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Dimple Roy
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Executive Summary

Governments must operate in an ever-changing and uncertain world. We know for example that the climate is changing, but not precisely how or what the specific impacts will be—introducing yet more complexity to fields such as agriculture and water resources management. We know that energy prices are highly unpredictable, and that international trade rules are in a state of flux, creating further challenges for development policy. The impact of our economic activity and our cultural connectedness today evoke types of responses in society and our ecosystems for which we have no prior experience.

In this setting, crafting policies to address acute issues, be they economic, social or environmental, is inherently complex and dynamic—this is the reality facing today's policymaker. The climate change issue is a case in point and has provided motivation for this research on adaptive policies. Higher variability in hydrology is projected by the *Intergovernmental Panel on Climate Change* in their most recent report, evoking great concern in such areas as world food supply, power generation and irrigation, just to name a few.

Experience demonstrates that policies crafted to operate within a certain range of conditions are often confronted by challenges outside of that range. The result is that many policies do not accomplish their goals and have unintended or perverse impacts. Therefore, in order to help policies help people, policymakers need ways to craft policies that can adapt to a range of anticipated and unanticipated conditions.

The multi-year *Adaptive Policies* research project endeavours to identify mechanisms that help public policies adapt to anticipated and unanticipated conditions. This report studies farm-level coping and adaptation measures for weather shocks (e.g., flooding) and stresses (e.g., drought), identifies policies that have aided these measures and analyses these policies for their adaptive mechanisms. It is the premise of this research project that policies that have either aided or impeded a farmer's ability to cope with change are also likely to either contain mechanisms that have helped the policy itself adapt to changing circumstances, or expose important policy features that were missing, but are necessary to help the policy perform successfully under changing conditions.

Thirty-three farm-level surveys were conducted for two locations in the southern region of Saskatchewan, Canada (K. Pearce, personal communication, 2007). Based on GIS mapping, it was determined that these two areas were likely to have similar levels of exposure to historic precipitation variability, but varying capacity to adapt. The most prominent weather-related shocks and stresses noted by farmers included: a hailstorm in the summer of 2005;

early frost in August of 2004; single-year droughts; and flooding/excessive moisture in 1999 and 2004.

Among the most common coping and adaptation measures cited by farmers were the following:

- Crop insurance, including government insurance programs and private ones;
- Farm management, including planting multiple crops in multiple locations to avoid total losses;
- Marketing change by selling inferior crops (from incidents of frost) as livestock feed to different buyers;
- Continuous cropping to maintain fertility and organic matter in the soil;
- Minimum-tillage farming;
- Water retention programs;
- Small scale land drainage projects;
- Intentional road cuts by the rural municipalities (RMs) to allow water flow; and
- Later seeding dates

While crop insurance emerged as the primary coping measure to weather-related uncertainties at the farm level in the areas of study in Saskatchewan, we had already assessed this practice and its related policies in a parallel case study in Manitoba. The other widespread practice of minimum-tillage farming (or zero-till farming) to help adapt to single and multi-year droughts (by reducing soil erosion and increasing soil-water retention) and to reduce the input costs of farming emerged as a coping mechanism from the farm-level interviews. One of the policy instruments most influential in this widespread use of minimum-tillage farming was the extension activities of the Saskatchewan Soil Conservation Association (SSCA).

The SSCA's extension activities were analyzed in detail using the methodology tested and documented in the Phase I Research Report of the *Adaptive Policy Project* (IISD and TERI 2006). This analysis is designed to search for adaptive policy mechanisms that have helped a policy respond effectively to *anticipated* and *unanticipated* conditions. The search for adaptive policy mechanisms is organized according to two main categories: those adapting to anticipated conditions and those adapting to unanticipated conditions.

The adaptive policy mechanisms that help a policy adapt to anticipated conditions included:

- **Automatic adjustments**, which monitor key underlying conditions and can trigger adjustments to the policy when necessary.
- **Integrated assessment**, which includes policy rules that are based on a sound assessment of causal factors, key impacts and scenario outlooks and perform well across a range of anticipated conditions including worst cases.
- **Multi-perspective deliberation**, which strengthens policies through a recognition of common values, shared commitment and emerging issues, and provides a comprehensive assessment of causal relationships.

The adaptive policy mechanisms that help a policy adapt to unanticipated conditions include:

- **Formal review and continuous learning**, which mandate periodic reviews of the policy instrument to assess performance and identify emerging issues.
- **Encouraging self-organization and networks**, which encourages interaction and initiative to foster the emergence of innovative responses to unanticipated events, and remove barriers to innovation and learning.
- **Subsidiarity** mechanisms that recognize that action will occur at different levels of jurisdiction, depending on the nature of the issue, and assign priority to the lowest appropriate jurisdictional level for effectiveness.
- **Promoting variation**, which allows for multiple small-scale interventions for the same problem for greater hope in finding effective solutions.

An analysis of SSCA's extension activities for zero-tillage farming reveals several adaptive mechanisms that have allowed SSCA and its extension activities to be successful in the high uptake of zero-tillage farming in Saskatchewan. As an integrated assessment mechanism, the SSCA's zero-tillage programming is based on an understanding of local soil types and farming practices. This ensures a more effective implementation and maximizes the advantages associated with zero-tillage farming.

With regard to mechanisms dealing with unanticipated conditions, we observed that the SSCA ascribes to the principles of subsidiarity, multiple perspectives, variation and self-organization. Devolution of decisions and management (i.e., subsidiarity) is demonstrated through the SSCA's five regional offices, whereby regional agrologists delivered programs and extension operations most appropriate to regional preferences. The value of centralized coordination and not replicating functions was also recognized despite decentralization.

Multiple perspectives are also incorporated through the SSCA's multi-stakeholder board of directors and membership that represent levels of government, the farming community,

agricultural industry and others. The SSCA minimum-tillage promotion has also acknowledged the importance of variation by combining crop rotation practices with zero-till farming. This has improved the performance and management of zero-tillage practice and helped overcome problems faced by zero-till practitioners in the other parts of the country.

Another aspect of complex adaptive systems is the concept of encouraging self-organization and networks. This aspect is demonstrated through the SSCA's farmer-to-farmer program, wherein farmers interested in learning about a zero-tillage-related farming practice are put in touch with a farmer implementing that farming practice. This ensures more direct learning, and also enables social networks that are advantageous for adaptation.

Formal review of SSCA's programs is conducted via an annual conference where the organization takes stock of its functions and determines its future path and actions. This conference allows members and the board of directors to contribute to this process and a formalized system ensures that a review of sorts is conducted even when there is no perceived need for it. As an example, the SSCA has gradually shifted its extension focus from zero-tillage for soil conservation to zero-tillage for soil conservation, carbon sequestration and climate change mitigation as part of shifting priorities at the federal and provincial government levels. While some of this movement has been related to priority shifts in funding sources, the SSCA board of directors and staff have also realized the value of "keeping up with the times" and enabling zero-tillage uptake with all its benefits.

1.0 Introduction

This report documents the second of three community-level case studies to be undertaken in Canada as part of the *Adaptive Policies Project,* a joint multi-year research project of the International Institute for Sustainable Development (IISD), The Energy and Resources Institute (TERI) and the International Development Research Centre (IDRC).

The *Adaptive Policies Project* attempts to address two main questions:

1. *Do public policies that build the capacity of communities to cope with surprise and longer-term change have adaptive features?*
2. *What are the adaptive features that enable policies to remain effective despite changes in external conditions?*

In this case study we report on the results of thirty-three farm-level surveys for two locations in the southern region of Saskatchewan, Canada. The surveys were conducted by Kent Pearce, a Masters candidate with the Natural Resources Institute at the University of Manitoba, Canada. The technical report being prepared by Pearce documents a range of weather-related and non-weather-related shocks and stresses in the region, and adaptive responses cited by farmers for dealing with such stresses. Also reported are incentives and impediments that farmers have experienced in the adoption and implementation of such responses, including public policy and policy instruments.

The fieldwork was supervised by Dr. Fikret Berkes, the current Canadian Research Chair for Community-based Natural Resource Management, and conducted under the auspices of the *Prairie Climate Resilience Project,* managed by IISD's Dr. Henry David Venema. The *Prairie Climate Resilience Project,* funded by Climate Change Impacts and Adaptation Directorate, Natural Resources Canada, was the model used for designing the field methods for the *Adaptive Policies Project.*

2.0 Research Methods

The research methodology used for this community case study is similar to the methodology of the first two community-level case studies undertaken in Manitoba and Saskatchewan. The methodology is based on four logical elements:

- selection of study sites that have been subject to high climatic variability;
- identification of adaptive measures by farmers at those sites;
- establishment of convincing linkages between those measures and the government policies that influenced them; and
- analysis of the policies themselves for adaptive features.

Previous IISD and TERI research has mapped areas of high climatic variability and vulnerability in the Canadian Prairies and in India. The research teams, both in Canada and India, are using this previous research to select case study areas that have been exposed to significant climatic variability/extreme events. The assumption is that community members who remain actively involved in agriculture have had to adapt in order to remain so. Therefore, these high-variability sites will be prime locations for seeking evidence of adaptive measures.

Through local surveys, interviews and other methods, the field researchers identified successful coping and adaptation measures used by farmers. The measures that were identified in the field include individual, household and collective behaviours at the community level. Using a variety of methods and informants, the field researchers studied the linkages between successful or popular adaptation measures and enabling factors that have facilitated these measures. These enabling factors include agricultural and water management policies, as well as other socio-economic and ecological factors.

Policy linkages may be first-order (direct) or second-order, acting through intermediate enabling factors. For example, local respondents may identify the diversification of their agricultural production among various crops with differentiated markets as an important adaptation measure. This behaviour may have been fostered by an intermediate organization (for example, a co-operative) that supports the marketing of different crops and provides market information and advice to farmer-members for a variety of crops. The co-operative itself is not a policy, but there may be national policies that played a strong role in the establishment of co-operatives (for example, financing, purchase agreements and transportation support). Crop diversification is the behaviour, co-operative organization is the key enabling factor, but credit guarantees for farmer co-ops may be an important

second-order policy supporting the diversification of agricultural production. This research may also choose to identify policies that appear to have hampered or constrained local adaptive measures.

Having identified a set of policies that can be linked to the observed and reported coping and adaptation measures, researchers will analyze these for their adaptive mechanisms. This work should help to confirm whether policies that aid local communities to adapt successfully are themselves intrinsically "adaptive."

2.1 Site Selection

Case study site locations were identified using a combination of historical climate data to describe climate exposure (E), and socio-economic data that described adaptive capacity (A). This methodology is founded in the vulnerability approach where system vulnerability (V) is conceptualized as a function of a system's exposure to E and A to deal with those effects. The more exposed a system is to a particular climate stimulus, the greater the system vulnerability; conversely, the greater the adaptive capacity of the system to a given climate event, the lower its vulnerability. Smit and Pilifosova (2003) express this relationship formally as:

$$V_{it}^{\ s} = f\,(E_{it}^{\ s}, A_{it}^{\ s})$$

Where

$V_{it}^{\ s}$ = vulnerability of system i to climate stimulus s in time t

$E_{it}^{\ s}$ = exposure of i to s in t

$A_{it}^{\ s}$ = adaptive capacity of i to deal with s in t

For the Saskatchewan case studies, we selected two case study locations that exhibited similar levels of exposure based on precipitation variability, but exhibited different levels of adaptive capacity based on available socio-economic data.

2.1.1 *Exposure Mapping*

An exposure map was generated based on a coefficient of variability calculated from average precipitation data (1960–2002). The data was compiled by the Prairie Farm Rehabilitation Administration (PFRA) for IISD's *Prairie Climate Resilience Project* (PCRP). The coefficient of variability is presented on Figure 2-2.

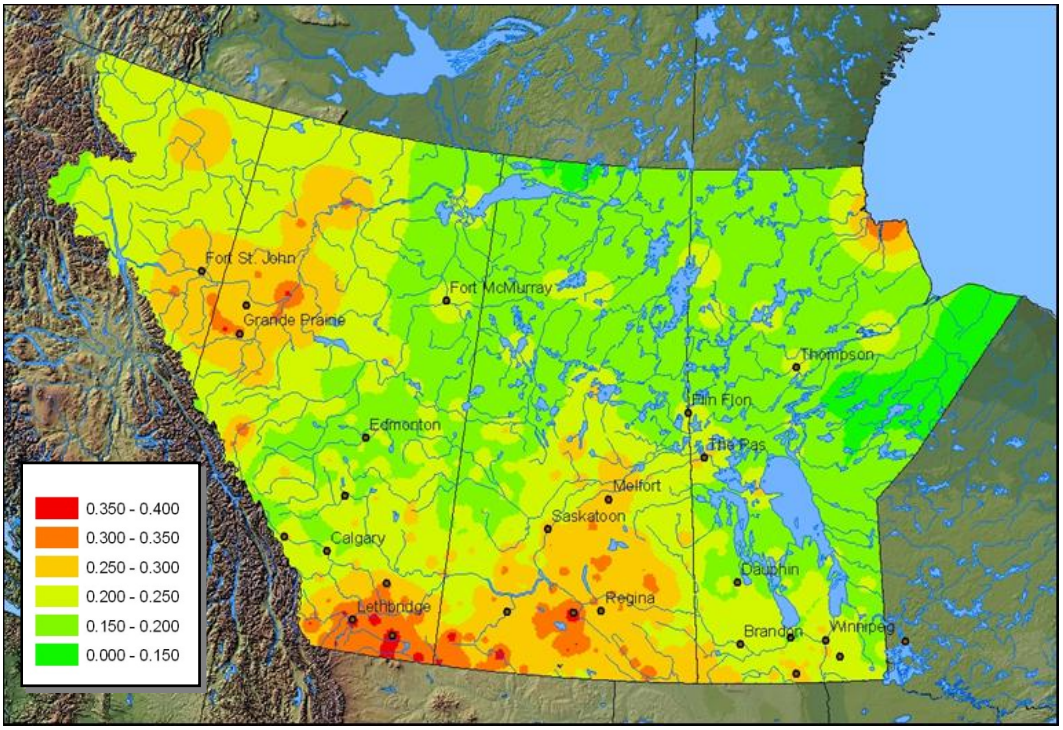


Figure 2-2. Precipitation variability map: Coefficients of variability calculated from average precipitation data (1960–2002)

2.1.2. *Adaptive Capacity Mapping*

As part of the PCRP, socio-economic and environmental data were compiled to map the adaptive capacity across 53 census divisions in the Prairie agriculture region (Swanson *et al.,* 2007). In our analysis, it was possible to extract data for 20 indicators from the 2001 Census of Agriculture and Census of Population relating to six determinants of adaptive capacity: economic resources; technology; infrastructure; information, skills and management; institutions and networks; and equity (based on Smit *et al.*, 2001). We developed an index of adaptive capacity for each of the 53 census divisions in the Prairie agriculture region and then mapped these indices on a relative basis for each census division (i.e., census divisions ranked according to index value).

The results of the adaptive capacity mapping are presented in Figure 2-3. Census divisions exhibiting the highest adaptive capacity were clustered near urban centres in three main corridors (in Manitoba, around Winnipeg extending south along and to the east of the Red River; in Saskatchewan, from the Saskatoon area to Regina; and in Alberta, extending southeast of Calgary to the United States border). Census divisions exhibiting the lowest

adaptive capacity were typically along the northern boundaries of the Prairie agricultural region.

Contributing to the higher adaptive capacity in census divisions near urban centres were aspects such as:

- off-farm earnings;
- diversity of employment opportunities;
- computer technology;
- use of computers in farm management;
- transportation networks;
- email and Internet use to keep abreast of current climate trends and innovative farming practices; and
- opportunities to access agricultural education institutions.

Census divisions along the northern extent of agriculture were disadvantaged with regard to these aspects of adaptive capacity.

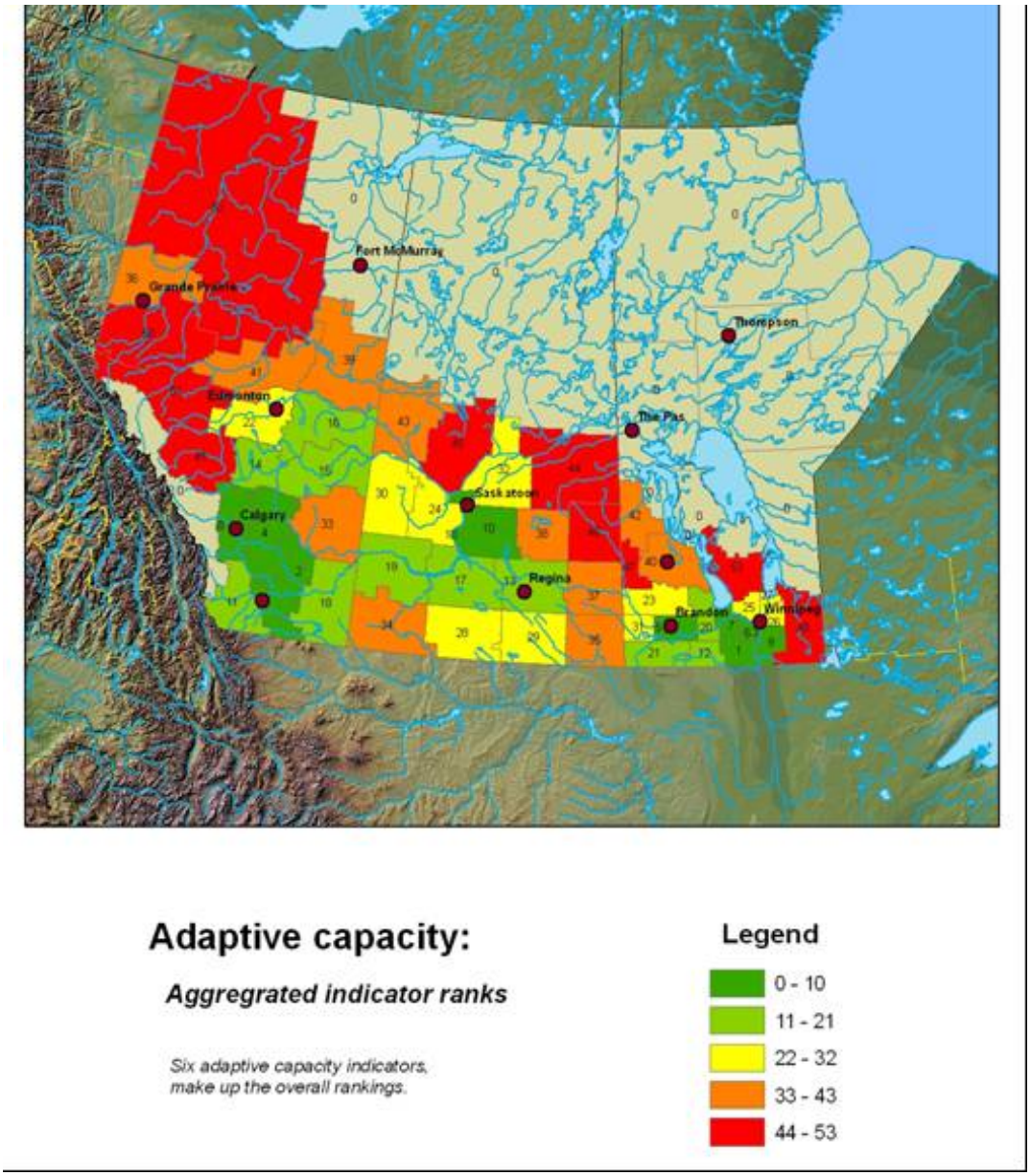
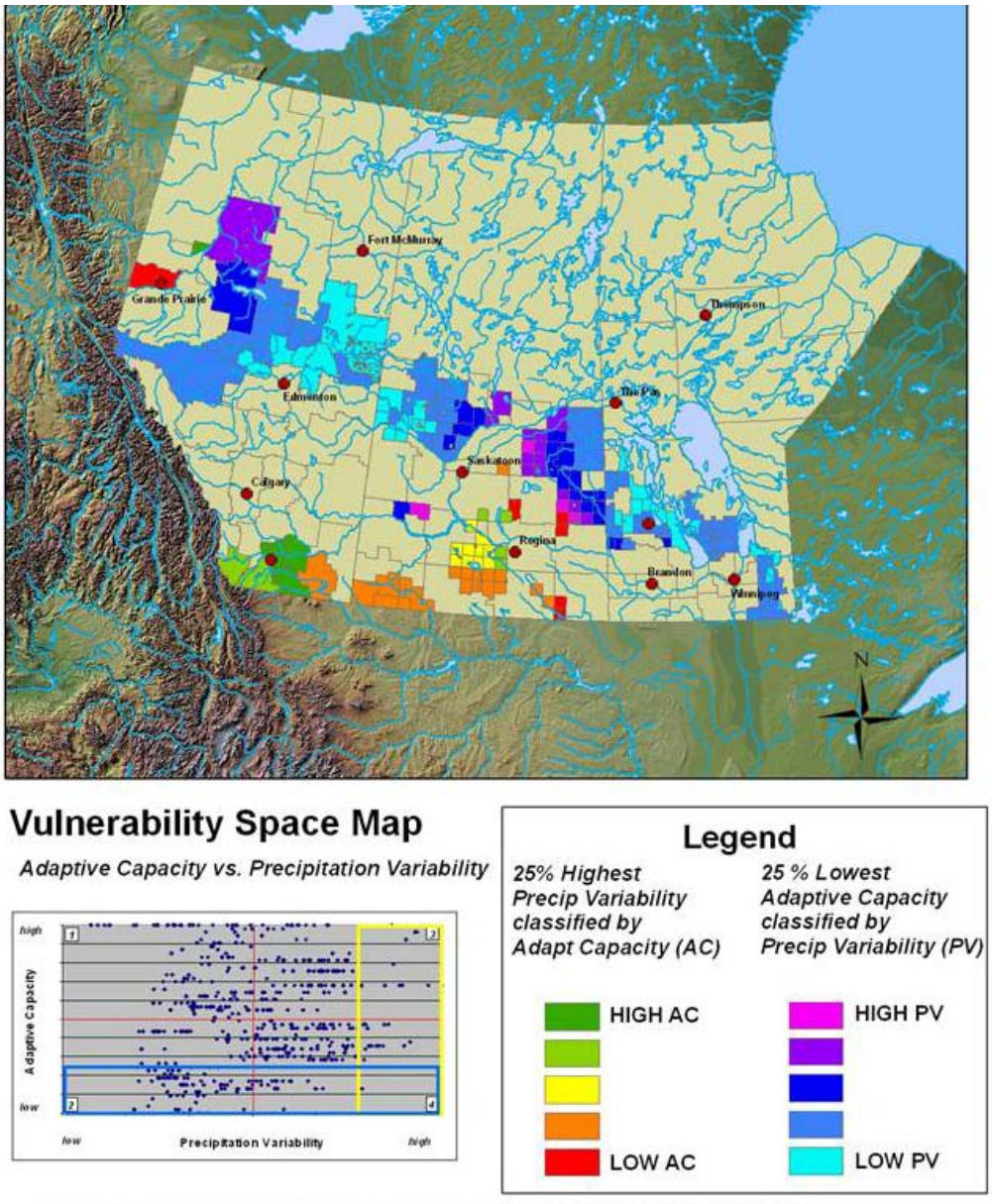


Figure 2-3: Adaptive capacity indices for census divisions in the prairie agriculture region–relative rankings (1 being the highest in rank and 53 being the lowest).

2.1.3. Combining Exposure and Adaptive Capacity Mapping

Field case study locations were identified in Saskatchewan by overlaying the exposure maps (precipitation variability map) with the adaptive capacity map (Figure 2-4). We refer to this map as a vulnerability space map. The intention was to identify two study locations that had similar levels of exposure, but which differed with respect to adaptive capacity.

Based on these criteria, two case study locations were selected, located to the west and southeast of Regina. These locations are shown on Figure 2-5. These two sites are labelled "northern" and "southern" relative to each other. The northern area encompasses the towns of Roleau, Pense, Abernathy and at its most northern boundary, Wynyard. The southern region encompasses the towns of Estevan, Benson, Carlyle and Redvers.



25% areas of lowest adaptive capacity, classified by precipitation variability.
25% areas of highest precipitation variability (exposure), classified by adaptive capacity

Figure 2-4. Vulnerability space map for the Prairie agriculture region

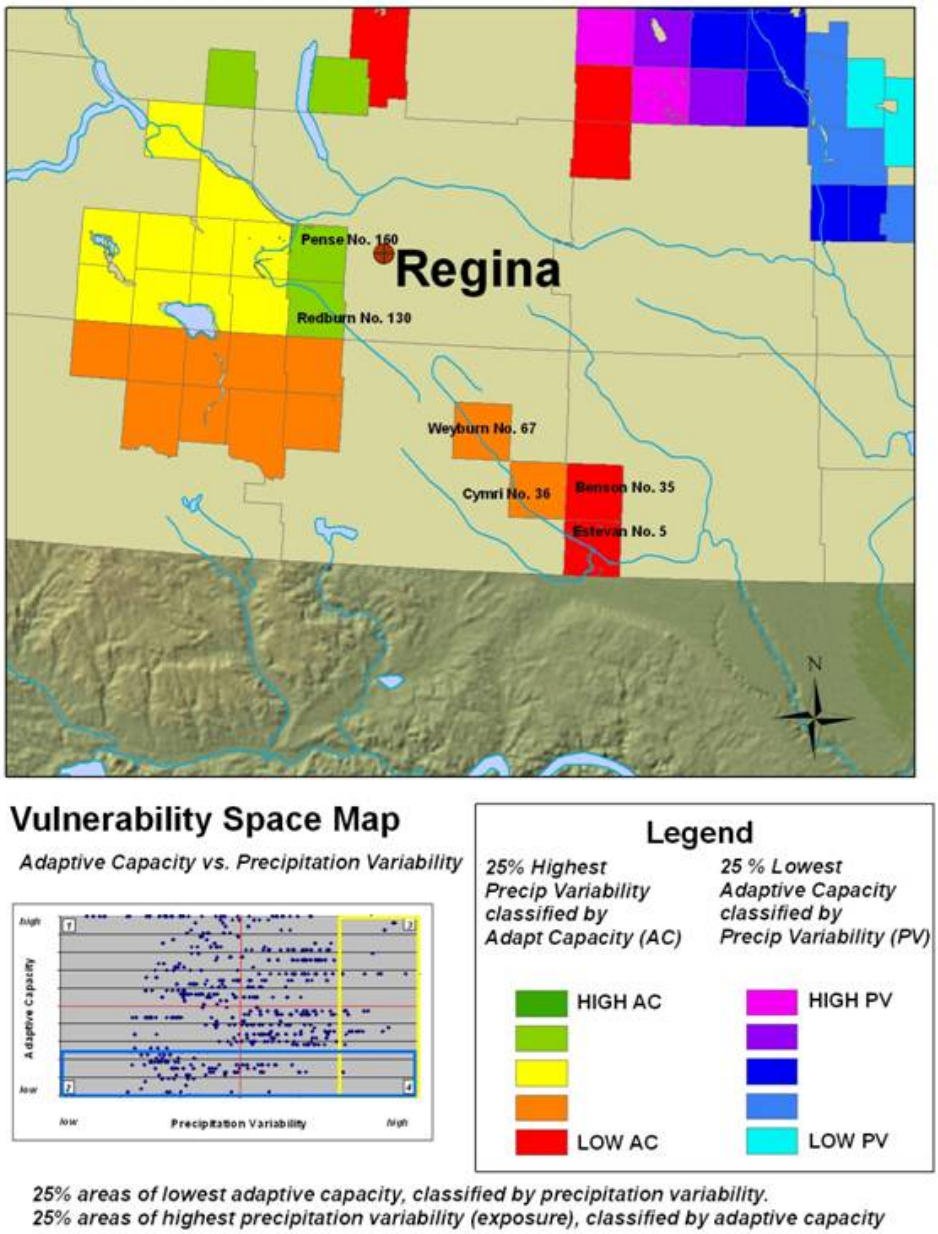


Figure 2-5. Saskatchewan Field Study Locations

2.2 Identifying Community-level Coping and Adaptation Measures

To identify farm-level coping and adaptation measures, field research was conducted by the Natural Resources Institute (NRI) at the University of Manitoba. Kent Pearce, an NRI graduate researcher, under the supervision of Dr. Fikret Berkes carried out research involving initial contact within two case study areas, and subsequent interviews. The

methods described below are excerpts from the field technical report (K. Pearce, personal communication, 2007).

2.2.1 *Farm-level Interviews*

A different interview methodology was used for the Saskatchewan work compared to that used for Manitoba. Pearce used the CRiSTAL tool to facilitate the farm and organizational-level interviews. This **C**ommunity-based **Ri**sk **S**creening **T**ool – **A**daptation & **L**ivelihoods enables project planners and managers to:

> (i) assess an intervention's impact on local capacity to cope with climate stress, and
> (ii) think about how to adjust project activities so that, at the very least, they do not undermine local coping capacity and, where possible, they further enhance coping capacity.

CRiSTAL was developed jointly by the International Institute for Sustainable Development, the Stockholm Environment Institute – Boston, IUCN and Intercooperation.[1]

CRiSTAL uses a Microsoft Excel workbook tool and basic visual programming to help a project manager explore and identify the potential climate change adaptation needs for his/her project. CRiSTAL was modified to suit the interview process necessary for this fieldwork. The benefit of using the computer tool during the interview was explored. The use of CRiSTAL allowed the interviewee to see how his/her responses were being summarized during the interview to identify key livelihood resources and coping strategies, as well as policies that helped or hindered the key coping strategies.

A total of 23 interviews were conducted in the northern study area and a total of 10 interviews were conducted in the southern study area. The structure of the interview using the CRiSTAL tool is summarized in Box 2-1.

[1] See http://www.iisd.org/security/es/resilience/climate_phase2.asp

Box 2-1: Farm-level Interview Questions (K. Pearce, Natural Resources Institute, University of Manitoba)

Interview Categories and Questions

Section 1: Farm Data

- Interview number
- Name
- Location
- Please briefly describe your operation including both size and type
- Have you changed your farming operation in the last five years?

Section 2: Historic Weather Events and Coping Strategies (now called adaptation measures in the report)

- Weather Events
- Coping Strategies
- Notes/additional comments

Section 3: Impacts of weather events on farm resources

- Impacts on natural resources on farm
- Impacts on farm infrastructure
- Impacts on financial resources
- Impacts on human resources
- Impacts on social/community resources

Impacts of policies/programs on farm-level resources

- Impact of program/policy on resources most negatively affected by weather events
- Impact of program/policy most important to coping

2.3 Policy Identification and Analysis

A set of criteria helped guide the selection of policies for further analysis of adaptive policy mechanisms. These criteria included:

- The policy is related to agriculture and water resources management.
- The policy is mentioned by more than one interviewee.
- The policy has been implemented in different locations, or over a long period of time, with some common basis of design.
- Information is available and the persons involved with the policy are accessible.
- The policy is not too outdated.
- The policy has been helpful or neutral over time, but not a constraint on adaptation.

Once an appropriate policy has been identified using the above criteria, it is analyzed for its adaptive mechanisms. These mechanisms and their supporting principles are summarized in

Table 2.1. A policy that has the ability to adapt to "anticipated conditions" is built upon insights into cause-and-effect relationships. Mechanisms include:

- **Automatic Adjustment** – Some of the inherent variability in socio-economic and ecologic conditions can be anticipated, and monitoring can help trigger important policy adjustments to keep the policy functioning well.
- **Integrated Assessment to Inform Policy Parameters** – Through an integrated assessment of causal factors, key impacts and scenario outlooks, policies can be crafted to perform under a range of anticipated conditions, and possibly function even in worst cases.
- **Multi-perspective Deliberation** – Deliberative processes strengthen policy design by building a recognition of common values, shared commitment and emerging issues, and by providing a more comprehensive understanding of cause-and-effect relationships.

The ability of a policy to adapt to "unanticipated conditions" is a newer notion, based on a holistic appreciation of system complexity, capacity, performance and dynamics. Mechanisms include:

- **Formal Review and Continuous Learning** – Policy review undertaken on a regular basis, even when the policy is functioning well, can help policies deal with "emerging" issues, and trigger policy adjustments.
- **Encouraging Self-organization and Networking** – By encouraging interaction, policies can foster the emergence of innovative responses to unexpected events.
- **Subsidiarity** – By recognizing that action will occur at different levels of jurisdiction, depending on the nature of the issue, policies can be crafted to assign priority to the lowest jurisdictional level of action consistent with effectiveness.
- **Promoting Variation** – Small-scale interventions for the same problem offer greater hope of finding effective solutions. Diversity facilitates the ability to persist in the face of change.

An analysis of the complete policy chain is necessary to identify important mechanisms that help policies adapt to shocks and stresses. The policy chain is a depiction of the stages of policy design and implementation as they pertain to the roles and responsibilities of the different actors involved. Figure 2-7 presents an idealized process of policy design and implementation. Policies are designed with varying degrees of consultation with relevant stakeholders and it is typically the case that an institution or organization different from the one that designed the policy is responsible for implementing the policy.

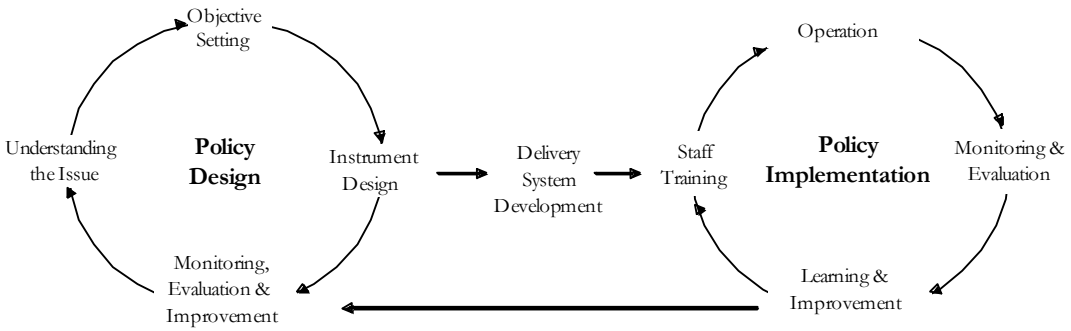


Figure 2-7. Idealized illustration of policy design and implementation.

Table 2.1. Framework for Adaptive Policies

Objectives	**Adapting to anticipated conditions**			**Adapting to unanticipated conditions**			
Analytical basis	*Analysis of cause/effect and outcomes*			*Holistic appreciation of system complexity, capacity, performance and dynamics*			
Adaptive policy principles	▪ Fine-tune the process.[4] ▪ Incorporate monitoring and remedial mechanisms.[8] ▪ Understand carefully the attribution of credit.[9]	▪ Respect history[14] ▪ Understand local conditions, strengths and assets.[4] ▪ Place effort on determining significant connections rather than measuring everything.[9] ▪ Look for linkages in unusual places.[9]	▪ Gather multiple perspectives from range of stakeholders.[8] ▪ Use deliberative practice to build trust and consensus.[10] ▪ Use epistemic communities to inform policy design and implementation.[11]	▪ Conduct selection by evaluating performance of potential solutions, and selecting the best candidates for further support.[4] ▪ Policies should test clearly formulated hypotheses.[5] ▪ Evoke disturbance.[6]	▪ Create opportunity for self-organization and build networks of reciprocal interaction.[4, 6] ▪ Promote effective neighbourhoods of adaptive cooperation.[9] ▪ Facilitate copying of successes.[9] ▪ Ensure that social capital remains intact.[12]	▪ Match scales of governance and ecosystems.[6] ▪ Clearly identify the appropriate spatial and temporal scale to enable integrated management.[13]	▪ Promote variation, diversity[4, 6] and redundancy.[6]
Adaptive policy mechanisms	**Automatic adjustment**	**Integrated assessment**	**Multi-perspective deliberation**	**Formal review and continuous learning**	**Encouraging self-organization and networks**	**Subsidiarity**	**Promoting variation**
	Some of the inherent variability in socio-economic and ecological conditions can	Through an integrated assessment of causal factors, key impacts and scenario	Deliberative processes strengthen policy design by building recognition of common values,	Policy review undertaken on a regular basis even when the policy is functioning well, will help policies	Encourage interaction and initiative to foster the emergence of innovative responses to unanticipated	Subsidiarity recognizes that action will occur at different levels of jurisdiction,	Small-scale interventions for the same problem offers greater hope of finding effective

	be anticipated, and monitoring can help trigger important policy adjustments to keep the policy functioning well.	outlooks, policies can be crafted to perform under a range of anticipated conditions, and possibly function even in worst cases.	shared commitment and emerging issues, and by providing a comprehensive understanding of causal relationships.	deal with "emerging" issues, and can trigger policy adjustments to conditions that could not have been anticipated.	events. Provide space for flexible responses and reduce barriers to collaboration and learning.	depending on the nature of the issue. It assigns priority to the lowest jurisdictional level of action consistent with effectiveness.	solutions.[4] Diversity facilitates the ability to persist in the face of change, and spreading risks is part of managing complex systems.[6]

Table Notes:

[1] Senge, 1993.
[2] Dewey, 1927
[3] Walker *et al.*, 2001, 282–289
[4] Glouberman *et al.*, 2003
[5] Lee, 1993
[6] Berkes *et al.*, 2003
[7] IISD, 1994
[8] Holling, 1978
[9] Axelrod and Cohen, 2000
[10] Forester, 1999
[11] Haas, 1992
[12] Ruitenbeek and Cartier, 2001
[13] IUCN, 2000

3.0 Observed Community-level Coping and Adaptation Measures

3.1 Socio-Economic and Ecological Context

The prairie region stretches across 550,000 square kilometres, spanning the provinces of Manitoba, Saskatchewan and Alberta. Prairie agriculture takes place in a physiographic region known as the Western Interior Basin, which includes the northern portion of the Great Plains "ecozone," essentially the northern geographic limit of arable land in North America.

For the prairie agriculture region, the combination of fertile soils and—on average—adequate precipitation, have generally been favourable to agricultural production since the original settlement. The region is home to approximately 170,000 farm operators (Statistics Canada, 2001), representing 80 per cent of all farms and total farm area in Canada. Red meats, grains and oilseeds typically account for over 80 per cent of market receipts (Statistics Canada, 2001).

Both of the case study locations lie within the famed Palliser Triangle. From 1857 to 1860, Captain John Palliser led a group of scientists into what was then the virtually unknown (to Europeans) territory lying west of what is now Manitoba. Palliser's group, known as the British North American Exploring Expedition, was charged by the government of the day with exploring, studying, and mapping the plains between the North Saskatchewan River and the American border (see Figure 3-1). They identified a triangular region roughly bounded by the lines adjoining Cartwright, Manitoba; Lloydminster, Saskatchewan; and Calgary, Alberta. This area has become known as the Palliser Triangle, an arid region unsuitable for settled cultivation. Palliser warned that disaster would befall those who tried to settle the region.

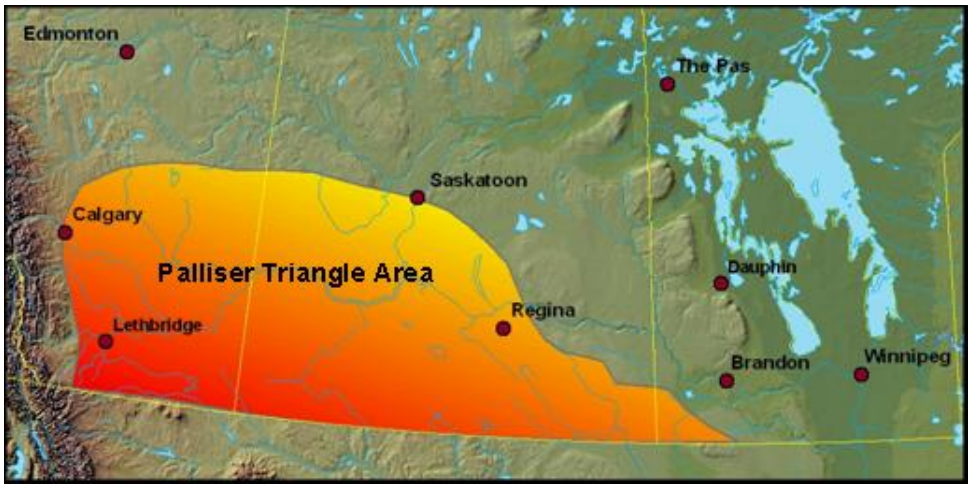


Figure 3-1. The Palliser Triangle within the Prairie agricultural region (from Spry, 1968; in Lemmen *et al.*, 1997)

Census data used to approximate adaptive capacity across the Prairie agricultural region suggests that farms situated within the north case study area, on average, have more economic resources at their disposal (e.g., income, off-farm earnings, diversity of employment opportunities), more technology (e.g., water access, computers, machinery) more infrastructure (e.g., better soils, roads), and have more access to agricultural institutions and networks (e.g., email and Internet use, proximity to educational institutions), relative to the south case study area.

Table 3-1. Relative adaptive capacities in the two study areas as assessed using census level data

Adaptive Capacity Determinant	**North Study Area Relative Adaptive Capacity** (Ranking out of 52 Prairie Census Divisions)	**South Study Area Relative Adaptive Capacity** (Ranking out of 52 Prairie Census Divisions)
Economic resources	11th	48th, 47th
Technology	17th	26th, 30th
Information, skills and management	28th	31st, 35th
Infrastructure	6th	43rd, 26th
Institutions and networks	4th	16th, 33rd
Equity	31st	12th, 18th

Overall Adaptive Capacity	**13th**	**29th, 35th**

3.2 Weather-related Shocks and Stresses

Field interviews in the two selected regions of Saskatchewan were undertaken and reported by Pearce (K. Pearce, personal communication, 2007). The same weather events were almost universally noted in every interview performed. These include:

1. A hailstorm in the summer of 2005
2. Early frost in August of 2004
3. Single-year droughts
4. Flooding/excessive moisture in 1999 and 2004

The field interviews included further questions on the impacts of these extreme weather events and revealed the following major impacts:

Hailstorm of 2005 – There was crop damage/loss of 50 per cent or greater in the area directly affected by the storm. This damage resulted in income loss as well as increased on-farm labour due to the difficulty faced in harvesting the damaged crops.

Early frost of August 2004 – The early frost had a large impact on local farming, including massive crop damage/loss and income loss. The losses varied but some farmers lost their entire crop. This resulted in at least one interviewee retiring from farming. Other impacts included added field operations such as soil movement to maintain organic matter in the soil.

Single-year droughts – For the most part, the RMs of Pense and Redburn are fortunate because they are situated on Regina heavy clay soil type. The high clay content in the soil helps minimize the impact of single-year droughts; however, if the drought lasts more then a year, the negative impacts are enhanced. Drought is a constant in Saskatchewan resulting in some interviewees not recognizing recent draughts as extreme weather events. The impacts of single-year droughts in the area include crop damage/loss, grasshopper infestations and reduced year-end crop residue.

Flooding/ Excessive moisture – The Regina heavy clay in the RMs of Pense and Redburn makes it vulnerable to flooding. This part of the province is extremely flat and roadside pooling resulting in washouts is a problem. The impacts of excessive moisture noted in the area include crop damage/loss, income loss, increased insect activity and slow crop growth.

3.3 Coping and Adaptation Measures

Short term measures adopted by farmers to deal with weather-related shocks are termed *coping measures* and long-term behaviour change adopted by farmers to deal with long term weather-related stresses are termed *adaptation measures*. Both are relevant to the scope if this study and are recorded as part of the case study.

The farm-level coping and adaptation measures observed through the farm interviews in the Saskatchewan study areas are summarized below in Table 3-2.

Table 3-2: Farm-level Adaptation Measures

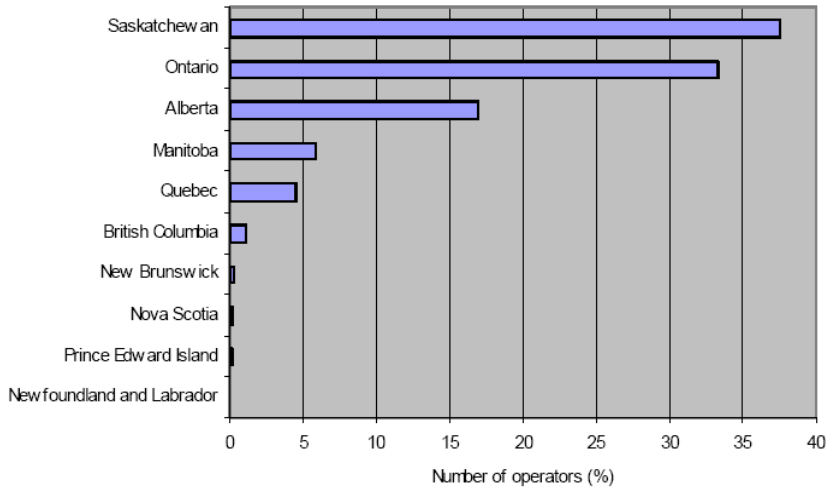
Stress	Coping and Adaptation Measures
Hailstorm of 2005	The most prevalent coping strategy for the hailstorm of 2005 was a heavy reliance on *private insurance*, Saskatchewan crop insurance and, most importantly, hail insurance. Some farmers did not purchase hail insurance, as they perceived the risk as not being high enough to warrant the cost. One interviewee noted that his father-in-law never purchased hail insurance as devastating events such as a massive hailstorm, flood, drought or frost were once in a lifetime events. Ironically all these events have occurred since the son-in-law took over the farming operation in 1995. A concern brought up was the basic insurance fact that every insurance claim made increases premiums, therefore when hit with multiple yearly events, insurance costs can become a major concern. Other coping strategies mentioned include on-farm management (planting multiple crop varieties in several locations to prevent total losses) and combining everything (plus mowing in certain areas) to remove debris from the field.
Early Frost of August 2004	The early frost of 2004 was so severe in the area that for many farmers the only coping strategies available were to *take the loss, claim insurance* if possible and increase their lending to keep the operation going. For farmers that could salvage some crop, the reduce quality resulted in their coping strategy being a *marketing change*. Since the normal buyers would not accept the product in its condition, the crop was sold as livestock feed to different buyers.
Single Year Droughts	During periods of drought, reduced crop quality and/or loss results, many farmers again turn to *crop insurance*. Farm coping strategies that have proven effective in the area include *continuous cropping*—maintaining the fertility program to ensure the soil maintains a high level of organic matter for moisture retention—and using *minimum tillage (including zero-till)* farming practices. Many farmers seem to be very supportive of *water retention projects*. Programs started by the PFRA in the 1930s are popular. It was noted that during the 1970s, many area farmers had the tendency to remove vegetation and water retention measures in favour of maximizing farmable land area. Today most area farmers acknowledge that drought is a common occurrence in Saskatchewan and preventative projects that help maintain soil moisture level should be promoted and funded.

Flooding/ Excessive moisture	The majority of water issues in the area occur in the springtime, which impacts seeding time. Coping strategies used in the area include *small scale land drainage projects*, intentional road cuts by the RM to allow for water flow, *later seeding dates* and *water avoidance*.

Among the most common coping and adaptation measures cited by farmers were the following:

- Crop insurance, including government insurance programs and private ones)
- Farm management, including planting multiple crops in multiple locations to avoid total losses
- Marketing change by selling inferior crops (from incidents of frost) as livestock feed to different buyers
- Continuous cropping to maintain fertility and organic matter in the soil.
- Minimum tillage farming
- Water retention programs
- Small scale land drainage projects
- Intentional road cuts by the RM to allow water flow
- Later seeding dates

The practice of minimum tillage is particularly noteworthy given the prevalence of the practice in Saskatchewan relative to other provinces including Manitoba. Statistics Canada claims that climate, soil characteristics and geographical factors influence the types of crops that are grown in different regions of the country. They demonstrate, in Figure 3-2, that while Ontario is an exception, where 33 per cent of all operators use zero-till, this practice is predominantly a Prairie practice. Saskatchewan leads all provinces with 38 per cent of them practicing zero-till on all or some of their land, followed by Ontario at 33 per cent, Alberta at 17 per cent and Manitoba at 6 per cent (Statistics Canada 2001).



Source: 2001 Census of Agriculture

Figure 3-2. Zero-tillage practices in Canada.

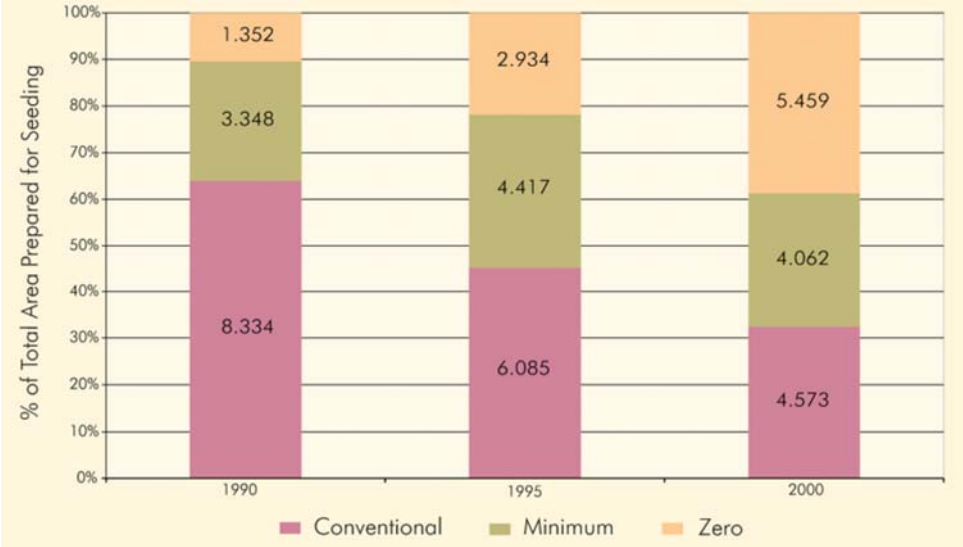


Figure 5-2. Trends in tillage practices, Saskatchewan, 1990–2000 (Canadian Plains Research Center. Accessed September 23, 2007 from: http://esask.uregina.ca/entry/soil_conservation.html).
Note: Figures are in millions of hectares.

Zero-till farming (also known as no-till or conservation tillage farming) is a way of growing crops from year to year without disturbing the soil through tillage. Tillage collapses the pores and tunnels that were constructed by soil animals, and changes the water holding, gas and nutrient exchange capacities of the soil. Reduced tillage and particularly no tillage, reduce soil disturbance, increase organic matter content, improve soil structure, buffer soil temperatures and allow soil to catch and hold more melt and rain water. No tillage soils are more biologically active and biologically diverse, have higher nutrient loading capacities, release nutrients gradually and continuously, and have better soil structure than reduced or cultivated soils (Clapperton, n. d.).

Producing crops involves regular tilling, which agitates the soil in various ways, usually with tractor-drawn implements. Tilling is used to remove weeds, mix in soil amendments like fertilizers, shape the soil into rows for crop plants and furrows for irrigation, and prepare the surface for seeding. This can lead to unfavourable effects, like soil compaction; loss of organic matter; degradation of soil aggregates; death or disruption of soil microbes, arthropods and earthworms; and soil erosion where topsoil is blown or washed away. Zero-till farming avoids these unfavourable effects by reducing or excluding the use of conventional tillage.

4.0 Policies Facilitating Coping and Adaptation Measures

The original policies that encouraged the adoption of zero-till by Saskatchewan farmers were a series of soil conservation policies from the 1970s and 1980s. That period in Canadian Prairie history reproduced elements of the dry dust bowl years of the 1930s and large amounts of topsoil were lost to wind erosion. Dry spells and the practice of summer fallow adopted by many Saskatchewan farmers as a means to conserve weeds and conserve moisture led to soil erosion and the loss of soil nutrients. Another factor in the success of zero-tillage in Saskatchewan can be attributed to the Saskatchewan Soil Conservation Association (Beckie, 2000)

> *"Soil erosion may well by the most underrated yet most damaging natural resource problem of the 80s. Must we wait for crisis conditions before action is taken to safeguard our scarce and dwindling soil resource base?"*[2]

A Standing Committee on Agriculture, Fisheries and Forestry agreed to investigate the problems of soil degradation and decided to hold hearings throughout the country to try and find out what was being done by farmers, by researchers and by government. The standing committee, through all its consultations, discovered that there was, in fact, an urgent need and the necessary pressure for consolidated action on soil conservation and made recommendations in its report (Sparrow, 1984) *against* summer fallow and *for* practices such as conservation tillage, crop rotations, grass waterways and the use of winter cover crops. They commented on the need for research and directed extension to convince farmers of the need to change their practices and for the need for good "Soil and Water Conservation Institutes at a regional level to develop cost effective conservation techniques." This institutional role, according to the standing committee report, was not being fulfilled any existing instate or agency.

One of the regional institutes formed as a result of action on the standing committee's report was the Saskatchewan Soil Conservation Association (SSCA). The SSCA was formed in 1987 by a group of producers who saw the need to increase the public's awareness of soil conservation and to share soil conservation information with others. The SSCA is a non-profit, producer-based organization whose mission is "to promote conservation production systems that improves the land and environment for future generations." While the formation was a "bottom-up" process of concerned farmers associating to work together on a common cause, the report made it possible for this regional organization to get adequate

[2] Opening quote in a Report on Soil Conservation by the Standing Committee on Agriculture, Fisheries and Forestry to the Senate of Canada, 1984.

federal and provincial funding to conduct a range of research, technology development and outreach functions. Today the Saskatchewan government displays the increase in conservation tillage (including zero-till) agriculture and decrease in summer fallowing on its website and attributes these changes to consolidated efforts by teamwork across the province by farmers, associations, researchers, equipment manufacturers and industries, as well as government.[3]

While soil conservation was the over-arching mandate, the SSCA has also worked on climate change policy, technology transfer, communication activities and extensive extension work across the province of Saskatchewan.

Zero-till is a coping response that helped Saskatchewan farmers deal with excess moisture (floods) and droughts. An analysis of the practice and popularization of zero-till in Saskatchewan revealed that the practice emerged from a combination of grassroots innovation, academic research and data and government priorities, funding and outreach. While this mix came through in most of our interviews and correspondence with regional experts on soil conservation, the overall impetus was provided by a federal and provincial priority area and policies on soil conservation from the early 1980s. This priority area helped with the funding, support and development of the SSCA, which was attributed with the increasing popularity of zero-till in Saskatchewan.

Zero-tillage agriculture not only helps with the soil conservation and nutrient management from agricultural sources, but also saves labour and energy use in crop production. The reduced use of fossil fuels leads to reduced emissions of carbon dioxide. Through zero-till and permanent cover crops, carbon sinks are created by plants that remove carbon from the air and store it in the soil. Because zero-till adoption increases soil organic matter, Saskatchewan producers have been able to decrease carbon dioxide emissions into the atmosphere by 3.83 million tonnes. These are being absorbed into international and national voluntary carbon offset trading programs.

For our policy review for the purpose of this research, we have examined the adaptive capacity of the SSCA with respect to the practice of zero-till as an adaptation measure.

Remarks from many of the experts interviewed for this policy analysis are summarized below.

[3] News release on National Soil Conservation Week at http://www.gov.sk.ca/news?newsId=a07cc937-e3cb-4ae5-a820-ae60885b9745

A big factor in zero-till becoming popular in Saskatchewan was the establishment of the organization Saskatchewan Soil Conservation Association (SSCA) in the late 1980s. The Saskatchewan Agriculture department supported SSCA in the early years by allocating staff for several extension positions. They established a mandate of promoting zero till and conducted field days and meetings across Saskatchewan.

Doug McKell (Soil Conservation Council of Canada)

The AAFC research stations at Indian Head, Swift Current and Melfort had zero-till days during the early 1990s that were very well attended. This was a significant source of information. The SSCA was also a very big driver.

Richard Gray,(University of Saskatchewan)

In Saskatchewan, zero-till was supported through cost sharing of university or ENGO research projects through the Agri-Food Innovation Fund, and through financial support to the SSCA. SSCA undertook the bulk of the applied research and demonstration that turned zero till from a technology into a proven farming system. SSCA received strong scientific support by research scientists from AAFC and the Universities.

Malcolm Black (Agriculture and Agri-Food Canada)

PFRA operated a pilot project through the ERDA program in the late-80s that helped establish demonstrations through local soil conservation clubs. In the late 80s, the federal government signed federal-provincial "Accords on Soil and Water Conservation" to be the basis of future joint programs. The National Soil Conservation Program operated in each province from 1990-93 with matching provincial funding. This program was a major effort. In Saskatchewan, $54,000,000 was spent over 3 years to promote soil conservation practices. The on-farm demonstration program was called the Save Our Soils program. It demonstrated a wide variety of soil conservation practices including zero-till. The SSCA coordinated the provincial extension effort for the program. It was apparent early on that zero-till was attracting the most interest from farmers. The program, driven by local ADD boards, began to emphasize Direct Seeding (zero-till still had negative connotations). SSCA focused the provincial extension effort towards direct seeding. This included the Annual Direct Seeding Conference and the development of the Direct Seeding Manual and direct seeding courses for farmers.

Blair McClinton (SSCA)

SSCA's focused extension effort helped farmers bring it all together. This last point was one area where Saskatchewan differed from the other Prairie provinces. Adoption in Saskatchewan was much higher in the early 90s than in either Alberta or Manitoba. Many

attributed this to SSCA's coordinated extension effort. In response, the Alberta Reduced Tillage Initiative (ARTI) was established in 1994, modelled on SSCA's efforts.

Blair McClinton (SSCA)

The AAFC research stations at Indianhead, Swift Current and Melfort had zero-till days during the early 1990s that we very well attended. This was a very significant source of info. The Saskatchewan Soil Conservation Association was also a very big driver.

Richard Gray (University of Saskatchewan)

5.0 Extension Activities of the Saskatchewan Soil Conservation Association (SSCA): An adaptive policy analysis

Minimum and zero-tillage practices are one measure used by farmers in Saskatchewan to adapt to single and multi-year droughts in Saskatchewan through conservation of soil and soil moisture and reduction of farm input costs. Soil and water conservation policies of the federal government enabled the formation of the Saskatchewan Soil Conservation Association (SSCA). As described in Section 4, the SSCA used extension activities to build capacity and help spread the practice of zero and minimum tillage in Saskatchewan.

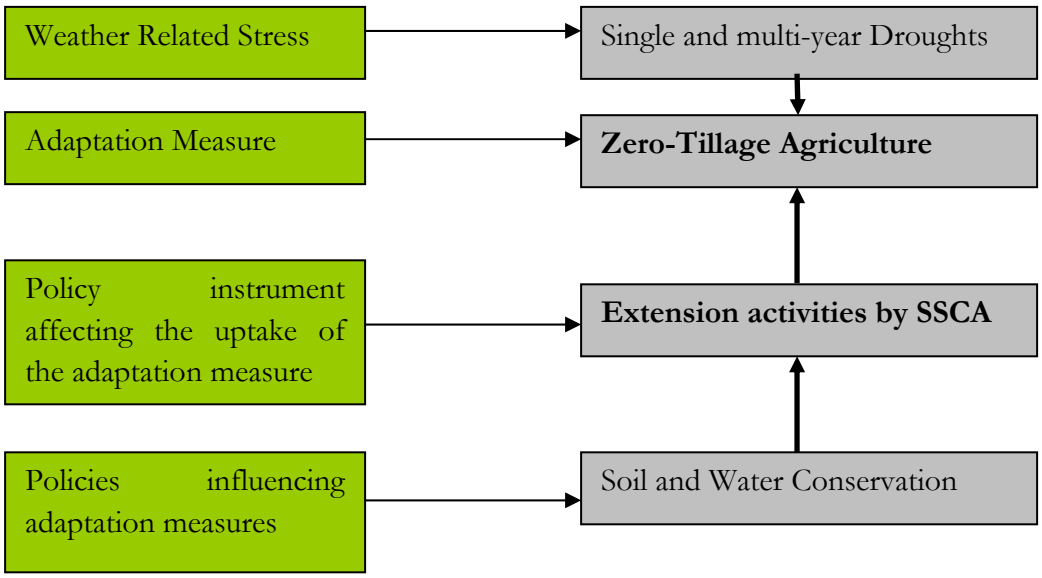


Figure 5-1. Relationship between the soil conservation policy, the SSCA extension policy instrument and the zero-tillage adaptation measure.

This section describes the SSCA's extension activities in more detail and analyzes the activities to identify adaptive policy mechanisms. Described below are the policy intent, specific changes, drivers and impacts of the policy instrument, and the adaptive policy mechanisms.

5.1 Policy Intent

The SSCA is a non-profit, producer-based organization whose mission is "to promote conservation production systems that improve the land and environment for future generations."

The SSCA is recognized as having taken a lead role in promoting zero-tillage in the

province. The organization is funded by Agriculture and Agrifood Canada and the Saskatchewan government through a number of programs, including the Green Plan and the Agri-Food Innovation Fund (D. Haak, personal communication, 2007). The SSCA also receives support from some crop input and energy companies, with the latter group pushing to have zero-till recognized for generating carbon credits (D. Haak, personal communication, 2007).

5.2 Policy Changes, Drivers and Impacts

The history of zero tillage and soil conservation programming relevant to Saskatchewan is depicted on Figure 5-3. In 1986, a group of enterprising scientists and farmers from Saskatchewan decided that Saskatchewan needed a soil conservation group like the Manitoba North Dakota (ManDak) Zero Tillage Farmers' Association and the Alberta Conservation Tillage Society (ACTS). This group came together to explore the possibility of such a group in Saskatchewan.

They submitted a proposal to the Agriculture Development Fund for a study to gauge producer interest in a provincial soil conservation group. Approval and funding for the project enabled the hiring of a coordinator and subsequently meeting dates were set.

One of the first meetings included cross-sectoral representation from government, academia and the farming community. Representatives from interested groups were also invited to discuss the formation of a provincial soil conservation group.

The coordinator then set out on a cross-province tour to discuss the idea with producers. He met with people identified by PFRA and agriculture representatives who might have been interested in various aspects of soil conservation. From each of the seven meetings, two reps were selected to attend another meeting in Saskatoon along with reps from the University of Saskatchewan. It was then that it was decided to hold a meeting in conjunction with the ManDak Zero Tillage Farmer's Association's Annual Conference in Regina.

At this point, the group hired a general secretary to co-ordinate activities between the official directors' meetings. With a secretary in place, the Saskatchewan Soil Conservation Association was essentially formed as a full-fledged organization with a constitution, bylaws and as an incorporated body by the spring of 1987. The first SSCA newsletter was produced in April 1988. Over the course of the next couple of years, the final touches were being put on the Canada-Saskatchewan Agreements on Soil and Water Conservation. When the federal government indicated it would like to see a provincial group involved in the soil conservation program, SSCA really got its formal support and mandate.

With funding from the Agriculture Development Fund, the SSCA began to hire staff. "The

original concept of SSCA was now like the ManDak model[4]—farmers sharing information by coming together once a year," said Glen Shaw, the first Executive Director of the SSCA (Polegi, 2005). The Soil Conservation Agreement provided funding that enabled the hiring of staff and widespread extension activities.

The first staff members attribute the success of SSCA to good timing. According to John Kiss, one of the first staff hired at the SSCA, "at the time that SSCA received its contract from the Agriculture Development Fund, there were serious concerns in the communities about the environment: grain prices were low, the price of Roundup dropped, and equipment manufacturers began focusing on new markets and new machines at that time. The producers were willing to change and try something different." (Polegi, 2005)

In the next few months, John and the Board's executive conducted countless interviews until specialists and regional soil conservationists were hired and in place by January, 1990.

Highlights of the organization's activities include an annual conference and tradeshow; field days (two per year); working with the Save Our Soils program; Town Hall meetings; Prairie Steward; Forage handbooks; Direct Seeding manual; SSCA videos; Project Soils; "Guide to Conservation Programs" handbook; Kitchen Table meetings; Half Ton Tours; Conservation Learning Centre; conservation awards and involvement with the Saskatchewan Soil Enhancement Research Project. Most of these activities are components of zero-till extension, education and technology innovation for zero-tillage farming practice.

In the early days, involvement and participation in soil conservation was not high. According to an early staff report, the extension staff managed to attract very few people to events around soil conservation. But participation peaked in the 1990s and early 2000s. The annual conference attracted hundreds of people; an average of 1,200 attendees between 1994–2001, down to 800–900 people in the next few years and then steadying at 300–400 attendees. The conference is called the Direct Seeding conference, since direct seeding is an integral part of conservation and zero-tillage and has fewer negative connotations than the term *zero-tillage*.

People involved with the SSCA believe that minimum and zero-tillage would never have moved so fast without the extension efforts of the SSCA. Jim Halford, the original secretary of the SSCA, sees some real differences in the SSCA and the level of soil conservation knowledge among producers: "When the SSCA was first formed we decided it should have a broad focus, although now it is almost completely working on zero tillage and related functions." He attributes this focus to funding sources and mandates. "With regards to the

[4] The Manitoba-North Dakota Zero Tillage Farmer's Association (www.mandakzerotill.org) was a model for the development of the SSCA structure and functions.

knowledge level of producers, in 10 years, the need for soil conservation and knowledge of it has changed a lot. Ten years ago, we talked about the basics of zero-tillage. Today, we're talking about improved changes. Back then, people didn't even believe you could grow a crop without tillage! The technology has changed, the information level has changed. Our activities have to be more advanced such as demonstrations on a large piece of land for a number of years." (Polegi, 2005)

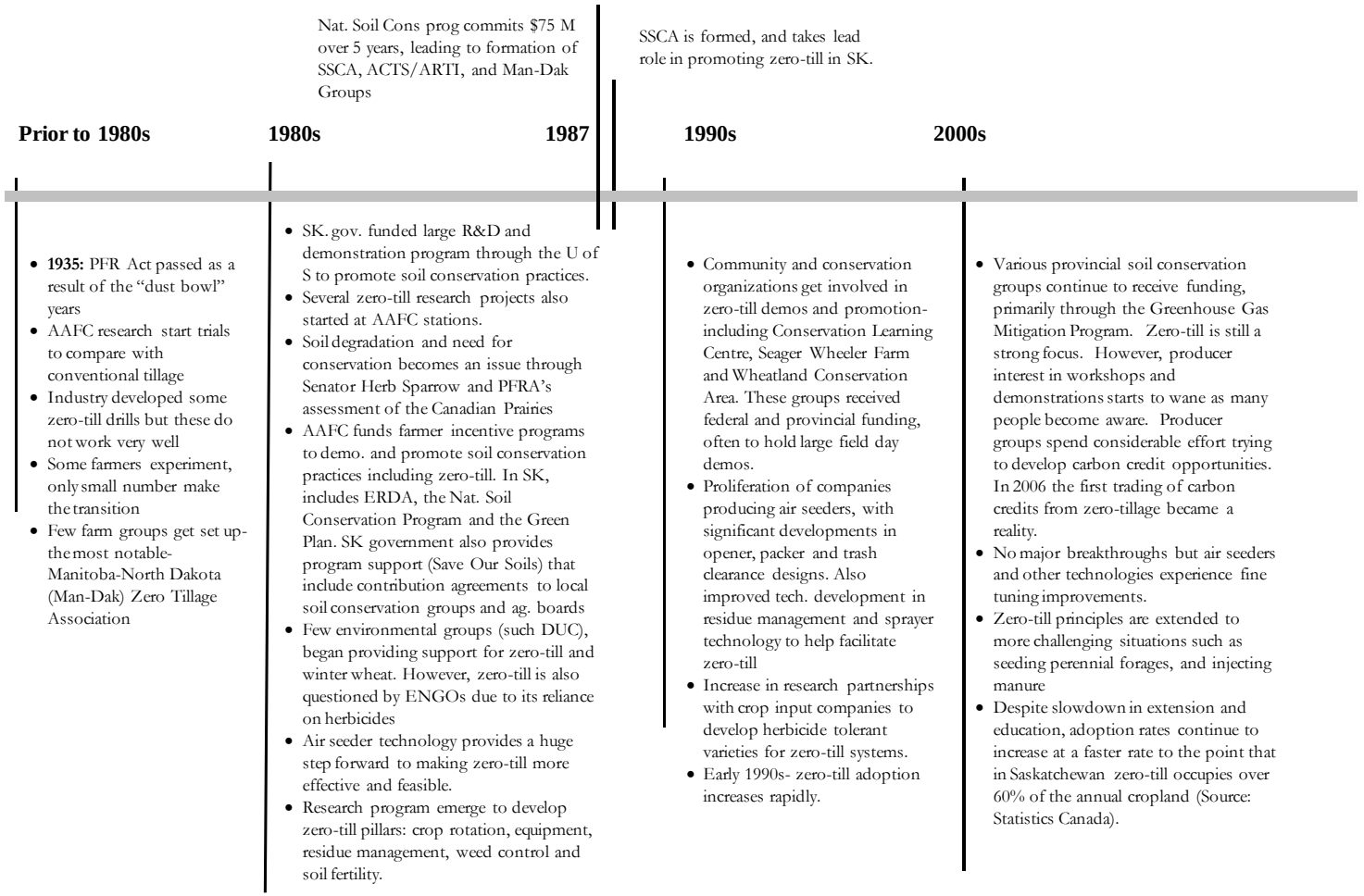


Figure 5-3. History of zero-tillage practice in Saskatchewan (Source: Personal communications with M. Black, D. Haak, C. Vanin, D. McKell, August, 2007)

5.3 Details of Policy Design and Implementation

The Saskatchewan Soil Conservation Association is an example of a policy instrument that demonstrates multi-level responsibility for policy implementation. While its formation is said to be grassroots and from the side of the producers, it was also aided in its efforts and in its formation by government agency participation and funding. In turn, the benefits are shared amongst the producers, and various levels of ENGOs and government agencies that are dealing with land and water management in the province. The mandate for zero-till was promoted by the federal and provincial governments, as well as by early farm practitioners who believed in the benefits of such practice. Funding for outreach and innovation has been provided by agro-industry, as well as government agencies. Farmers, in turn, have to implement the practice at the farm-level.

The SSCA has been successfully providing information and training on direct seeding (zero-till) systems for the last decade. Direct seeding aids in zero-till implementation, but its current popularity is also due to the fact that direct seeding systems have been proven to sequester carbon on the Canadian Prairies.

SSCA developed the "Do's and Don'ts of Direct Seeding" in the late 1990s to showcase how costly common seeding mistakes can be especially when interactions between more than one mistake occur. This series of 2003 demonstrations looked at post-emergent glyphosate applications, the interaction between seeding depth and seed-placed fertilizer or inoculant use; and skipping the pre-seed glyphosate treatment.

The overall activities of the SSCA included:

- **Annual Direct Seeding Conference and Tradeshow –** A conference to disseminate information and technology related to direct seeding (zero-till) farming and to provide a forum for gauging the future of zero-till farming in Saskatchewan.
- **Field days** (two per year) – Usually held in two different areas of Saskatchewan (such as in the north and in the south), these field days use farms to demonstrate direct seeding do's and don'ts, new technologies (including seeders and spraying equipment), residue management demonstrations, information on herbicide tolerant crops and pest management
- **Information dissemination –** The SSCA website has fact sheets on Direct Seeding Agronomics, Forage and Riparian Areas and on Soil Facts relevant to direct seeding/zero-till farming. In addition, the SSCA also produces a regular newsletter as the Spring, Summer and Winter issues of the Prairie Steward Newsletter, which provides updates on zero-till related developments, highlights the positive work of

local farmers and allows for a printed forum to share information and opinions about zero-till and direct seeding. In addition, the SSCA has also produced videos on soil conservation.

Apart from field days, the SSCA also organized Kitchen Table meetings (5–15 people), local information meetings (25–50 people); local tours of farm operation (10–20 people); local field tours of SSCA established plots and dealer-sponsored meetings with SSCA presentations (50–200 people). Additionally, the SSCA organized Farm Family Awards and SSCA Merit Awards that were announced annually at the Direct Seeding conference.

SSCA functions have been carried out in the past through five regional offices (Yorkton, Swift Current, North Battleford, Tisdale and Saskatoon) with five regional SSCA staff agrologists. Regional agrologists would organize region-specific extension projects and programs and organize larger activities and common interest activities together (B. McClinton, personal communication, September 2007). Unfortunately, in the past year, funding has been uncertain; only one staff agrologist was retained and extension activities have been correspondingly reduced.

The SSCA has also conducted at least one member survey to determine the priority of its members and its own program matches. In 2005, the SSCA sent a mail-out survey to its members asking them to prioritize the activities of the SSCA according to their usefulness to them. According to the results of the survey, the conference was definitely the highest in popularity amongst SSCA members (28% respondent rate). In order of popularity, the tours of direct seeded plots in SSCA's own farms, local meetings, meetings with technology dealers and field days were the SSCA's other top five activities.

Box 5-1 Producer Directed Information Delivery – Sustainable Agriculture Sector
[From Canada-SK Agri-food Innovation Fund Agreement Final Report]
The SSCA received funding from the Canada Saskatchewan Agro-food Innovation Fund agreement near the end of June 1997. At that time, producers faced several land resources management issues, including: the need for a more rapid information system on new production techniques associated with sustainable agriculture, support for developing solutions for new problems emerging in longer-term low-disturbance seeding (LDS) systems, diversifying extended rotations in the brown soil zone, a need for economic comparisons between conventional and LDS systems in all regions, and learning and understanding soil carbon sequestration and how this process can be developed as a mitigation strategy for greenhouse gas (GHG) emissions. To address these issues the SSCA developed a program of producer information extension to assist producers in making more informed decisions regarding the adoption of sustainable land management practices. The program established an information network among researchers, industry and producers to ensure the adoption and retention of sustainable practices. This network involved not only the SSCA but also government extension workers, ADD boards, producer-directed research associations, industry and Agriculture and Agri-Food Canada.
Key thrust areas for the project included: promoting reduced tillage systems, incorporating forages into annual rotations using low disturbance seeding techniques, precision farming as it relates to conservation systems and developing carbon sequestration awareness and strategies for mitigating GHG emissions.

5.3.1 Federal Roles and Responsibilities

The government's version of agricultural sustainability, as outlined in a revised edition of Canada's Green Plan (Environment Canada, 1990) and in subsequent agriculture policy documents (e.g. Agriculture and Agri-Food Canada, National Agriculture Strategy; Future Directions for Canadian Agriculture and Agri-Food, 1995; Profile of Production Trends and Environmental Issues, 1996) was consistent with the position first outlined in "Growing Together."[5] These documents present a clear message that the government is primarily committed to trade liberalization and to maintaining the productivity of the resource base. The links between these two goals is described in the 1995 National Agriculture Strategy: "Over time, trade liberalization is expected to lead to a more market oriented system of production, with fewer incentives for destruction and waste overproduction that has negative environmental effects" (Agriculture and Agri-Food Canada, 1995,).

This version of sustainable agriculture reflects the continued reliance on a traditional scientific and neo-classical economic framework to examine the issues facing agriculture and to devise a formula for sustainability. This perspective and focus on economic and technical

[5] Minister of Supply and Services, (1989). *Growing Together: A Vision for Canada's Agri-Food Industry. Ottawa: Minister of Supply and Services.*

strategies for sustainability exclude social issues and a broader range of economic and environmental issues from the equation.

It is within the context of a prevailing emphasis on certain economic and environmental objectives that conservation tillage, particularly zero tillage, became identified as the way to meet these objectives, and hence, as the route to farm-level sustainability. The selection of zero-tillage as a sustainable practice was backed by numerous scientific and economic studies that showed that, by eliminating tillage and summer fallowing, soil and water erosion could be reduced, which would also allow farmers to increase the yearly productive capacity of the land base and maintain high yields (Lindwall *et al.,* 1998; Lindwall and Larney, 1993; Lal *et al.,* 1990).

The federal government has had a large role in the SSCA and its workings. While funding and programming support have been provided fairly consistently from the federal government agencies, there are also currently two board members from Agriculture and Agri-Food Canada on SSCA's Board of Directors.

5.3.2 *Provincial Roles and Responsibilities*

The funding history of the SSCA indicates that the provincial government has had a major role in funding the SSCA's programs and projects. Apart from funding support, Saskatchewan Agriculture and Food has contributed to the SSCA in kind—in the form of office space and expertise (B. McClinton, personal communication, September 2007). In addition, the SSCA Board of Directors has had numerous representatives from the provincial government.

5.3.3 *Producer Roles and Responsibilities*

While the federal and provincial governments have been promoting zero-till practice through their programs, policies and funding, it is the producers who are attending workshops, sharing their knowledge with each other and, eventually, applying the zero-till mechanisms on their farms.

Peer-to-peer communication has had a major impact on zero-till uptake in the province. This has been encouraged through SSCA programs such as farmer-to-farmer networking, but has also been driven largely by producers who have personally felt the need for long-term solutions to soil erosion in the region. Droughts have been cited as common weather-related shocks and soil erosion had been a common farm-stress experienced as recently as the 1990s.

Zero-till has been promoted by industry, government agencies, conservation agencies and producer groups as a solution to soil erosion and water management, and as a practice that is

less intensive in farm preparation than traditional farming.

5.4 Identification and Analysis of Adaptive Policy Mechanisms

In this section, we study the specific design features of SSCA's zero-tillage-based extension programs to identify adaptive policy mechanisms. The adaptive policy analysis is organized according to seven broad categories of pre-determined adaptive policy mechanisms, illustrated previously in Figure 2-1 and summarized below:

The ability of a policy to adapt to anticipated conditions is measured by:

- **Automatic adjustments** – policies that monitor key underlying conditions and can trigger adjustments to the policy when necessary
- **Integrated assessment** – policies that respond to a thorough assessment of causal factors, key impacts and scenario outlooks and perform under a range of anticipated conditions, including worst cases
- **Multi-perspective deliberation** – policies that recognize and incorporate common values, shared commitment and emerging issues and provide a comprehensive understanding of causal relationships

The ability of a policy to adapt to unanticipated conditions is measured by:

- **Formal review and continuous learning** – mandated periodic reviews of the policy instrument to assess performance and identify emerging issues and improvements
- **Encouraging self-organization and networks** – policies that encourage interactions to foster the emergence of innovative responses to unanticipated events. These include those policies that reduce barriers to collaboration and learning.
- **Subsidiarity** – policies that assign priority to the lowest appropriate level of implementation and action consistent with effectiveness.
- **Promoting Variation** – policies that allow for a variety of small-scale interventions for the same problem and facilitate a diversity of solutions in the face of uncertainty and change.

The following sections explain relevant adaptive policy mechanisms in some detail in the context of zero-till agricultural extension through the work of the SSCA in Saskatchewan.

5.4.1 Integrated assessment mechanism

A no-regrets policy or mechanism can perform effectively in a range of circumstances

anticipated by the policy designers. It reflects three principles related to effective intervention in complex adaptive systems. First, no-regrets policies and mechanisms are based on a sound understanding of local conditions, strengths and assets (Glouberman *et al.,* 2003). Second, they respect history; that is they respect that complex adaptive systems "are shaped by their past and a knowledge of this history may suggest constraints on and opportunities for what can be done in the future" (Glouberman *et al.,* 2003). Third, they understand interactions with the natural, built and social environment (Glouberman *et al.,* 2003).

The extension activities for the promotion of zero-till farming in Saskatchewan were based on an understanding of soil types and crops most suitable for zero-tillage (direct seeding) systems. This understanding and dissemination has resulted in the adoption of zero-tillage systems in ways that are specific and most suitable to local conditions. "Soil testing was used at all demonstrations to optimize application [of direct seeding systems] rates."[6]

The no-till practice in Saskatchewan has defied some of the traditional critiques of reduced productivity and higher initial costs by a combination of soil type prevalent practice and overall interest in the mechanism. Many of the problems faced by minimum-tillage practitioners in other parts of the world are because of the lack of awareness of crop rotation. The SSCA programs promote minimum tillage practices in combination with crop-rotation practices as a prerequisite for success. This has improved the overall performance and management of the minimum tillage practice (B. McClinton, personal communication, September 2007).

5.4.2 *Multi-perspective deliberation*

The SSCA also incorporates multiple perspectives into its planning and implementation. The SSCA is governed by a board that primarily represents farmers, but also includes government representatives. In addition, the membership of the SSCA comprises primarily farmers, but does include non-farmer members as well (www.ssca.ca). Decisions are also informed through annual meetings in conjunction with the annual conference where members, including farmers, farm industry, conservation agencies and government agencies can provide inputs to future programming.

5.4.3 *Formal Review Mechanisms*

Formal review is a similar category of adaptive policy mechanism to automatic adjustment, in that it acknowledges that monitoring and remedial measures are integral to complex adaptive systems (Holling, 1978) and that it is necessary to constantly refine interventions

[6] From SSCA Fourth Quarter Report, (December 2002-March 2006). Obtained through personal communications with B. McClinton, September 2007

through a continual process of variation and selection (Glouberman *et al.,* 2003). Yet formal review is fundamentally different from automatic adjustment. Automatic adjustment can anticipate what signposts to use and what actions might need to be triggered to keep the policy effective. Formal review, on the other hand, is a mechanism for dealing with unanticipated circumstances and emerging issues.

There is also a subtle, yet fundamental difference between formal review and *ad hoc* review. Both can accomplish the intended result—that being critical policy adaptations, but *ad hoc* review relies often on a long and protracted process of public opinion and debate before a formal review is triggered (IISD and TERI, 2006). Formal reviews in the context of this category are preset processes that occur even if the policy appears to be functioning well and there appears to be no need for review and assessment. This regularly scheduled assessment process is necessary to detect emerging issues that can impact on the policies performance.

A formal review mechanism adopted by the SSCA is the annual conference hosted by the organization that acts as a review and reporting mechanism for the organization. While the annual conference was planned and is named the Direct Seeding conference (synonymous with zero-till in Saskatchewan), it has, over the last few years, taken on additional roles as research and crop production needs have changed. (B. McClinton, personal communication, September 14, 2007).

SSCA's early work on soil conservation was driven by a regional and federal motivation to prevent the widespread soil erosion being experienced in the Canadian Prairies. As a result, their initial extension work focused on the goal of soil conservation and farming mechanisms such as zero tillage for the fulfillment of this goal.

Over the years, with the high uptake of zero tillage farming in Saskatchewan, provincial and federal policy has shifted focus, and funding priorities have shifted corresponding to policy shifts. The SSCA still works on zero-tillage issues such as direct seeding, but the motivation has shifted slightly to accommodate a demand for carbon markets and carbon sequestration through zero-till farming. Carbon markets now drive the need for adopting zero-till farming and much of the extension, research and annual conference focus is on the possibility of carbon market-based revenue for farmers through zero-tillage and direct seeding practices.

5.4.4 *Encouraging Self-organization and Networks*

In this section, we restrict our analysis to principles that are integrated directly with the intent and structure of the policy. This includes the list of principles under the policy design and implementation section of this policy. Included are such principles as: creating opportunity for self-organization; building networks for reciprocal interaction that foster

trust and cooperation; ensuring that social capital remains intact; promoting variation and preventing redundancy; and facilitating the copying of successes.

The initially identified complex adaptive principles in the analysis of the SSCA include: the encouragement of self-organizations and networks, the devolution of decisions and management and other complex adaptive principles such as the presence of multiple perspectives in the policy, and in the promotion of variation.
The encouragement of self-organization and networks is demonstrated through the formation of the SSCA, through a grassroots-based awareness for the need for soil conservation practices and outreach in Saskatchewan. In addition, the SSCA incorporates networking and social capacity-building through its programming, including its annual conference, extensive meetings and educational events and, more specifically, through its "farmer-to-farmer program."

In the SSCA's farmer-to-farmer networking program, farmers who are interested in a zero-tillage-related practice are put in touch with a farmer implementing that practice. This allows a learning forum among farmers where they can communicate and learn from each others' successes and mistakes. It also allows for the building of informal learning groups and social capital.

5.4.5 *Subsidiarity*

The devolution of decisions and management is demonstrated in the SSCA through the localized regional offices and outreach at the community level. This local-level action and implementation translates national level policy (including the Federal National Soil Conservation Program, and the Agriculture Green Plan through provincial support and funding) into local-level outreach and implementation.

5.4.6 *Promoting Variation*

With a goal of promoting zero-tillage and reduced tillage practices to prevent soil and water erosion in Saskatchewan, the SSCA developed programs that worked towards this goal in multiple ways. Demonstration days showing the multiple values of adopting this practice, promoting related technology through exhibitions and training, allowing peer networking, promoting the multiple benefits of conservation tillage, including soil and water conservation, as well as carbon sequestration for greenhouse gas trading benefits all demonstrate the various ways to promote the practice of conservation tillage.

6.0 Conclusions

This Saskatchewan case study focused on an adaptation measure that is of interest due to its potential to aid adaptation to climatic stresses on the Prairies. In this section we address two high-level questions relevant to this research project. First we consider the question, *Do public policies that build the capacity of communities to cope with surprise and change have adaptive features?* And second, we address the question, *What adaptive features enable policies to remain effective*?

6.1 Do public policies that build the capacity of communities to cope with surprise and change have adaptive features?

It is evident from the responses of farm-level interviews that zero-tillage farming does act as a coping and adaptation measure that aids in farm-level adaptation to long and short term drought in Saskatchewan. In Section 5, we analyzed the policy instrument of SSCA's extension efforts regarding zero-tillage farming and compared them with mechanisms of adaptive policies. We determined that the SSCA and its extension efforts included several adaptive policy mechanisms that helped contribute to its success in the high uptake of zero-tillage agriculture in its outreach area.

While the benefits of zero-tillage to soil and water conservation and carbon sequestration are quite clear, there are still some unanswered questions regarding whether the practice builds resilience. Recent studies have also proved that while zero-tillage had positive impacts on soil erosion, it actually required more chemical fertilizer and therefore has negative impacts on nutrient loads on watersheds (EcoRessources and IISD, 2008 [unpublished draft]). Some scientists in the past have expressed concern about potential problems in soil fertility with a zero-tillage system, due to decreased mineralization and immobilization of soil nitrogen, and denitrification caused by lower soil temperatures and increased moisture.

Other problems associated with zero-till have also been identified. An increased dependency on the use of agrochemicals increases the risks to humans (McDuffie *et al.*, 1995) and environmental health (Pimental *et al.*, 1992), and has been accompanied by increased genetic resistance to pesticides in weed and insect populations (e.g. Morrison and Devine, 1993). Zero and minimum-tillage systems are most dependent on glyphosate (Roundup), a broad-spectrum herbicide, for weed control. Although scientists originally claimed that there was a very low probability of resistance to Roundup, due to the chemical make-up and action of the herbicide, some weeds have begun to develop resistance (Western Producer, 1994). Roundup has also been identified as one of the safest pesticides in use, but a study has shown a positive correlation between exposure to glyphosate and the incidence of non-Hodgkin's lymphoma (Hardell and Eriksson, 1999). While zero-tillage farming is considered

to be an effective way of sequestering carbon and mitigating the effects of climate change, the process of producing fertilizers needed for the effective implementation of zero-tillage farming may prove this role to be less efficient than espoused.

A table of advantages and disadvantages of zero-tillage agriculture as given by Beckie (2000) is included below as part of this analysis.

	Advantages	**Disadvantages**
Environmental	- increase soil organic matter - carbon sequestration - preservation of soil structure - increase in earthworm pop. - prevents soil and water erosion - conserves soil moisture - improved aeration of soil - improved infiltration of soil	- changes in weed populations - increased use of herbicides - increased herbicide resistance - increases in diseases and pests - increased de-nitrification - decreased nitrogen availability - restricted distribution of soil phosphorous - energy intensive
Economic	- decreased fuel use (20–70%) - decreased machine inventory - increased production due to more intensive cropping - facilitates increased scale of operation	- high cost of large-scale and specialized machinery - increased cost of agrochemicals
Other	- labour and time efficiency in field operations - greater flexibility in decision making - smaller range of skills required	- facilitates increased farm size, which may impact on community structure.

(Source: Adapted from Baker *et al.*, 1996)

However, it is widely acknowledged that despite the potential problem with the long-term practice of zero-tillage farming, there are benefits in the field of soil and water conservation and since this is the basis for our adaptive policy research, we have focussed on the adaptive policy aspects of SSCA's extension efforts that enable the uptake and implementation of zero-tillage farming in Saskatchewan.

In response to our research question, our analysis of SSCA's structure, planning and programs revealed that the policy instrument for federal soil and water conservation incorporated several adaptive policy mechanisms that allowed it to work effectively on zero-till extension and implementation for the last few decades. The last few years have seen a decline in its activities and capacity. This is primarily related to the fact that the original

policy that allowed the formation and functioning of the SSCA, the national soil and water conservation policies, are now relatively low priorities issues.

Our communications with SSCA staff and other related experts have led us to believe that the extension structure and mechanisms are an adaptive mechanism and could be used to the advantage of similar and related federal priority areas and policies such as climate change. The other important adaptive feature of the organization and its extension work has been to adapt programming and the focus for zero-till farming from soil and water conservation to carbon sequestration in a time of changing priorities for the region.

6.2 What adaptive features enable policies to remain effective?

An analysis of SSCA's extension activities for zero-tillage farming reveals several adaptive mechanisms that have allowed SSCA and its extension activities to be successful in the high uptake of zero-tillage farming in Saskatchewan. As a no-regrets mechanism, the SSCA's zero-tillage programming is based on an understanding of local soil types and farming practices. This ensures a more effective implementation and maximizing the advantages associated with zero-tillage farming.

With regard to complex adaptive systems principles, we observed that the SSCA ascribes to the principles of subsidiarity, multiple perspectives, variation, and self-organization. Devolution of decisions and management (i.e., subsidiarity) is demonstrated through the SSCA's five regional offices, whereby regional agrologists delivered programs and extension operations most appropriate to regional preferences. The value of centralized coordination and not replicating functions was also recognized despite decentralization.

Multiple perspectives are also incorporated through its multi-stakeholder board of directors and membership, which represents levels of government, the farming community, agricultural industry and others.

The SSCA minimum-tillage promotion has also acknowledged the importance of variation by combining crop rotation practices with zero-till farming. This has improved the performance and management of zero-tillage practice and overcome problems faced by zero-till practitioners in the other parts of the country.

Another aspect of complex adaptive systems is the concept of encouraging self-organization and networks. This aspect is demonstrated through the SSCA's farmer-to-farmer program wherein farmers interested in learning about a zero tillage-related farming practice are put in touch with a farmer implementing that farming practice. This ensures not only more direct learning, but also enables social networks that are advantageous for adaptation.

Formal review of SSCA's programs is conducted via an annual conference where the organization takes stock of its functions and determines its future path and actions. This allows members and the board of directors to contribute to this process, and a formalized system ensures that a review of sorts is conducted even when there is no perceived need for it. As an example, the SSCA has gradually shifted its extension focus from zero-tillage for soil conservation to zero-tillage for soil conservation and carbon sequestration and climate change mitigation as part of shifting priorities at the federal and provincial government levels. While some of this movement has been related to priority shifts in funding sources, SSCA board of directors and staff have also realized the value of "keeping up with the times" and enabling zero-tillage uptake with all its benefits.

Table 6-1. Summary of adaptive policy mechanisms observed for no-tillage

Integrated Assessment	Multi-perspective deliberation	Formal Review	Encouraging self-organization and networks	Subsidiarity	Promoting variation
▪ Evolution of different SSCA outreach programs on the basis of regional soil types and in conjunction with crop rotation	▪ The SSCA incorporates multi-perspective deliberation through stakeholder representation on its board and through inputs at the annual conference and review.	▪ Annual conference for planned review of activities and future planning	▪ Devolved decision making through regional offices and staff	▪ Devolved decision-making through regional offices and staff.	▪ Promoting zero-tillage farming in a variety of ways including education, capacity building, technology development and transfer, etc.
		▪ Evolution of zero-till motivation from soil conservation to carbon sequestration. This move has been facilitated by staff, board and funder priorities.	▪ Farmer-to-farmer program of the SSCA		▪ Combining crop rotation practices with minimum tillage practices to improve overall performance.

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