict as a result of competing water needs.

Dryland farmers will face serious challenges because of reduced soil moisture caused by less summer precipitation and increased evapotranspiration. The expected climate conditions may facilitate an earlier growing season, but farmers also have to face the possibility of too many hot days in a dry summer, which could stunt crop growth. Dryland agriculture is highly sensitive to drought, and a severe, multi-year drought could be disastrous for this sector.

Ranchers need precipitation for grass growth and reliable water supplies for stock. Dugouts that catch snowmelt during spring currently satisfy stockwater needs, but with warmer winters this strategy could become problematic, especially in the case of sustained drought periods.

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.

Rural people and agricultural producers in the SSRB may be exposed and sensitive to the new conditions brought by climate change. As in the past, they will need to accommodate the new conditions by drawing from their current suite of adaptation strategies or developing new ones, as their current suite of strategies may not be sufficient under a changing climate.

Given Outlook, Cabri and Stewart Valley's close geographic proximity to Lake Diefenbaker, the tourism industry may be one way to stimulate rural economies, although this industry faces potential challenges in the future, especially if river and lake levels decline. The construction of more water storage infrastructure (e.g. dams, reservoirs) may reduce the risk of water scarcity, but if there is no water available, these strategies are useless. Community members feel that anticipatory and proactive water management approaches as well as increased cooperation and communication between and among communities and government are a good starting point in reducing vulnerability to climate change.

CONCLUSION

The rural population of the South Saskatchewan River Basin is heavily reliant on agriculture, and agriculture and climate are inextricably linked. The climatic changes expected in the coming century, and current exposure-sensitivities will only be exacerbated with the attendant warmer winters, higher moisture requirements, and possibly decreased snowpack and thus surface water availability.

Currently, agricultural operations in the SSRB are well adapted to climate change, but these adaptive strategies generally come at an economic cost and are only effective under certain conditions, which may be exacerbated in the future. Thus, there is a direct relationship between the frequency at which some costly adaptive strategies are employed and the overall viability of farm enterprises. In this way, adaptive capacity is a function of available capital resources. In light of the current economic boom, management of problematic conditions has been achieved without widespread farm bankruptcy as there was during the dry years of the early 20th Century. However, if oil revenues dry up or climate change increases the frequency of employing adaptive strategies, the currently high adaptive capacity cannot be maintained. Furthermore, a substantial reduction in overall moisture, particularly in the rivers in the southern portion of the basin, may be beyond the capacity of the system to adapt regardless of the buffer of capital. Finally, it should be noted that an adaptive capacity which is strongly related to the infusion of non-agricultural capital introduces differential vulnerability among producers, particularly the “haves” with oil leases and the “have-nots”.

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