

Adaptation to Drought in Saskatchewan Rural Communities: A Case Study of Kindersley and Maidstone, Saskatchewan

A Thesis

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By

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Abstract

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The main aim of this thesis is to gain knowledge of the processes of adaptation that have enabled communities and agricultural producers to function in a relatively dry and drought prone region of Saskatchewan. This investigation was limited to two rural communities - Kindersley and Maidstone. Historically, vulnerability to natural hazards has been considered only a physical phenomenon. As a result, the social characteristic of a place/system, which contribute to vulnerability to natural hazards, are not well studied.

This study used both secondary (quantitative in nature) and primary (qualitative in nature) methods to understand exposure, sensitivity and adaption to droughts in two study communities. Quantitative method included estimating drought condition from time series data for both communities. Intensity of the drought was based on Palmer Drought Severity index and Standard Precipitation Index. Given this background, qualitative techniques (semi-structured interviews and participation observations) were employed to explore the sensitivity and adaptation to droughts in the two communities.

The results indicated that drought had caused significant economic hardships for farmers and ranchers during the 2001- 2003 period. Crop yield declined more than 50% of normal level for some crops during this period. Producers had undertaken some adaptive actions to counteract the adverse effect of the drought. These included changing their farming practices -- intensive tillage to minimum or zero tillage, diversification in terms of types of crops grown, off-farm employment, and participation in business risk management programs.

Respondents reported that drought was not the sole cause of their vulnerability. Social factors such as changing government policies, reduced profit margins, insufficient business risk management programs, and international markets shaped their vulnerability to climate-related natural hazards. The study found a strong sense of alienation between respondents and federal government agencies. The combination of

economic stress, inadequate government risk management programming translates into a very narrow window of sustainability for producers should they face a severe multi-year drought in the future.

Keywords: Drought, Vulnerability, Adaptive Capacity, Climate Change

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"I can no other answer make but thanks, and thanks." – William Shakespeare

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Chapter 1

Introduction

1.1 Background

The ensuing impact of climate change on agriculture sector is an emerging issue for many communities around the globe. According to Frederick (1997), the hydrology of arid and semiarid areas is particularly sensitive to climate change. Some areas in the Canadian Prairies provinces are in the semi-arid climate zone and constitute one of the world's most variable climates¹ (Natural Resources Canada, 2010).

Agriculture is one of the main industries in the Canadian prairies. Farming in this region entails 'dryland farming', which is heavily dependent on timely rains and suitable temperatures. Deviations in precipitation and temperature from normal range impact agricultural activities in the area. Climate change scenarios for the Canadian Prairies indicate an increase in temperature under global warming. The Canadian Prairies average temperature has warmed up at a faster rate than the global average and future climate will be outside the range of natural variability (Sauchyn et al., 2009). According to the Canadian Global Climate Model, the southern Prairies could experience serious summer deficiencies in soil moisture by the end of this century (Pomeroy and Fang, 2009). More variable precipitation accompanied with increased temperatures translates into more frequent droughts.

Drought refers to "a prolonged period of abnormally dry weather that depletes water resources for human and environmental needs" (Bonsal et al., 2012). Drought has been mainly classified as meteorological and agricultural drought. In meteorological terms, a drought is defined as "an extended period of time with inadequate precipitation" (Maybank et al., 1995). Agricultural drought does not necessarily begin with the cessation of rain, but rather when available stored water in the soil cannot meet the evaporative demands of the atmosphere. Agricultural drought has been a big concern for the economy of the Canadian Prairies. Prairie droughts have been reported as one of

¹ This area is sensitive to any changes in hydrological cycle, which may lead to variable precipitation patterns.

the great natural disasters in terms of socioeconomic cost to the region (Natural Resource Canada, 2010). The Canadian prairies are marked by a history of severe droughts, as these are recurrent phenomena over a long history. According to Bonsal et al. (2004), over 40 severe droughts have occurred in the past 200 years. During the 20th century, the droughts in this region were frequent and relatively short (Sauchyn et al., 2003). The recent multiyear drought, which occurred in 2001-2002, highlighted the vulnerability of Canadian Prairies to droughts. The net result was that net farm income in Saskatchewan was negative and dipped down to zero in Alberta. Moreover, employment losses exceeded 41,000 jobs, and agriculture production losses reached over \$3.6 billion in the two provinces. Gross domestic product (GDP) losses were 5.8 billion (Sauchyn and Kulshreshtha, 2008:301; Wheaton et al., 2005, 2008).

The prairies are currently vulnerable to drought impacts. According to Hogg and Bernier (2005), this vulnerability is expected to increase in the future, given strong evidence that droughts will be more severe in the future. Within the Canadian Prairies, Saskatchewan has 43% of Canada cultivable land (Statistics Canada, 2011a). General circulation models (GCM) for the Saskatchewan region indicate an increase in frequency and intensity of droughts (Nyirfa and Harron, 2002). By 2050, Barrow (2009) has projected an increase of 1 to 4°C in mean annual temperatures for the southern grassland of Saskatchewan and a decrease of mean annual precipitation by 10 to 20 % in the summer months. These conditions could impact the agriculture sector in this region. Paleoclimatological evidence also shows that multiple-year droughts before 1900 were frequent and that the conditions leading to these extreme droughts could easily reoccur (Sauchyn et al., 2002). As mentioned above, with the escalation of global climate change, the frequency of droughts and the areas affected are expected to increase sharply (NCAR, 2005; IPCC, 2001 and 2007). These predicted changes could have far-reaching implications for ecological and socioeconomic processes. As society's vulnerability to drought increases, in order to reduce adverse impacts of such events, decision makers need information to help prepare for droughts, and allocate resources effectively.

Historically droughts were considered as 'acts of nature' and negative impacts of droughts were often addressed through adoption of reactive and technological approaches. Disaster management has typically focused on analyzing the hazard, such

as the severity of drought due to a shortfall of precipitation. However, there is an increasing need to analyze not only the hazard, but also the vulnerability to the hazard. For example, assessment of vulnerability may include identifying the impacts of inadequate precipitation on users, the causes of those impacts, and the actions that can reduce the impacts. Recent studies (Wilhite and Glantz 1987; Wilhite et al., 2000; Hooke, 2000) have emphasized that in order to reduce impacts more effectively, disaster management has to move away from solely emergency response, initiated during or after an event, towards mitigation and preparedness initiated before an event. The climate change literature also emphasizes the role of planning, as well as water and land use to mitigate the impacts of extreme climatic events (Field et al., 2012). As a result, adaptation to extreme climatic events has become the focus of recent research on climate change (IPCC, 2012).

Given the probability of more frequent and severe droughts in the future, it is important to prepare communities and individuals to adapt to future extreme climatic conditions. In order to recommend possible adaptation options to deal with predicted future extreme climatic events, it is important to understand how communities were exposed to drought? What actions had been employed to reduce the impacts? How effective were the adaptive measures? What were the constraints of effective adaptive measures? Understanding the answers to these questions can help in better planning for future extreme events. This study was undertaken to analyze both physical and social aspects of past drought exposure, impacts and adaptation strategies.

1.2 Research Context

This research is part of a larger project funded by the Social Science and Humanities Research Council of Canada (SSHRC). The research project was implemented in partnership with the Prairie Farm Rehabilitation Administration (PFRA), a leading federal agency in the area of drought adaptation, and with the Saskatchewan Research Council, a leading provincial agency in the area of drought research. In the large study, six communities (Coronach, Gravelbourg, Kindersley, Maidstone, Maple Creek, and Shaunavon) were selected for community-based vulnerability assessment to

droughts. The five communities were located in Palliser Triangle², a region characterized by higher aridity and repeated occurrence of dry spells. The community of Kindersley I studied is located within this region. However, given that drought has recently expanded to the north affecting communities not accustomed to it, Maidstone was selected as a special case study community in the northern agricultural region of Saskatchewan.

1.3 Objectives of the Study

In order to improve the adaptive capacity of the two communities (Kindersley and Maidstone) under study to droughts, the major objectives of this study are to assess the nature of exposure to drought, sensitivity to droughts and understanding the process of adaptation to drought. This overall goal of the study was achieved by meeting the following specific objectives:

- To develop a time series of drought frequency and intensity for the study communities with emphasis on the characteristics of recent 2001-2002 drought;
- To document the impacts of droughts on the communities and compare the differences and similarities of the impacts on them;
- To identify adaptation strategies to previous droughts undertaken by the residents of the two communities;
- To assess effectiveness of institutional measures by community residents; and
- To identify future climate related risks for the study communities.

1.4 Scope of the Study

This study is based on results of investigation conducted in Kindersley and Maidstone. Both communities are located in west central Saskatchewan. Kindersley is located in Palliser's Triangle in the brown soil zone. Here droughts are recurrent phenomenon. The community of Maidstone is located in the black soil zone. This community is less accustomed to occurrence of droughts. In fact the 2001-2002

² Palliser's Triangle covers most of the southwestern section of the province of Saskatchewan, extending from the area south of Regina to the border with Alberta (the mixed grassland prairie ecoregion) (Shorthouse, 2010).

droughts were a new experience for this community. The differences in soil zone and relative level of experience with droughts provide an ideal context to compare these two communities for their adaptive capacity to droughts.

1.5 Thesis Outline

This study is divided into eight chapters. Chapter one is the introduction, which briefly describes the context of the study and its objectives. Chapter two provides the literature review and the theoretical context for the study. This chapter includes a brief introduction to droughts, provides the concept of vulnerability and highlights the empirical methods used in assessing community vulnerability based on available body of literature. Key elements of vulnerability are synthesized to develop a conceptual model of vulnerability to droughts. This model serves as a framework that guides the research process and is used in the interpretation of research results.

Chapter three describes the methodology used to collect and analyze the data for this study. Chapter four provides a description of the two study communities: Kindersley and Maidstone. Included here, for example, are background information on geographic location, water system, economy, and climate. These details would help to provide a context for the interpretation of the research results. Chapter five presents the current exposure and sensitivity to drought based on secondary data, which is supplemented by people's responses to exposure, impact and sensitivity in chapter six. This chapter also reports current adaptation and a discussion of adaptive capacity. Chapter seven presents the possible future climatic vulnerabilities of the two communities and a discussion of current factors that can enhance or constrain adaptive capacity. The final chapter contains summary and major conclusions of the study, with areas for future investigation.

Chapter 2

Literature Review

To set the stage for the current study, this chapter provides an overview of droughts and its impact on the Canadian Prairie rural communities. To offer a theoretical context for this study, three fields of study were consulted. These are: natural hazards, political economy and climate change dealing with vulnerability science. In Section 2.1, various concepts adopted in this study are defined, followed by an examination of conceptual framework of vulnerability assessment applied in natural hazard, political economy and climate change in Section 2.2. Section 2.3 contains a review of vulnerability assessment approaches. The final section (Section 2.4) describes this study's conceptual framework developed from a synthesis of literature related to community vulnerability assessment to drought.

2.1 Droughts, its Impacts and Adaptation

Drought is a normal component of climate variability, and is common around the world. The definition of drought varies depending on the types. Droughts are widely classified into four categories: meteorological, hydrological and agricultural, and socio-economic drought (Dracup et al., 1980; Wilhite and Glantz, 1987; Hisdal and Tallaksen, 2003). In general, all categories of drought are associated with a lack of precipitation over an extended period of time, usually a season or more, which results in a water shortage for some activity, group or environmental sector (Wilhite and Glantz, 1987; Al-Taher, 1994). Meteorological drought means an extended period of time with inadequate precipitation, often but not always, accompanied by unusually high temperature, high winds, low humidity and high solar radiation, which results in increased evapotranspiration (Dingman, 1994).

Meteorological drought is widely identified as the cause of agricultural and hydrological droughts. An agricultural drought is commonly defined as a state of deficient moisture conditions, which produce a lasting adverse effect on crops of

economic importance and other natural plant growth. Hydrological droughts are prolonged periods of unusually low surface run-off and shallow groundwater level. All types of water shortages have adverse effects on the society and economy, and are usually referred to as socio-economic droughts (Maybank et al., 1995). Thus, one can hypothesize that different types of droughts occur in sequence where precipitation is the input and soil moisture, groundwater, and stream flow are the outputs (Figure 2.1).

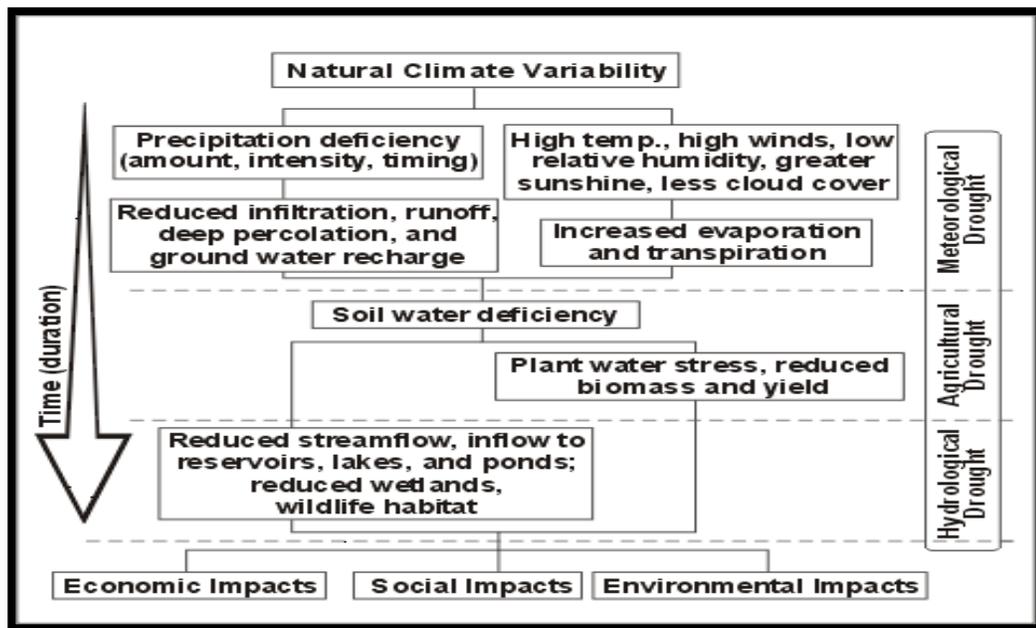


Figure 2.1 Sequence of drought occurrence and impacts

Source: National Drought Mitigation Centre (2006)

Different indices have been developed to quantify agricultural drought. These include Standardized Precipitation Index (SPI), Palmer moisture anomaly index (Z-index) and the most widely used Palmer Drought Severity Index (PDSI). The SPI was developed by McKee et al. (1993) to quantify the precipitation deficit on multiple time scale. It is a simple index, which is calculated from the long term record of precipitation. It can provide early warning of drought and its severity, but it neglects the temperature and soil moisture conditions for identification of drought. In contrast, the PDSI takes into account the precipitation as well as the temperature to identify drought conditions. The index is a function of the length of abnormal moisture deficiency and the severity of the

deficiency (Smith et al., 1993). Since it is standardized to local climate, it is able to demonstrate local drought conditions in the region.

The socio-economic impacts of drought on the Canadian prairies during the last century have been dramatic. The drought of the Great Depression (1930s) affected millions of acres and forced thousands of people to migrate into less affected areas (Marchildon et al., 2008; Venema, 2006). The 1961 drought was worse than that of the 1930s, in terms of economic losses for the Canadian Prairies, as it caused losses of \$665 million in value of wheat production (Koshida, 2010). Similar negative impacts were observed during the droughts of the late 1980s. The recent Canadian Prairie drought of 2001 and 2002 had a catastrophic impact on many sectors of regional socio-economic activities including agriculture and agri-food production, hydro-electrical power generation, and water resource management (Wheaton et al., 2005; Evans, 2008). According to Wheaton et al. (2007), net farm income was negative in Saskatchewan and almost zero in Alberta. The losses in agriculture production reached over 3.6 billion dollars in these two provinces (Sauchyn and Kulshreshtha, 2008: 301; Wheaton et al., 2005, 2008). In fact, the Prairie drought of 2001 and 2002 affected the economy on a national scale and has been rated as one of the costliest natural disasters ever experienced in Canada (Environment Canada, 2003).

Prairie communities and governing institutions have developed a wide array of adaptive strategies to reduce the negative impacts of droughts. However, in spite of these programs, agricultural production in the region has declined during periods of droughts. The relevant economic loss of the recent drought of 2001-2002 has shown that these measures are not sufficient to deal with more intense and longer droughts. Most of the past approaches have been reactive in nature. An example of this is providing financial assistance after a disaster. Proactive planning, plus comprehensive and systematic approach to deal with droughts are absent from the past policies for the region.

As noted in Chapter 1, studies of droughts have focused mainly on the analysis of frequency, intensity and physical causes of droughts (Hayes et al., 2004). The role of social environment as well as the manner in which the human system mitigates their adverse impacts (for example, by adjusting their behavior) is a less well-studied area.

The earlier approach of studying drought only in biophysical terms is simply a reductionist way, as it fails to acknowledge that ecosystem and social system are interconnected (Smit and Wandel, 2006). The 'act of nature' paradigm for understanding drought often leads to the adoption of engineering strategies for managing the drought impacts (Nelson et al., 2010).

A drought is rarely the sole cause of human system vulnerability. Human demand and management of water also play a key role. The severity of drought is directly related to the demand and supply relationship of water (Dracup, 1980). It is society's needs and misuse of water that defines water shortages. For example, ten inches of rain per year may be enough for dryland farmers in Saskatchewan, while it could be a threat to rice farmers in southern China where they are used to having 30 inches of rain per year. Thus, both social and physical factors play roles in creating vulnerability to climatic factors. Consideration of drought as the only environmental deficiency of climate change produces a lack of efficient and effective way to deal with these factors (Trottier, 2008). Drought, as with many other extreme climate hazards, must be understood not just in terms of climatic parameters, such as timing, duration, intensity and geographic scope, but also in terms of its relative exposure and sensitivity of human activities. A full understanding of the socio-economic conditions, which define human sensitivity, vulnerability, and adaptive capacity, is fundamental to grasping the implications of drought (Wheaton, 2007).

Drought studies mainly focus on regional scale and document losses in Gross Domestic Product (GDP). How droughts impact different communities is not a well studied. Yet, the different categories of droughts are unique and impact everyone differently, even within the same region. To be able to deal with water scarcities in an effective, fair, and sustainable way, rural people must manage a broad portfolio of adaptive assets or resources (Wisner et al., 2004; World Bank, 2002). These assets or capital can be grouped as natural, financial, technical, social and institutional. Governing institutions must play a role in building the adaptive capacity of communities to deal with any external risk. However, communities are not localities with a homogeneous distribution of these assets but have social structures characterized by differential access and distribution of resources (Agrawal and Gibson, 2004). These differences

determine their members' exposure and coping capacities to environmental hazards. Thus, to better understand drought vulnerabilities, it is necessary to increase knowledge of the specific impacts of drought on different social actors and their individual and collective capacities to access and manage assets.

Drought research has been mainly oriented toward understanding the biophysical characteristics and their macro-economic impacts on regions (Wheaton et al., 2005; Wheaton, 2007). For Saskatchewan fewer studies (for example, Wittrock et al., 2006 and 2007) have focused on how droughts may differentially impact specific communities and livelihoods, and the assets mobilized by rural people to cope with the hazard. This knowledge is highly relevant to development of government policy and making strategies that seek to reduce risks associated with droughts and climate change. Effective governance strategies to reduce drought impacts must have meaning and practicality among rural people and offer cooperative approaches to provide solutions to rural actors. Thus, it is fundamental for government agencies to identify both how institutional resources are used by rural people, and the multiplicity of rural needs and problems in relation to droughts, in order to balance competing interests in developing comprehensive regional drought strategies.

2.2 Vulnerability Assessment

The simplest meaning of vulnerability is "potential to be harmed by a risk". The term 'vulnerability' has been applied to risk assessment in various disciplines. Research on vulnerability can be classified in three distinct ways. First way to define it is that vulnerability is related to potential exposure to a physical hazard (Handmer, 2003). This view is based on a premise of 'environmental determinism', whereby humans are controlled by and dependent upon the surrounding physical environment (Burton et al., 1978). Vulnerability is thus considered to be the result of environmental factors influencing human activities (Handmer, 2003). Early hazard research has focused on case-specific development, paying particular attention to the risks of particular environmental locations (e.g., semiarid areas, flood plains) and events (e.g., floods, droughts, earthquakes). According to this approach vulnerability is considered as an outcome (Kelly and Adger, 2000; O'Brien et al., 2007). As second way to define

vulnerability is that it is based on a **social construct**. According to this concept, social, political and economic conditions (e.g., unequal distribution of wealth and power) play a crucial role in making a system vulnerable, rather than just environmental conditions (e.g., droughts, floods) (Watts and Bohle, 1993). The third way to define vulnerability is an **integrated approach** in which both biophysical exposure to hazards and social conditions of a system are considered as contributing factors that are making the system vulnerable (Cutter et al., 2000). For example, famine is often the result of both socio-political processes (e.g., poverty, distribution of food) as well as physical processes (e.g., drought). This approach uses elements from the both physical and social approaches in a more integrated way and gives the assessment process a geographical domain (e.g., community), allowing for site-specific assessments.

Recently in climate change studies, the concept of vulnerability has been applied, although there are many definitions of vulnerability depending on the context. However, the most common definition of vulnerability is "the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2001). Vulnerability is thus a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2001). This definition incorporates both biophysical and social factors as determinants of vulnerability. In short, vulnerability is considered as a function of the "severity and probability of occurrence of the hazard and the way in which its consequences are likely to be mediated by the system itself" (Brooks, 2003). Once vulnerability is identified, the next stage is to focus on consideration of adaptive capacity to address vulnerability to drought.

Many studies have been undertaken on building the adaptive capacity to deal with future extreme climate events. The concept of adaptation and adaptive capacity has initially emerged from the climate change impact assessments. Adaptation is commonly defined as "adjustments in a system's behavior and characteristics that enhance its ability to cope with external stress" (Brook, 2003, p. 8). In the climate change context, adaptation means "adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts" (Smit et al., 2000).

Climate change impact assessment studies are classified into first generation and second generation studies. In the first generation studies, simulation models have been created with the objective of predicting the impact of climate change on different sectors, such as water resources and agriculture. However, these studies have been criticized for ignoring the possibility of adaptations for reducing the impact of climate change. As a result, later studies (second generation) corrected this oversight by incorporating the possibility of adaptation by society in order to reduce the impacts of climate change. In the IPCC's Third Assessment Report (IPCC, 2001), various adaptation options were summarized for different sectors. For example, the IPCC proposed the enlargement of reservoir capacity, and conservation measures to deal with expected drought conditions. As the literature on adaptation developed, adaptive capacity became the critical determinant of vulnerability. In the IPCC (2001) report, the adaptive capacity was encouraged as a distinct field of inquiry.³

Adaptive capacity refers to the ability of a system to recover from any stress. According to IPCC (2001), adaptive capacity is “the characteristics of communities, countries and regions that influence their propensity or ability to adapt”. In the climate change context, Adger and Vincent (2007) have defined adaptive capacity as “a vector of resources and assets that represent the asset base from which adaptation actions and investments can be made”, while Fussler and Klein (2006) defined it as “the ability of a system to adjust to climate change to mitigate potential damages, to take advantage of opportunities, or to cope with the consequences”. The adaptive capacity of a system is affected by a variety of resources available to individuals. In the literature (Smit and Wandel, 2006; Brooks and Adger, 2005) these resources are classified into four categories: (1) natural (2) technological (3) financial and (4) social. The availability and distribution of these types of capital impact the adaptive capacity of an individual or a group. The IPCC (2001) has suggested eight factors that influence the adaptive capacity of systems: (1) availability of technical options for adaptation, (2) availability and distribution of resources, (3) governance and the structure of decision making, (4) human capital, (5) social capital including property rights, (6) access to risk spreading processes, (7) ability to manage information, and (8) public perception of risk. This list of

³ In TAR a chapter is devoted to adaptive capacity and its determinants (IPCC 2001, Chapter 18).

determinants of adaptive capacity has generated studies devoted to testing, applying and refining the list of relevant factors. Quantitative methods have been applied to assess and compare adaptive capacity of different countries and communities, while qualitative methods have been used to explore the factors which affect the adaptive capacity in various locales.

In this thesis, definition of adaptive capacity by Smit and Wandel (2006) was adopted. Similarly the IPCC (2001) list of determinants was used in the study as a guide to assess the adaptive capacity of research communities to deal with droughts.

2.3 Evaluating Vulnerability

Vulnerability is a phenomenon that cannot be measured or observed on its own (Downing, 2002). Rather, there are many factors that contribute to the vulnerability of a system. As a result, it is necessary to identify proxy variables or indicators that can be used to assess vulnerability. Different indicators, such as income, education, health standards and infrastructure, have been used to compare the vulnerability of different regions and nations. The main purpose of using indicators is to simplify complex phenomena and change them into useable forms. The objective of these exercises is to select a small, yet comprehensive, set of indicators that can be tracked over time in a particular social unit (Brenkert and Malone, 2005).

Several previous attempts (Brooks et al., 2005; Cutter et al., 2003; Hurd et al., 1999; Metzger et al., 2005; Schröter et al., 2004; Sullivan et al., 2003) have attempted to create a quantitative index of vulnerability. The scale of these assessments can vary from the individual or household with a single stressor, such as drought or flood, to the vulnerability of a community to multiple stressors, or even to the global vulnerability of humans or ecosystems. Typical regional drought vulnerability indicators include (1) water availability and use (2) gross domestic product (GDP) or poverty (3) population (density), and (4) proxies for resource and social infrastructures or institutional capacities (Downing and Bakker, 2000; O'Brien et al., 2004). In these studies, individual indicators are aggregated into a vulnerability index (either assuming they all carry the same weight or are weighted according to the subjective judgment of the analyst), which is computed for spatial-administrative subdivisions, and illustrated on vulnerability maps

(O'Brien et al., 2004). Vulnerability maps visualize regional hot spots and focus policy or media attention (O'Brien et al., 2004). According to Brant (2007), these studies assess the vulnerability of a system to create a starting point for evaluating potential adaptations. Examples of this type of index include O'Brien et al., (2004), Moss et al., (2001, 2005) and Vincent (2004). These studies are discussed now in detail.

The first study by O'Brien et al. (2004) built maps of agricultural vulnerability to climate change and globalization in India by creating indices of adaptive capacity, climate sensitivity, climate change vulnerability and import-sensitivity in various districts. These indices used biophysical, socioeconomic and technological factors that affect agriculture production. Specific indicators used in these indices were soil conditions, groundwater availability, levels of human and social capital, presence of alternative economic activities, literacy rates, and gender equity (O'Brien et al., 2004). These maps highlighted the vulnerability of a region to both climatic and social factors.

Another example of these quantitative vulnerability indexes is reported by Moss, et al. (2001), eight indicators were selected. These included: settlement/infrastructure sensitivity, food security, ecosystem sensitivity, human health sensitivity, water resource sensitivity, economic capacity, human and civic resources, and environmental capacity. The purpose of this index was to illustrate society's ability to recover from extreme events and adapt to long-term climatic changes. Using these indicators, a country's vulnerability to climate change and created an index of countries' vulnerability relative to the world average and the United States was developed. Overall, Moss et al. (2001) found the technique to be a technically sound means for creating a first approximation of vulnerability to begin to consider adaptive actions. Brenkert and Malone (2005) also scaled down their model to the state level in India.

Vincent (2004) compared vulnerability of African countries to climate change by creating indices of economic well-being and stability, demographic structure, institutional stability, strength of public infrastructure, global interconnectivity, and dependence on natural resources. These sub-indices were then used to create a weighted combined index of social vulnerability. In creating this index, Vincent (2004) used a theory-driven approach to select indicators of vulnerability to climate change induced changes in water availability.

While the above approaches have used indices to compare levels of vulnerability at the national level, they can also be applied at the local level. For example, Wilhelmi and Wilhite (2002) reported a study focusing on Nebraska, where they assessed vulnerability to drought based on several key factors affecting agricultural production. This study used several environmental factors such as climate data, crop production statistics and soil type, type of irrigation as well as the way land was being used in order to assess vulnerability to drought. This was by using a weighted combination of data on probability of moisture deficiency, capacity of the soil to hold water, land use and irrigated cropland. Each of these factors was assigned a vulnerability ranking. The results indicated that non-irrigated cropland and rangeland on sandy soils in areas with high probability of moisture deficiency were most vulnerable to agricultural drought (Wilhelmi and Wilhite, 2002).

The creation of indices has been the most common method used in quantifying vulnerability to climate variability and change. While indices-based vulnerability assessments are valuable for monitoring trends and exploring conceptual frameworks, this approach has several weaknesses. First, the relevance and weight of indicators are subjective and change with scale, degree of data aggregation, and context of application, whether social, economic or biological systems are considered (Smit and Wandel, 2006; Eakin and Lemos, 2006). Second, single indices hide instances where a system is more vulnerable in one way, but less in another (Smit et al., 2001). Let us take an example of a region whose GDP per capita increases, as do summer demands for irrigation water. Vulnerability might decrease as people have more money to access water and food and increase as water stress intensifies. It is unlikely that any cumulating index can do justice to these conflicting trends. Third, indicators presume and oversimplify causation, missing important qualitative differences or nonlinear relationships. For example, population growth, assumed in most studies to increase vulnerability by increasing resource stress, can also be a force of economic growth that may (or may not) reduce vulnerability. Fourth, most of the vulnerability indicators developed are from developing country contexts and have little applicability in the industrial world (Eakin and Luers, 2006).

In order to compensate for above limitations, Luers et al. (2003) have proposed that rather than the creation of indices, attempts should focus on assessing the

vulnerability of selected variables of concern to specific sets of stressors. This could be done through measurements of the variability of selected variables, or calculation of the probability that levels would cross a specified threshold. They do this for wheat yields of the Yaqui Valley in Mexico, demonstrating that both soil type and management systems affect vulnerability (Luers et al., 2003). While this approach solves the problem of overgeneralization encountered with the indices, it perhaps goes too far in specificity. This is because well-being of an individual, or a group, may be influenced by many factors besides yields.

An alternative to subjective indicators derived by external analysts or administrators is collective vulnerability assessment involving the participation of scientists, policy makers, and the vulnerable population themselves (Smit and Wandel 2006; Hayes, 2006). This approach is termed as participatory vulnerability assessment. According to Smit and Wandel (2006), in this assessment researchers begin with an appraisal of current risk conditions employing ethnographic in-community methods, interviews, and focus groups and collecting published and unpublished literature. The means by which people deal with risks and the factors and processes that constrain choices are identified. Information from other scientists, policy analysts, and decision makers is then integrated into the analysis to characterize future exposure, sensitivities, and ways the community may potentially plan for or respond to them. Opportunities to reduce future vulnerabilities are debated in public or stakeholder meetings. The final product is not a vulnerability score or rating but information on the structure of vulnerability and avenues for increasing adaptive capacity in order to reduce vulnerability. Participatory vulnerability assessments are in their infancy. This approach was applied by Young et al. (2010) in assessing the vulnerability and adaptation in a dryland community of the Elqui Valley in Chile⁴. Instead of adopting predetermined indicators or factors to assess vulnerability of a sector, the analysis in the study began with the community as the starting point with the objective of identifying how the community is currently exposed and sensitive, and in which ways its capacity to adapt is enhanced and constrained. This involved identifying and documenting the nature of past and current exposure faced by the community (what has affected them, how and why),

⁴ The purpose of their study was to understand the process which makes a community adaptive or vulnerable.

the adaptive strategies they have employed, and how these results reflect their capacity to adapt. Examples of some of the questions included in this methodology were: When adaptation strategies took place? How effective were various adaptation measures in limiting exposure-sensitivity in local communities? What lessons were learned from the past that could be used to improve adaptation measures in the future? In past studies adaptive capacity was found to be determined by a wide range of factors, such as availability and distribution of resources, institutional structure, perception of risk, income diversity, geographical location, physical infrastructure, land use planning, health status and availability of technological options (Yohe and Tol, 2002; Smit and Pilifosova, 2003; Brooks and Adger, 2005).

2.4 Conceptual Vulnerability Assessment Framework

A review of the literature indicates that meaning of vulnerability and thus its identification and measurement are a subject of debate, and that there is no single method of evaluating the vulnerability of a community, region or state. It more or less depends on the question of interest. Vulnerability assessment is most useful and relevant when applied to a defined human-environment system, and particular place instead of a single sector.

The Intergovernmental Panel on Climate Change (IPCC, 2001) has defined vulnerability to climate change as follows:

The degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001).

Vulnerability of a community is a multi-dimensional concept and may be associated with external hazards (Wittrock, 2011). Drought affects both biophysical and socioeconomic systems. Both biophysical and social characteristics of a place contribute to the vulnerability of a system to an external risk. Therefore, an integrated

approach which includes both biophysical and socioeconomic factors can capture the vulnerability of a community to drought.

To assess community vulnerability to drought, a conceptual framework (as shown in Figure 2.2) can be adopted.

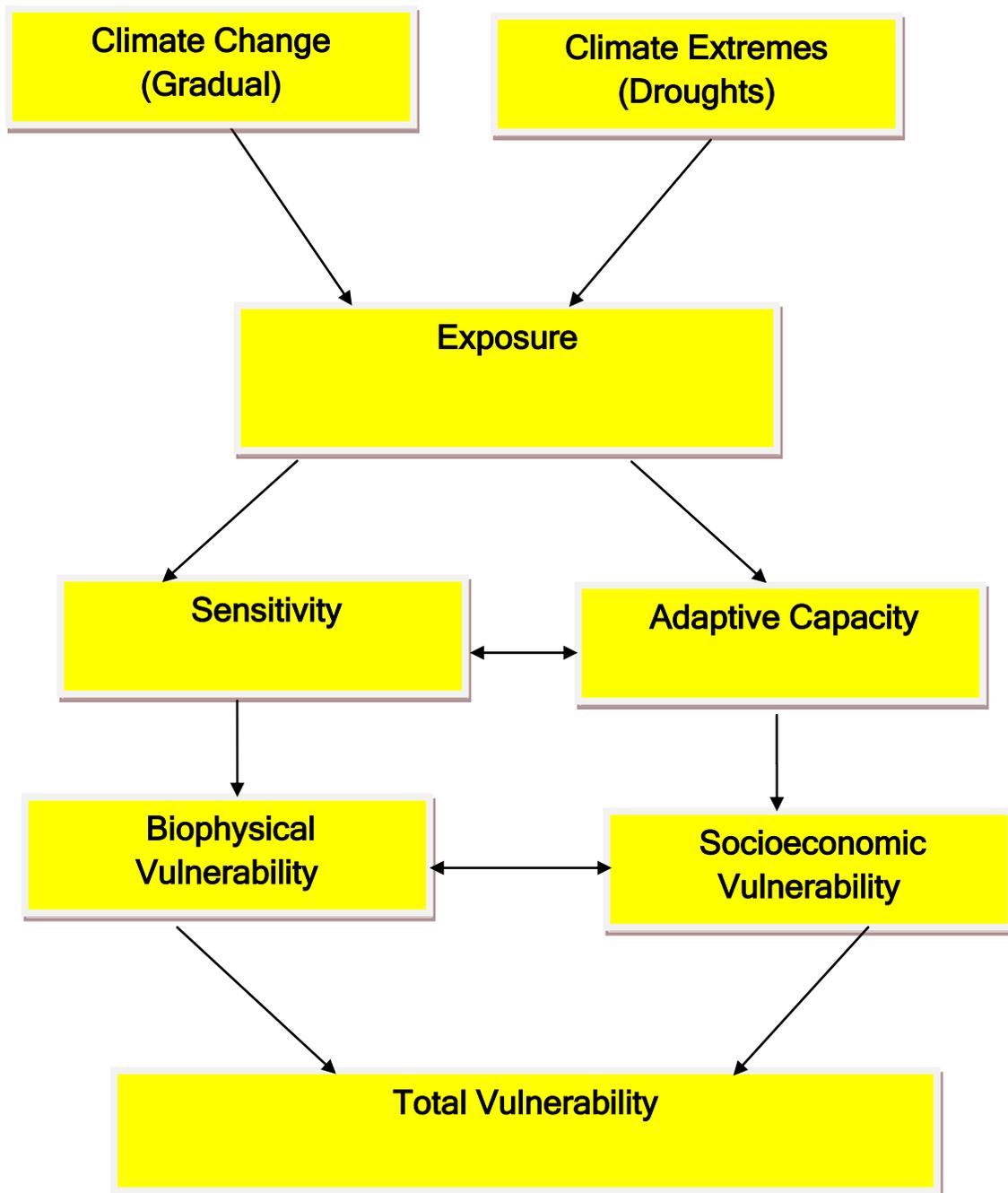


Figure 2.2 Conceptual model of vulnerability assessment

Source: Adopted from Deressa (2008)

This model is illustrated by Fontaine et al. (2009) and Schröter et al. (2004) and defines vulnerability as based on three primary variables: (1) exposure and severity; (2) sensitivity; and (3) adaptive capacity. Exposure incorporates frequency and severity of drought, where severity includes magnitude, and duration of drought. Sensitivity is the susceptibility of a community to the effects of the drought. Adaptive capacity is the ability to manage or reduce adverse effects of a drought, through actions taken before, during, or after the drought. In this study, community adaptive capacity is considered as a combination of assets or capitals.

Discussion of adaptive capacity is categorized around natural, technological, financial, and social capital. In social capital category, the role of governing institutions in the mitigation of drought impacts can be included. Further, vulnerability of a community to any change caused by a hazard such as drought is also related to past experience, which is related to the manner in which these individuals coped with the hazard. Vulnerability and adaptive capacity have an inverse relation -- if adaptive capacity is higher, it results in lower vulnerability.

This conceptual framework was adopted in this study to assess vulnerability to droughts in two communities in Saskatchewan- Kindersley and Maidstone (municipal and agriculture). The approach provides an important perspective on vulnerability by highlighting the vulnerability at a community scale using secondary sources of data and complementing it with information gathered from those who experience the vulnerability, by examining links between the hazard, the impacts, and ways to adapt to the impacts.

In Figure 2.2, community residents are shown to be exposed to both gradual climate change (mainly temperature and precipitation) and extreme climate change (mainly drought). Exposure affects sensitivity, which means that exposure to higher frequencies and intensities of drought risk highly affects outcome (e.g., yield, income, health). Exposure is also linked to adaptive capacity (Deressa, 2008).

For example a high level of adaptive capacity can reduce the potential damage from high exposure to risk. "Sensitivity and adaptive capacity are also linked: Given a fixed level of exposure, the adaptive capacity influences the level of sensitivity. In other words, higher adaptive capacity (socioeconomic vulnerability) results in lower sensitivity and vice versa" (Deressa, 2008). Therefore, exposure sensitivity and adaptive capacity are major factors leading to vulnerability.

This literature review indicates that past drought studies have been mainly focused on the analysis of biophysical aspects, such as analyzing the intensity and frequency of droughts. Only few studies highlighted the impact of droughts on the communities. Even in these studies, economic impacts have been documented by quantifying the losses in crop yields and in gross domestic product. Only a few studies have been done to answer the questions, such as: how communities are responding to droughts? What resources are available to deal with droughts? What are other factors that can enhance or constraint communities' ability to deal with droughts? This study will fill this gap by using integrated participatory vulnerability approach to understand exposure, impacts of droughts and also adaptation strategies to droughts.

Chapter 3

Data and Methodology

This study adopts a case study methodological approach to document how vulnerability and adaptation are experienced at the local level during a selected period of stress -- the 2001-2002 droughts. These case studies constitute a form of empirical inquiry that investigates a phenomenon within its real-life context using a variety of data sources. It involves the exploration of an issue through a variety of lenses which allow for multiple facets of the phenomenon to be revealed and understood (Baxter and Jack, 2008). This research adopts a critical realist approach⁵ (Archer et al., 1998; Danermark & Bhaskar, 2002; Dickens, 1992; Sayer, 1994) that recognizes both the constraints imposed by social and biophysical conditions and the presence of governing institutions, which are able to recognize and foster changes that enhance adaptation to desired conditions.

3.1 Selection Criteria for Research Communities

As already mentioned in Chapter 1, this study is a part of a larger research project on, "Rural communities' adaptation to droughts in Saskatchewan" (RCAD, 2012). Under this large project, six communities (Coronach, Gravelbourg, Kindersley, Maidstone, Maple Creek, and Shaunavon) were selected. All communities, except Maidstone, are located within the Palliser Triangle and are in Crop Districts which have been subjected to three or more years (between 1971 and 2002) of lower production. The community of Maidstone is located in a region that has not experienced frequent drought. However, it was also severely affected by the drought of 2001-2002 based on crop yields observations. Another selection criterion was population size. All the

⁵ Critical realism is a philosophy introduced by Bhasker (1998) in the 1970s in social science research; in simple words it means reality has multiple facets. Only empirical and scientific methods are not sufficient to explore a phenomenon\event. Phenomenon\events can be best understood in a real life context.

selected communities had a population within the range of 500-5,000 people. It was assumed that communities over 5,000 people, which are classified as cities in Saskatchewan, might lack the town and country character of smaller centers (RCAD, 2012). The lower limit of 500 was set because it would ensure a broader mix of agricultural and other services available in smaller centers. All the selected communities had core market town services, such as grain delivery and handling facilities, farm equipment dealerships and repair services, retail services, schools, health centers, care homes, police detachments, rural municipality (RM) offices, etc. Source of water was used as a criterion for selection of these communities. These communities had a variety of water sources, such as surface water (including pipelines) and groundwater. Finally, the availability of weather monitoring stations, which is helpful in assessing the community's exposure-sensitivity and adaptive capacity in the face of drought, was also a criterion used for selection.

Sources of data included published secondary source materials, including census and instrumental records, and primary data based on interviews with key informants and stakeholders. The data generated were analyzed both quantitatively and qualitatively. First, the community exposure to drought was documented using Palmer Drought Severity Index (PDSI) and Standardized Precipitation Index (SPI) values for the 1901-2004 period. This resulted in a time series of droughts for Kindersley and Maidstone communities for the growing season. Sensitivities to drought were highlighted using crop yield data (for major crops, spring wheat, canola and lentils) along with dugout levels and pasture growth. This quantitative data laid the ground work for highlighting the exposure and sensitivities. The qualitative data were used to explain the impacts of drought on the people, who faced these challenges, using semi-structured interviews and participant observations. **Semi-structured interviews** were used to gather information from the community residents about their exposure-sensitivity and adaptive capacity to droughts. Such interviews were an important tool for conducting case studies, as they helped in exploring the experience dimension of human's lives and social world (Bernard, 2012). In this study, an interview guide with open-ended questions on general topics and themes was used. Use of this technique allows researchers to collect information on events, experience and opinions of respondents (Hay, 2000). Furthermore, it allows participants to explain their point of view on different

themes, while researchers can employ probing to get required information as well as bring up new questions in response to the participants' comments. Probing is a useful tool to clarify concerns and issues raised by the respondents (Hutchinson and Skodal-Wilson, 1992). In this process, the respondents can recall information (Hay, 2008; Brock, 1984), as well as develop a sense of two-way communication between researcher and participant. Non-verbal gestures are also useful for supplementing information provided verbally (Hay, 2008). This format helps interviewers to probe respondents for more in-depth answers. It also allows the researcher to explain unclear questions, whereas in self-administered questionnaires respondents have no chance to clarify issues, if faced. Without the presence of the researcher, participants may simply choose an answer randomly from the list of choices, which affects the accuracy of results. Moreover, close-ended questions may not be able to explore the complexity of the issue. Finally, semi-structured interviews can help to overcome the weaknesses of poor response rate as well as unanswered questions in survey instruments. In addition, interviews are the most suitable qualitative research tool to find out how people think and how they react to issues.

In this study, the main purpose of using semi-structured interviews was to identify the stresses that are important to the respondents and their communities. Initially communities' governing institutions, the town and RM administration, were officially informed about study by the project head. These institutions helped in the identification of key informants for the interviews. Then the snowball sampling⁶ technique was employed to identify other participants. Snowball sampling proved to be very useful, as the communities were relatively small in size and everyone knew the people in their surroundings. In addition, they were able to suggest other informants that faced problems related to droughts and other water issues. This also enhanced the participation rate for the study, as people who knew that their friend or neighbour had referred them for participation. This process helped the study to achieve a good

⁶ In social research, snowball is a non-probability sampling technique, where existing study subjects refer their acquaintances as a possible candidate for the study. Thus the sample group appears to grow like a rolling snow ball (Heckathorn, 2002).

participation rate⁷. In order to minimize the issue of biased sampling, non-discriminative snowball sampling was used in this study. Because of the size of the community, informants were encouraged to nominate people that could provide different perspectives on the issue.

Table 3.1 shows the basic themes used to guide the research. A detailed interview guide is provided in Appendix A. Copies of consent forms given to respondents are presented in Appendix B.

A total of 40 individuals from Kindersley and 32 from Maidstone were interviewed. A distribution of these respondents is provided in Table 3.2. In the Kindersley community, 31 of 40 respondents were farmers. The number of farmers in the Maidstone community was slightly lower – 29 of 32 total respondents. In both the communities the respondents were dominated by farming operations.

All of the questions used in the interviews were open-ended in order to obtain in-depth thoughts on people's opinion on their vulnerability to drought. The interview guide included questions regarding people's opinion on environmental issues (those that they thought were relevant to them); issues that make them vulnerable; the manner in which those issues affected their livelihood; how they dealt with those issues; and whether their solutions were effective.

Scenario-based questions (based on future climate predictions) were also asked in order to gather information to supplement data collected from climate models in order to assess their future exposure sensitivity and adaptive capacity. The participants were encouraged to elaborate on their answers in order to obtain as much information as possible. After the interviews, a review was conducted by researcher on all the interviews to see if any issues arose and a summary was prepared, which contained key points from the interviews.

⁷ By random selection many people refuse to participate as they are constantly surveyed by government and commercial interests such as agriculture chemical companies.

Table 3.1 List of themes and examples of interview questions

Theme	Example Questions
<p>Background History: Life and work history Livelihood</p>	<p><i>How long have you lived in the community? How old are you? How many people live in your household? Are</i></p>
<p>Current and Past Exposures: Problematic conditions Issues with current situation Change in aspects of life</p>	<p><i>What sorts of things hinder your ability to earn a living? Are there any problems within the community? How do these affect you? How have these changed over the years?</i></p>
<p>Current and Past Adaptive Strategies: Techniques used to cope or manage exposures Aids and constraints to adaptation</p>	<p><i>What have you done in light of the exposures (from above)? What should you have done? What would you have liked to do? What could you do in the future?</i></p>
<p>Current and Past Climatic/Environmental Exposures: Problematic stimuli (especially droughts) Implications for the community Change in climate/environment</p>	<p><i>Are there any problems with the weather? Are there any problems with water quality/quantity? How have these changed and what do they mean to you?</i></p>
<p>Current and Past Climatic/Environmental Adaptive Strategies: Techniques used to cope or manage climatic/environmental exposures Aids and Constraints to adaptation</p>	<p><i>What do you do on exposure to climatic extremes (i.e. moisture deficiency) happens? How have you adjusted? Have your adjustments dealt with the problem? What do you wish you could do? What is keeping you from doing it?</i></p>
<p>Future Vulnerability: Future exposures Future adaptive capacities</p>	<p><i>What do you foresee for your future? If predicted climatic extreme events, their impact on your livelihood? How are you</i></p>
<p>Conclusion: Additions Gaps Other potential participants</p>	<p><i>Is there anything else that you would like to add or discuss? Are there any other people in this community that you think would be interested in participating in this</i></p>

Table 3.2 Sample distribution for study areas

Key Informants	Kindersley (KD)	Maidstone (MD)
Town and Federal Government representatives	7	3
Agriculture related Business Representatives	2	-
Grain Farmers	22	16
Mixed Farmers	7	13
Retired Farmers	2	-
Total	40	32

*Maidstone is a small community with the population of 1,156. Federal government offices and agriculture related businesses are not located in the community. Thus, these respondents could not be interviewed.

3.2 Participant Observation

Participant observation involves the inclusion of the researcher in the events being observed (Hay, 2000; Kearns, 2000). Such a process allows researcher to participate in the events, and observe the different daily routines of the people in study area. In this study the researcher visited respondents' homes and got a chance to see their daily activities, such as spraying, haying and ranch activities. This method is used to make responses more relevant and context-specific. It also helps to identify appropriate informants for subsequent interviews. Another advantage of participant observation is that by immersing oneself in the community, the researcher's experience can assist in understanding and enriching the data collected through interviews.

3.3 Sampling Strategies and Sample

This study is based on a total of seventy-two interviews (40 interviews in Kindersley and 32 interviews in Maidstone) that were conducted during eight-week period in the summer of 2010 from first week of July to last week of August, 2010. Sample sizes were determined in the field when the point of data saturation was achieved and no new insights emerged from the data. All the interviews were approximately 60 minutes each in duration. Throughout the field study, trust was developed between researcher and study communities (including respondents) through informal interaction and conversation with community members, by living with a local family, and frequently visiting public spaces, such as local coffee shops and grocery stores. Multiple snowballs⁸ were started by making initial contacts with the RM Reeve, Town Administrator, local PFRA officers (only in Kindersley), and economic development officer(s). Further participants were suggested by key informants. The end result was that the sample contained a mixture of people from different genders and socioeconomic characteristics (size of farm, education level, age, experience in farming, etc.), which is a representative sample of the community. Figure 3.1 and 3.2 show the age and education profile of respondents. In Kindersley, most respondents were of 55-60 years of ages, whereas in Maidstone, the majority was slightly younger (51-55 years of age). In terms of educational achievement, completing high school was the modal category.

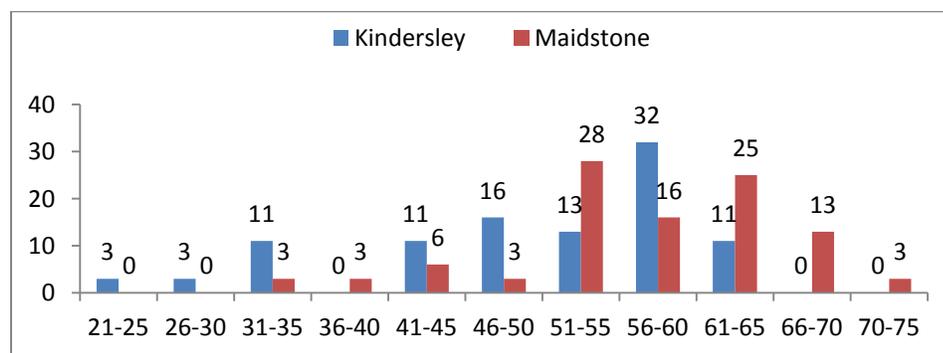


Figure 3.1 Age profile of interviewees in Kindersley and Maidstone

⁸ Multiple snowballs means asking many key informants to identify study participants, followed by asking current participants to nominate others in the study area.

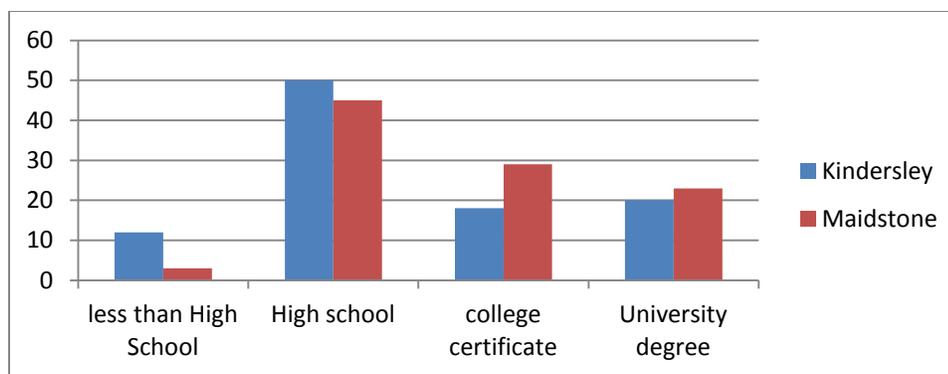


Figure 3.2 Educational profiles of interviewees in Kindersley and Maidstone

3.4 Data Interpretation and Analysis

All the interviews were digitally recorded and transcribed in Microsoft word processor. Transcriptions were exported to qualitative data analysis software - NVivo 9, a program commonly used for the analysis of qualitative data (QSR International, 2009). This software allows researcher to organize large amount of textual data. Data were coded for different nodes. A list of these nodes and coding scheme is provided in Appendix D.

Nodes are different themes, which are used in an interview guide and also the key themes which become apparent during the transcription review process. The main theme was coded as 'free node' and different responses about a particular free node were subcategorizing as tree nodes. The tree nodes used in this study were livelihoods, water use, climate exposures and sensitivities, adaptive strategies, and adaptive capacity. Free nodes included barriers to adaptive capacity, improving institutional support, future resilience, gender roles, water financial management, and other issues.

3.5 Research Ethics

This study required an approval by the Behavioral Research Ethics Board (REB), University of Saskatchewan. In order to ensure the safety and well-being of the participants and the communities, the ethics clearance process was adopted and ensured that the study conformed to the Guidelines for Research with Human

Participants of the REB and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans⁹. The information letter (shown in Appendix D) and consent form (as presented in Appendix B) were given to each participant so as to provide them with the background of this study and information of the expectations of the researcher. In the information letter, it was stated that participation was voluntary and that they could choose to withdraw from the study at any time without any consequence. Utmost care was undertaken to conduct this study to the best of the researcher's ability. Interviews, recordings, and transcripts were labeled with project codes to ensure anonymity of the informants. A report was sent to the communities for their feedback and reference in hopes of bringing benefits to the communities by helping them to better prepare for future climate-related events.

⁹ Detailed information on the Ethics policy of the University, see USASK (2012).

Chapter 4

Description of Study Communities

This chapter provides a description of the two study communities in rural Saskatchewan – The Rural Municipality of Kindersley (including the Town of Kindersley) and The Rural Municipality of Eldon (including the Town of Maidstone). The characteristics of study communities provide background information, which is helpful in understanding vulnerability to droughts. The current biophysical aspects (such as climate, source of water, soil type) and socio-cultural aspects (such as economic activity, socio-cultural factors and demographic information) of two study communities are described now in detail.

4.1 Community of Kindersley

4.1.1 Location

The Kindersley town and rural municipality 290 study areas are located in west central Saskatchewan in crop district 7A (Saskatchewan Ministry of Agriculture, 2010a). This area is located within Palliser's Triangle¹⁰. Climatologists refer to the region as an area of net moisture deficit since levels of evaporation and evapotranspiration exceed that received from precipitation (Sauchyn, 2007).

Aggravating the average conditions, the region is subject to periods of extreme droughts, sometimes lasting for years. According to paleo-climatological records multi-year droughts were common in this region. Since the settlement of this area in early 20th century, many multiyear droughts have been observed, including 1920, 1930s, 1961, and 1980s. During 1930s, drought lasted from 1929 to 1937 and forced many families to abandon their farms. This era is remembered as 'dirty thirties'. These droughts impacted

¹⁰ The term Palliser's Triangle reflects the impressions of a 19th Century British expedition led by Captain John Palliser that described a triangle shaped sweep of country that was deemed unfit for conventional agricultural production due to its lack of moisture. Palliser referred to the region as a northern extension of the great western desert of the United States of America.

settlers socially, economically and psychologically. In Saskatchewan, per capita income decreased 72 percent; from \$478 in 1928 to \$ 135 in 1933 (Marchildon et al., 2008). Government distributed almost \$4 billion (constant dollars) in relief. It took decades to recover from the losses of 1930 droughts.

In the early 21st century, the province was struck by a severe drought in 2001-2002. This drought is considered as one of the coast to coast drought on record, as it covered much of Canada (Wheaton et al., 2005). The net farm income in Saskatchewan was negative or zero and the gross domestic product (GDP) decreased by \$5.8 billion (Statistics Canada, 2003).

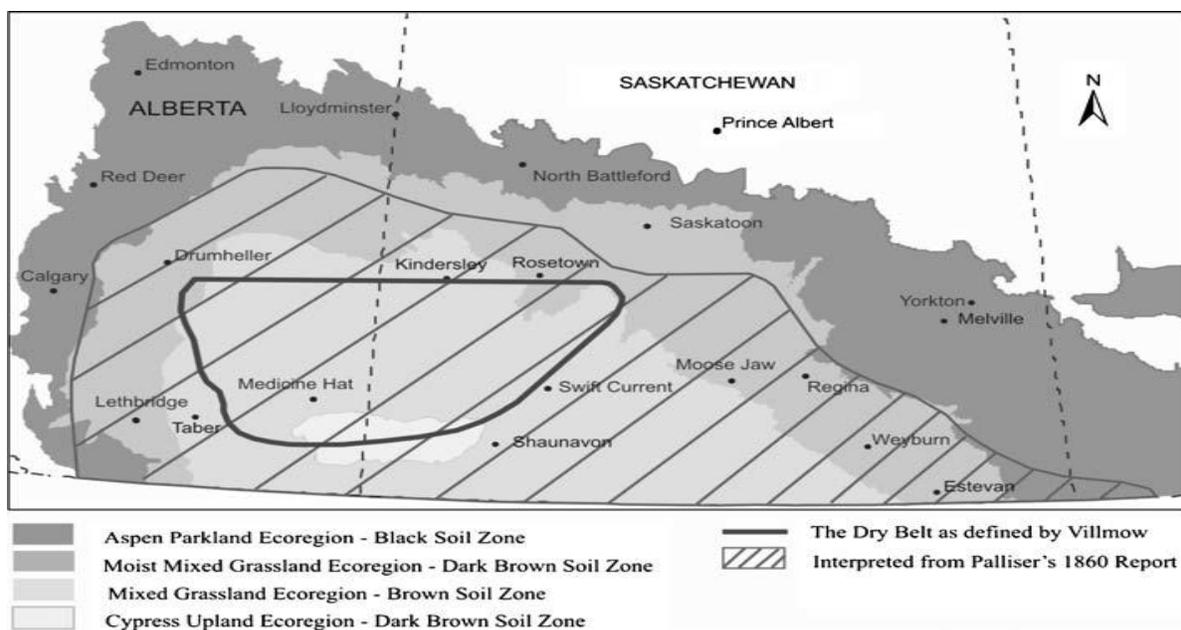


Figure 4.1 Map of Palliser's Triangle

Source: Marchildon et al. (2008)

4.1.2 Demographic Information for Kindersley

The town of Kindersley had a population of 4,412 in 2006, a decline of 5.7 percent compared to 1996 population of 4,680 people. According to the 2011 census, the town's population was estimated at 4,678 people, which showed an increase of 6% over the 2006 level. The town has rich natural resource base with agriculture and oil and gas production being the primary industries. Agriculture is the main driver of

Kindersley's economy followed by oil and gas extraction (KD1)¹¹. The town is the hub community for a trading population of 40,000 from the surrounding agriculture region. Moreover, Kindersley's location midway on the highway from Saskatoon to Calgary supports a range of services for travelers. The town has a wide number of big conglomerates such as Wal-Mart, Ford dealership, Tim-Horton's and McDonald. According to the 2006 census, accommodation and food services employed 7.4 percent of the labor force (Statistics Canada, 2007a). The town has full range of social services, including a hospital, high school, library, two senior's homes and a recycling facility.

The town of Kindersley is the Administrative Centre for Rural Municipality 290, which contains Netherhill and Brock on the east side of Kindersley along Highway 7 and Flaxcombe on the west side of Kindersley (Figure 4.2). The population of RM 290 declined by 12.4 percent in 2006 (1,042) as compared to 1996 census (1,190). According to the 2011 census the RM population (estimated at 987 people) declined by 5.3% compared to 2006 data (Statistics Canada, 2011).

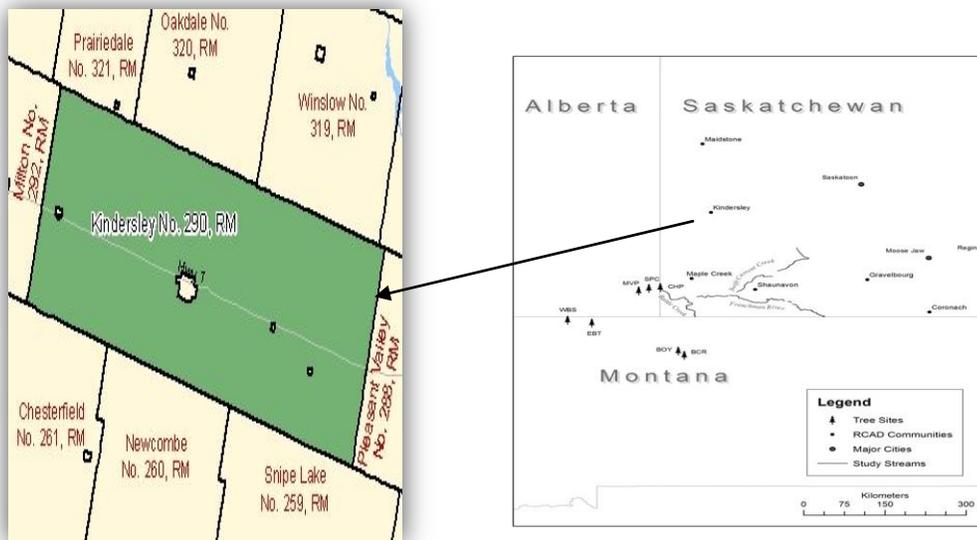


Figure 4.2 Map of Rural Municipality of Kindersley (RM No. 290)

Source: Statistics Canada (2007a).

¹¹ KD is the abbreviation for Kindersley, to hide identity of interviewees number has been used to refer a quote or response of respondents from Kindersley study area.

All these communities (Netherhill, Brock and Flaxcombe) are agriculturally based. In fact for the RM 290, 47.5 percent of labor force was employed in agriculture industry in 2001, although in 2006 this percentage was reduced to 37.4% (Statistic Canada, 2007a). Most local businesses in the town of Kindersley offer services to the agricultural community and provide goods, such as machinery, fertilizers, seeds, equipment repair services and transportation services. The oil and gas industry plays a crucial role in supporting agriculture by providing off-farm employment to the local farmers, especially during the low farm income periods.

4.1.3 Source of Water Supply

The residents of the Rural Municipality rely on various water sources for their domestic use (Table 4.1). Groundwater and potable surface water from the South Saskatchewan River are the dominant sources for domestic use reported by participants.

Table 4.1 Water sources in the Kindersley area

Type of water source	Number of respondents	Percent of total
Pipeline and dugouts	3	9%
Only pipeline	4	12%
Well and pipeline	9	27%
Well and dugout	4	12%
Only dugouts	4	12%
Well	9	27%
Total respondents	33	100%

4.1.4 Town Water Supply System

The main source of water for the town of Kindersley is a pipeline from the South Saskatchewan River. The pipeline is owned and operated by the town. In 1964, the town of Kindersley and the neighboring town of Eston jointly built a water pipeline from the South Saskatchewan River to an open reservoir, called Snipe Lake, located in rural municipality of Snipe Lake (RM 259), 3 km east of Eston and approximately 37 km away

from Kindersley. From that reservoir, Kindersley constructed pipelines to its own reservoirs. This system had a potential to pump 600 gallons per minute to Snipe Lake Reservoir. In 1964 this line was the longest water line in Saskatchewan (KD4). Moreover, Kindersley also obtains water from runoff at the Motherwell dam (Figure 4.3), located 3.3 km northeast of the town. The Motherwell dam is the backup source for the town to meet high water demand during the summer months.

Droughts of 2001-2002 placed a stress on the town water, resulting of low stream flow and also some technical problems with the river pumps. According to the town water plant manager:

“Winter was never a problem - we had adequate supply for winters, but summers, if we had a dry spring and there was no runoff, our system definitely relied on runoff to buffer us for the summer months. The seasons that we didn’t get that spring runoff, we definitely had to implement water rationing”.

The town imposed water rationing, such as outside water use on alternate days during summer months on several occasions in 2001-2002. To address the drought issue and to increase water storage capacity, in 2003 the town of Kindersley initiated a water line upgrade and extension project, called Kindersley ‘East Water Pipeline’. The total cost of the project was \$4.3 million.



Figure 4.3 Motherwell dam on the east side of Kindersley

The town got a grant of one million dollars from Canada Saskatchewan Infrastructure Program (CSIP), and the remaining \$3.3 million dollars were borrowed from the local bank. Under this project, 140 farms and acreages on the east side of Kindersley were provided with the town water in 2007 (KD4). Subscriber's cost was about \$30,000 per individual, whether they were landowners or users. Each subscriber had the option of either paying their portion up front or paying it over a period of time through taxation (KD4). The town also upgraded its storage capacity and constructed a new water tower in 2009 (Figure 4.4), which can hold 726,000 imperial gallons (3,300 cubic meters) of water. This upgrade on the water storage system dramatically increased the water supply in the town (KD 4).

According to the town administrator, this new water storage system opens the door for economic development in the Kindersley. Previously, the town lost many small industries because of water scarcity. For example, the town official mentioned that during the 2002-2003 timeframe, there was an interest from a company from the United States to look at a malt barley plant. This development did not take place perhaps partly due to the insufficient water supply (KD5).

The upgrades on the Kindersley water system, besides opening the window of economic opportunities for the town, also improved the water availability for many rural farmers in the surrounding area. One of the farmers considered himself lucky that he hooked up to the town water. According to this respondent: "*secured and treated water reduced my tension, I am lucky enough. Still many people in the area rely on well or dugout water, which is a continuous headache, because of low water pressure and high mineral contents*" (KD1). Kindersley town water meets the quality standards set by Health Canada. The respondents, who had well water for domestic use, had not felt any significant impacts of the 2001-2002 droughts on the levels of their well water. However, well water quality was a concern for many respondents. Some respondents have used reverse osmosis system to filter minerals (such as iron and magnesium) found in groundwater.



Figure 4.4 Kindersley's old and new water towers

Source: Researcher personal album

Presently, the town has a proposal for a project called 'Water West Project'. Under this project, Kindersley will increase the size of pipeline from eight inches in diameter to twelve inches at the river supply outlets. This upgrade will increase the water pumping capacity from the river from 600 to 1000 gallons per minute. Estimated cost for the improvement on the water system is \$6 million. It is expected that the CSIP will provide 50 % of the cost, with the remaining provided by the community. In the near future, plans are to provide lateral water lines to the neighboring RM of Newcombe and Chesterfield from Kindersley. In fact, these rural municipalities will buy water from Kindersley. In order to fund this project the current water rates will be increased by 15% for Kindersley residents (KD4).

The town administrator reported that, they planned their water system by looking 15-20 years down the road in terms of population and economic growth (KD7). According to the town water plant manager, *"considering the reserve capacity built into the water system, the town has a secure source of water"*. According to her, presently the town of Kindersley has no water concerns. Town officials are confident of handling any future water stresses. Presently, the main water users of the pipeline are the town residents and agriculture producers on the east side of Kindersley. The oil and gas

exploration companies are not using town water; they are buying dugout water from the farmers.

4.2 Community of Maidstone

4.2.1 Location

Maidstone is located in the northwestern part of Saskatchewan, about midway between two cities, North Battleford on the east and Lloydminster on the west. It is on the corridor that connects Saskatchewan to Alberta. Maidstone is located in the Aspen parkland ecoregion, which is considered as a transitional ecosystem between the boreal forest to the north and the grasslands to the south. The soil in this region is classified as Black Chernozemic, which is high in organic content. Fertile soils and favorable climate condition make this region one of the most suitable areas for farming. The mean annual rainfall of the area ranges from 400-500 mm (Environment Canada, 2013). The 2001-2002 droughts were the first multi-year disaster for the area.

4.2.2 Demographic Information of Maidstone

The population of the town of Maidstone was estimated at 1,156 in 2011, which was an increase of 11.5 percent over the 2006 level. The town is surrounded by Rural Municipality of Eldon 471, which includes the town of Maidstone and village of Waseca, which is 13 kilometers west of the Maidstone. The town of Waseca had a total population of 154 people in 2011 (Statistics Canada, 2011b).

Agriculture and oil industry are the major economic drivers of the town. The town and RM are the one of the affluent area of rural Saskatchewan. The total assessment for the town was \$38.8 million, as compared to a value of \$335.0 for the entire RM. In 2006, 15.7% of the experienced labor force was employed by oil companies, followed by 13.6% employed by agriculture industry. The accommodation and food services sector has shown an increasing trend in 2006 and employed 11.11% (Statistics Canada, 2007b).

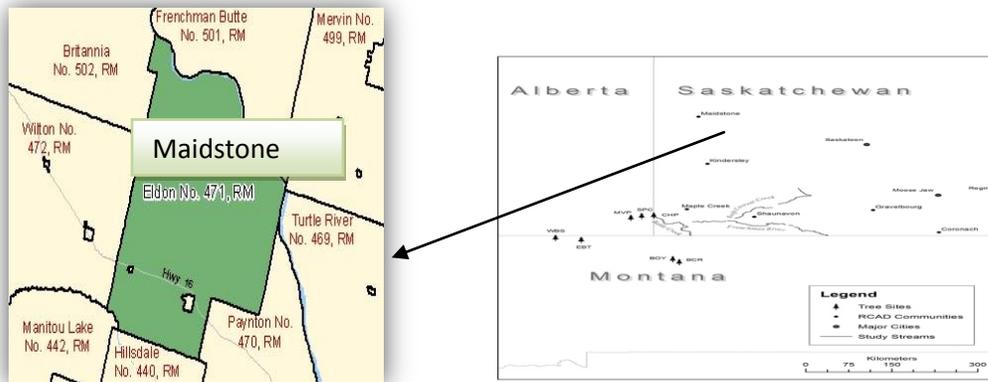


Figure 4.5 Map of Rural Municipality of Eldon (RM No. 471).

Source: Statistics Canada (2007b)

The oil company workers are the main users of accommodation and food services in the town. Some oil company personnel work in Lloydminster but prefer to live in Maidstone. This is because of low cost of living and the presence of competitive high school in Maidstone, which provides a friendly atmosphere for a small town to raise kids (MD16).

The town of Maidstone is the administrative center for the Rural Municipality of Eldon 471 (Figure 4.5). This RM lies in the aspen parkland, which indicates a climate gradient from southwest short grass prairies to the northern boreal forest ecozone. The area is rich in natural capital. The soils are in the black zone, which has high content of organic matter (3.5-4.5 %). The annual average precipitation for the area is 424 mm. This area is called 'Canola capital' besides being famous for pure bred cattle. The population of RM was 750 in 2006, which has shown a decline of 2.1 percent since 2001. Agriculture and ranching are common in this area. The major crops in the area are canola, wheat, barley and peas. Some farmers have also tried lentils and sunflower, but found them unsuitable for the climate of the area (MD9).

4.2.3 Water Supply Sources for Community

In RM 471, the main water source for domestic use is wells, but some respondents also had to rely on dugout water for domestic use (Table 3.2). One

respondent, who lived only 2 km north of the town, relied on the dugout water until August 2010.

Table 4.2 Water sources in the Maidstone area

Type of water source	Number of Respondents	Percent of the Total
Town Water	2	6%
Town water and dugouts	3	9%
Well and dugout	16	52%
Only dugouts	4	13%
Only well	5	16%
Town water, dugout and well	1	3%
Total respondents	31	100%

According to him, although he tried to clean the algae from the water using a fish, it was unsuccessful. As a result he had to rely on smelly water for domestic use. Ultimately, in August 2010, he hooked up to the town water. He mentioned “*it is a huge, huge relief for me*” (MD 30). Wells in the area vary from shallow (15 feet deep) to deep (100-150 feet). Few respondents, who owned deep wells, have no quality concerns, whereas for the majority (45 %), water quality is a big issue. Many respondents (70% of total) buy bottled water for drinking purposes because of the high iron content in the groundwater. Moreover, the RM has provided three community wells, which are being used by farmers for spraying and livestock purposes.

4.2.4 Town Water Supply System

The main source of water for Maidstone is groundwater. At the time of the interviews, water came from the wells in Waseca. In terms of history, a water line was constructed in 1962 from the Maidstone Lake (located 8.2 km south of the town), which was the main source of water for the town. According to the water manger, these pipes were made of asbestos cement, which were not recommended any more for use in the

province (MD12). Currently the town has faced many problems of leakages on this pipeline (MD12). The Maidstone area was struck by a severe drought during 2002, which resulted in very low water levels in the Maidstone Lake. As a result, the town was not able to fulfill water demand during 2002 (MD12). Based on this experience, in 2003, the town initiated a project to bring water from Waseca with financial support by CSIP. The total cost of constructing this pipeline from Waseca wells was \$3.06 million. The CSIP contributed \$845,290 and the town spent the remaining \$1.37 million (MD12; Government of Saskatchewan, 2003). Under this project, the town has drilled two supply wells, put in a pipeline and a storage facility and undertaken water treatment plant improvements. This project was able to eliminate the community's concern about the water quantity. The town of Maidstone is presently mixing Waseca well and Maidstone Lake water to meet the water demand for the community. Many town residents reported no concern on the quantity or monthly water cost. The Maidstone town water meets the Health Canada's standard, but the majority of the respondents were still buying bottled water for drinking purposes. The high mineral content in the town treated water was a huge concern for the town's residents. The town of Maidstone has currently no local watershed committee. For this reason, the town administration, at the time of this study, was not able to provide data on the current water availability, storage capacity and current water demand. Nonetheless, the town administration was optimistic about the future water availability of the town, *"I think the town will not grow more than 1,500 people in the near future, we have a sufficient source of water, and we can meet our water demand easily in next 5-10 years"* (MD1).

The sewage system in the town is a conventional two cell lagoon; sewage stays in one cell for 120-150 days and then moved into next one. Currently, the town is releasing its sewage to irrigate some alfalfa on the land owned by Saskatchewan Ministry of Agriculture. The lagoons have reached to their maximum capacity. During the study period (during August, 2010), on account of excessive rain fall, the lagoon's capacity was a concern for the town. The town officials mentioned that if town needed some immediate infrastructure improvement, it would be the expansion of the lagoons capacity.

Chapter 5

Exposure to Past Droughts

One of the objectives of study was to highlight communities' past exposure to droughts. This objective was achieved by analyzing the extent and severity of drought using data for 1901 to 2005 period for Kindersley and Maidstone, Saskatchewan. This was accomplished by using Palmer Drought Severity Index (PDSI) and Standardize Precipitation Index (SPI). This chapter explains the drought conditions in the two study communities based on quantitative analysis of drought indices. One of the advantages of using drought indices is the ability to conduct standardized and quantitative comparison of droughts from different regions and eras (e.g. Dai et al., 1998; Weber and Nkimderim, 1999). For example, PDSI has been used to evaluate the droughts of 1988, 1929, 1936 and 1937, leading the conclusion that the severity and the spatial extents of these droughts were highly correlated on the Canadian Prairies (Evans, 2008).

5.1 Selection of Indices

In the literature, several drought indices have been designed to monitor moisture levels, but like defining drought, there is no single index suitable for all purposes (Dai, 2011). Generally speaking, indices are used to facilitate an assessment of complex phenomena and are an important means to provide scientific information, which can be used without requiring an extensive knowledge of the data and science behind the calculation (Quiring and Papakyriakou, 2003). An index is often in the form of a dimensionless number that can be associated with a qualitative description of a given (environmental) condition. In the case of drought indices, the goal is to have a straightforward but quantified measure of drought intensity, duration and spatial extent (Evans, 2008). There are numerous existing drought indices, but the PDSI (Palmer, 1965) is one of the most commonly used. According to Hayes (2006), it is known to be well suited to agricultural drought monitoring. It is also preferred as it accounts for many hydrologic factors, such as precipitation, temperature, and evapotranspiration that control moisture in a given region, not just precipitation. The PDSI attempts to quantify

the cumulative departure of moisture supply from normal conditions, encompassing both past and present moisture levels. It is based on a water-balance equation and accounts for the preceding moisture conditions, as well as regional moisture supply and demand.

The SPI index was designed to be a relatively simple index, as it is based solely on precipitation (McKee et al., 1993). This index interprets observed rainfall in the context of a probability distribution and computes a standard departure from the historical conditions. While the PDSI is somewhat limited in its utility when describing mesoscale droughts (Robinson and Fesperman 1987), the SPI is capable of describing the precipitation shortages across various timescales, including mesoscale periods (Quiring and Papakyriakou, 2003).

Given the societal impacts of drought discussed in Chapter 2, there is a strong motivation to understand the sustaining mechanisms of drought and to better characterize its behavior. This in turn can contribute to more effective drought policies to address management, mitigation and coping strategies. The literature indicates that, the previous work on drought has been mostly focused on the regional scale analysis of drought. However, the (smaller-scale) interactions between the surface and the atmosphere and the associated feedbacks, which define the water cycle, may also be important. For example, Roberts et al. (2006) indicated a positive feedback between a lack of precipitation leading to dry surface conditions, resulting in a continued lack of precipitation and drier surface conditions.

Drought intensity for a given location can be done using value of these two indices. Table 5.1 shows the criteria to classify droughts in various types. An extreme drought condition prevails if the PDSI values are less than -4 or if the SPI values are less than -1.5.

5.2 Methods

The spatial and temporal scale of drought in Kindersley and Maidstone communities were analyzed using climatological data for six grid cells for each community (Figure 5.1). The gridded drought index data were calculated from a larger data set which contained monthly temperature and precipitation developed by Mckenney et al. (2006). The data set contained observations of monthly precipitation,

and minimum and maximum temperature grids for Canada for the 1901- 2005 period. These data were calculated from monthly climate station data from 1901 to 2005 obtained from Meteorological Service of Canada (MSC)¹².

Table 5.1 Classification of drought based on PDSI and SPI values

Classification		PDSI	SPI
Drought	Exceptional	≤ -5.0	≤ -2.5
	Extreme	> -5.0 to -4.0	> -2.5 to -2.0
	Severe	> -4.0 to -3.0	> -2.0 to -1.5
	Moderate	> -3.0 to -2.0	> -1.5 to -1.0
	Mild	> -2.0 to -1.0	> -1.0 to -0.5
Near Normal		> -1.0 to 1.0	> -0.5 to 0.5
Wet	Mild	1.0 to < 2.0	0.5 to < 1.0
	Moderate	2.0 to < 3.0	1.0 to < 1.5
	Severe	3.0 to < 4.0	1.5 to < 2.0
	Extreme	4.0 to < 5.0	2.0 to < 2.5
	Exceptional	≥ 5.0	≥ 2.5

Source: McKee et al. (1993)



Kindersley Community

Maidstone Community

Note: Selected weather stations are shaded in light blue color.

Figure.5.1 Grid cell distribution for Kindersley and Maidstone

¹² Details of Canadian historical data used in creation of the grid cells are outlined in McKenney et al. (2006).

In this study, data from six grid cells in each of study areas were obtained from the larger data set called ANUSPLIN for analysis of characteristics of drought¹³. The PDSI and SPI values were calculated by Meinert et al. (2010), which were used in this study. Using monthly values, averages for each year were calculated for each agricultural year. The agricultural year period was defined from September through August. For example, values for 2001 refer to the period of September 2000 to August 2001.

In this study, drought patterns were identified for the period of 1901-2005 for both the communities. This included identification of top ten dry years, as well as characteristics of recent 2001- 2002 droughts and their comparisons for the two study communities. In order to describe drought frequency and intensity patterns, data are presented graphically.

5.3 Quantification of Drought Intensity for Kindersley

On the basis of mean annual PDSI values from six grids, the year 2001 was ranked as the driest year in Kindersley when the PDSI value of -3.7 was obtained. This was followed by the year 2002 with a PDSI value of -3.5. Table 5.2 shows the top ten driest years for the community over the period 1901-2005.

**Table 5.2 Ranking of top ten dry years in Kindersley over (1901 - 2005)
based on PDSI Values**

Year	Mean PDSI values
2001	-3.7
2002	-3.5
1988	-3.1
1977	-2.8
1937	-2.7
1987	-2.4
2004	-2.4
1980	-2.3
1949	-2.3
1958	-2.2

¹³ This dataset is available on the website of Drought Research Initiative (DRI).

When PDSI values were analyzed over an agricultural year, 2002 was found to be the worst drought followed by the 1988 and 2001 years. During the period 1901-2005, Kindersley had three severe drought years, i.e., 2001, 2002 and 1988 (Figure 5.2).

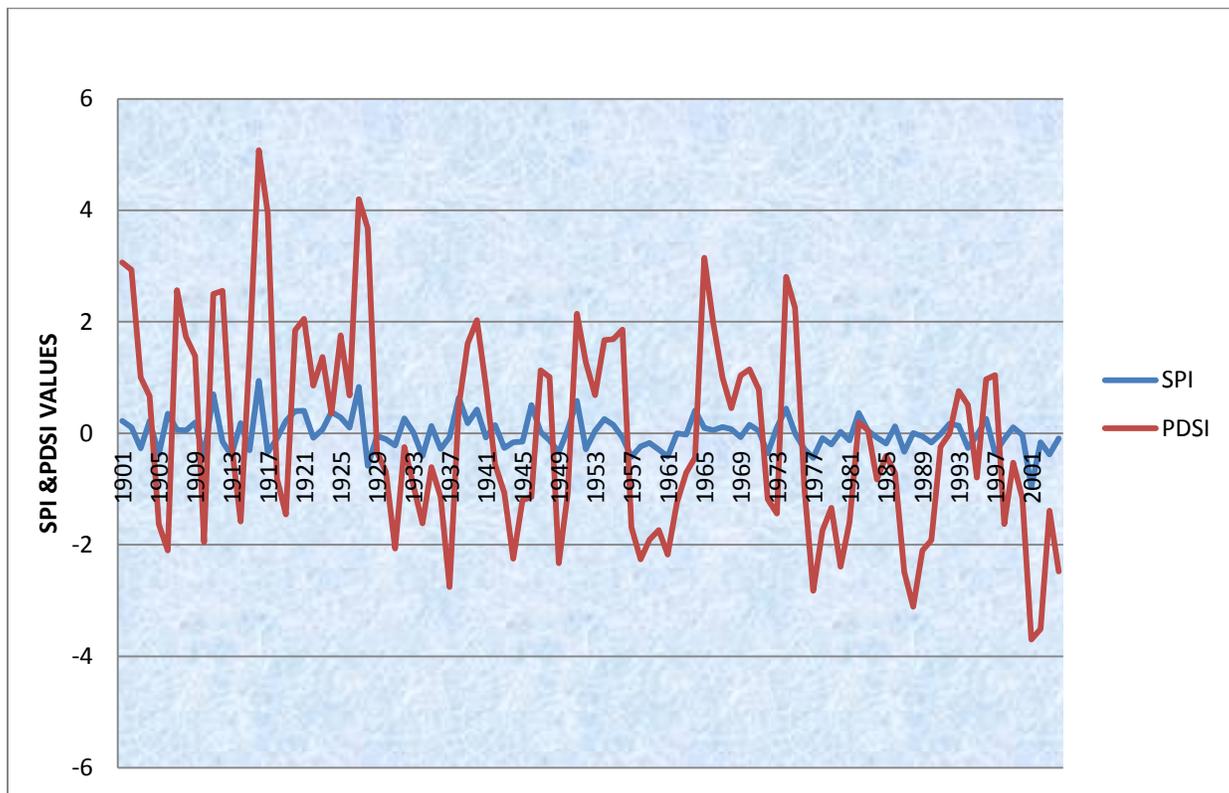


Figure 5.2 Patterns of Drought Indices for Kindersley (1901- 2005)

Among them, 2001 drought was recorded as the worst one, particularly during the growing season, as shown in Figure 5.3. In August 2001, the area was exceptionally dry with a PDSI value of -5.4. The second driest year in Kindersley was the 2002 growing period from April to August (Figure 5.4). This period was exceptionally dry with PDSI value less than -4. Kindersley area was in severe drought (PDSI -3 to -4) from May 2001- August 2002 (Figure 5.5).

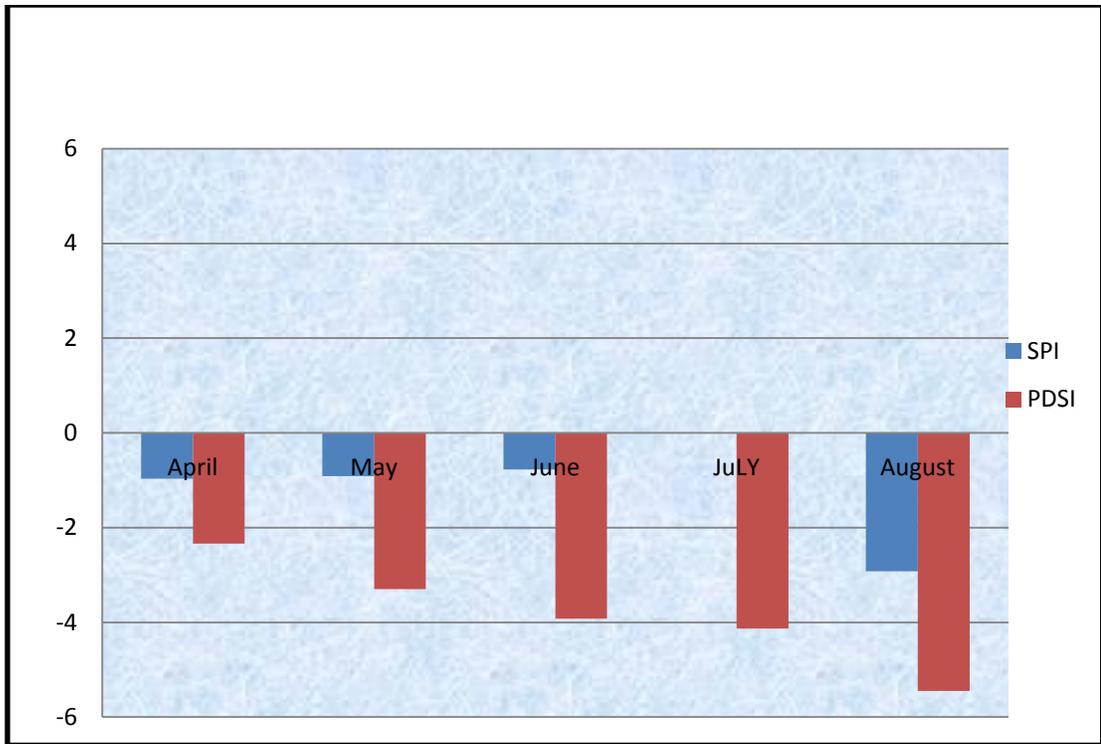


Figure 5.3 Growing season SPI and PDSI values for 2001 in Kindersley

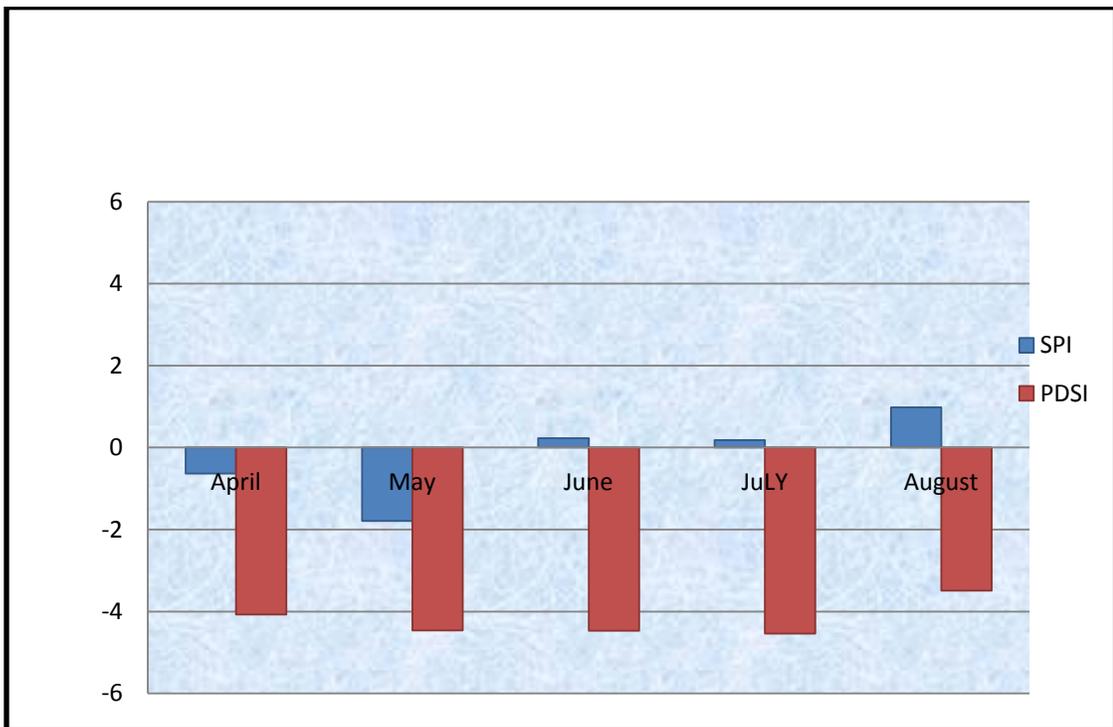


Figure 5.4 Growing season SPI and PDSI values for 2002 in Kindersley

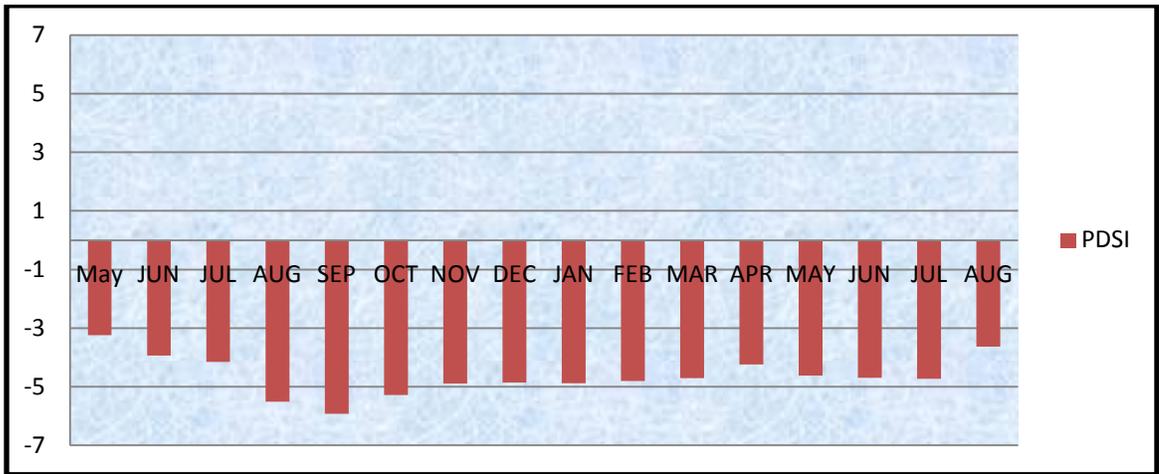


Figure 5.5 Monthly PDSI values showing severe drought conditions in Kindersley May 2001 - August 2002

5.4 Quantification of Drought Pattern for Maidstone

Drought pattern and frequency in this relatively northern community of Maidstone were different from those experienced in Kindersley. Pattern of dry and wet years for this community are shown in Figure 5.6. This long term analysis indicated that droughts impacted Maidstone in the early part of century with agriculture year 1919 being recorded as an exceptionally dry one.

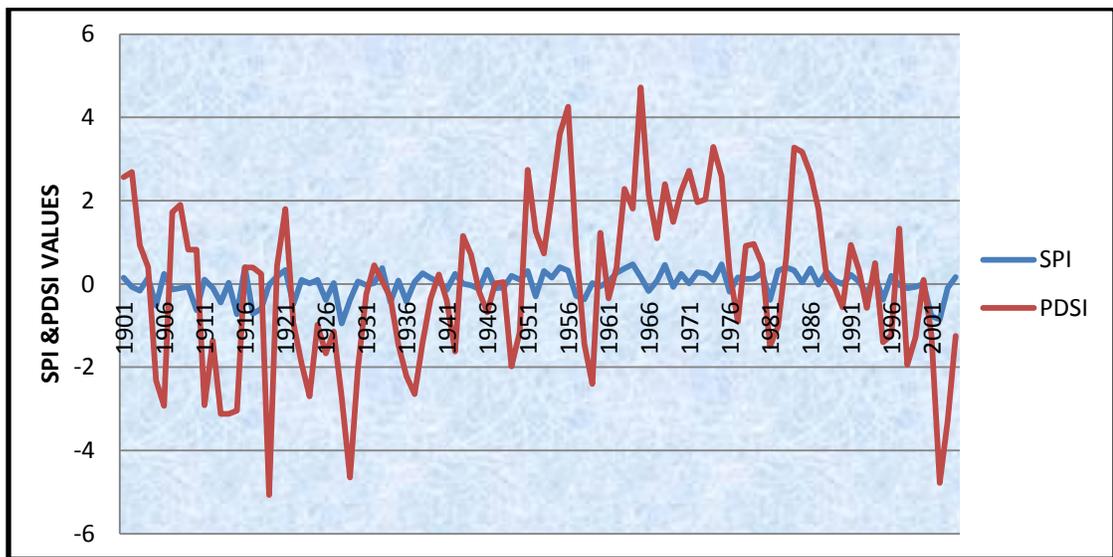


Figure 5.6 Pattern of drought indices for Maidstone, 1901-2005

Maidstone area was not in severe drought in 1930s relative to Kindersley area. Based on mean PDSI values, the year 1919 was ranked as the exceptionally driest year, when a PDSI value of -5 was estimated (Table 5.4). The next dry year for this community was experienced in the 2002, when a PDSI value of -4.8 was estimated. The 2001-2003 droughts were the most recent multi-year droughts recorded in this period for the area.

Table 5.3 Ranking of top ten dry years in Maidstone over (1901 - 2005) based on PDSI Values

Year	PDSI (mean from six grid cells)
1919	-5.0
2002	-4.8
1918	-3.2
2003	-3.1
1914	-3.1
1915	-2.9
1906	-2.8
1937	-2.5
1928	-2.2
1913	-2.2

The drying trend started in August 2001 and continued until August 2003 (Figures 5.7 and 5.8). The Growing season in 2002 and 2003 also showed severe drought conditions in Maidstone.

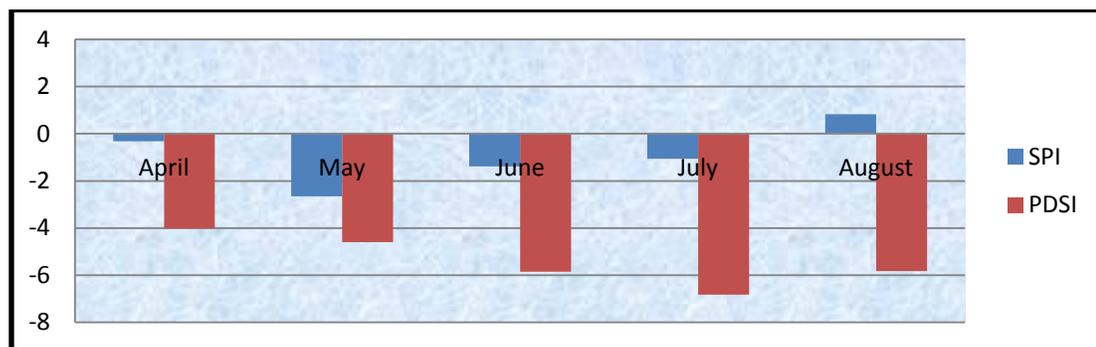


Figure 5.7 Growing season SPI and PDSI values for 2002 in Maidstone.

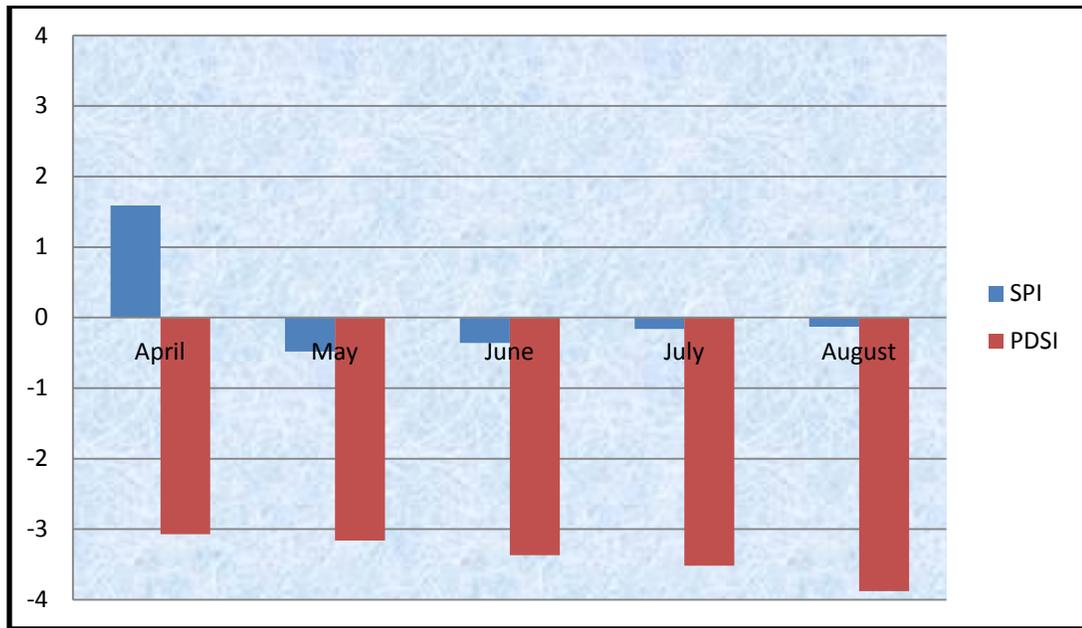


Figure 5.8 Growing season SPI and PDSI values for 2003 in Maidstone.

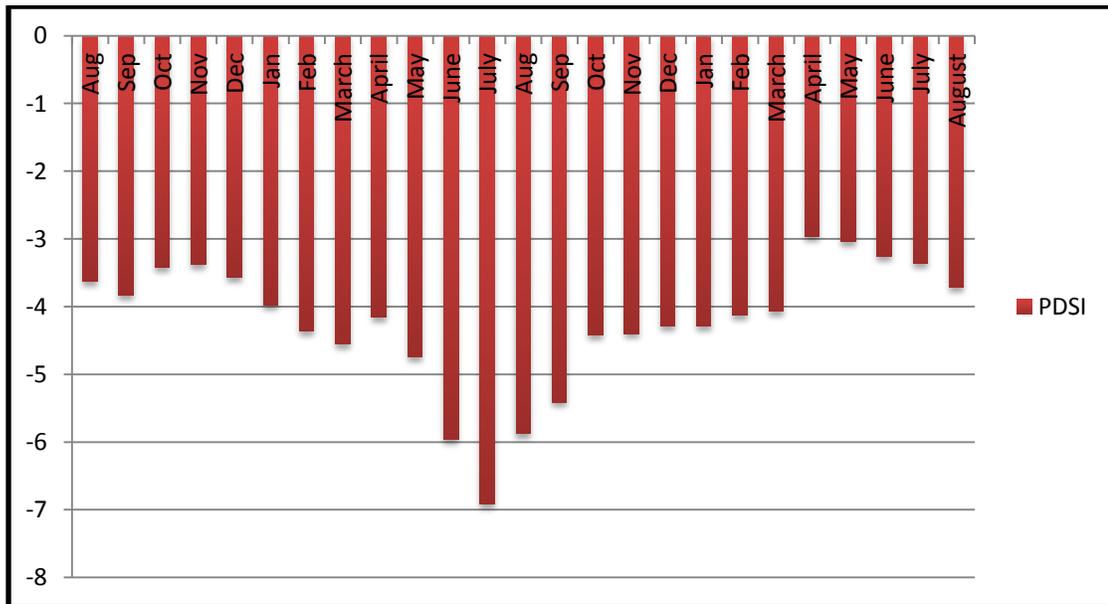


Figure 5.9 PDSI values for the period of August 2001 - August 2003 for Maidstone

Maidstone had several severe consecutive monthly drought periods during August 2002 - August 2003. The worst month was July 2003 with a PDSI below -6. In

fact the entire growing season in 2003 was under severe drought conditions (Figure 5.9).

5.5 Comparison of Drought Conditions in Study Communities

A comparison of PDSI values for the two study communities illustrates the contrast in drought period, frequency, and severity. This comparison was done for the 2001-2003 period. Based on the evidence presented above, it appears that Maidstone had a lengthy and severe drought compared to Kindersley. Maidstone also had moderate drought from August 2001-December 2001. After February 2002, this area became severely dry for 20 consecutive months ending in August 2003. In contrast, Kindersley showed a different pattern during the same time period. The period from May 2001 to June 2001 was a severe drought period in Kindersley. After June 2001, this study area became exceptionally dry with a PDSI values of < -4 for 13 consecutive months (i.e., from July 2001-July 2002). Drought became less severe after August 2002 until July 2003 in Kindersley, which was not the case with Maidstone. Wheaton et al. (2005) also reported that during 2001-2002, the summer droughts extended much farther northward and both eastward and westward than the earlier major droughts in the region. This illustrates that fact that communities differ in timing and severity of droughts. For this reason, it is important to understand and characterize droughts at a local level.

5.6 Sensitivities / Impacts of 2001-2002 Drought in Kindersley

The extent of the early 21st century droughts in the Canadian Prairies is well documented (Wheaton, 2007). Multiyear droughts in Kindersley had devastating effects on crop yields. In 2001, yields of spring wheat, canola and lentil decreased by more than 50% of the historical average (1971-2000). Similarly, in 2002 wheat and canola yields were reduced by almost 100% (Table 5.6).

Table.5.6. Impact of 2001-2002 drought on agricultural yield in Kindersley.

Year	Spring Wheat		Canola		Lentils	
	Yield (bu/acre)	Percent of Historical Average	Yield (bu/acre)	Percent of Historical Average	Yield (lbs/acre)	Percent of Historical Average
Historical (1971-2000) Average	28.0		17.0		1,020.7 ^a	
2001	15.1	53.9%	8.7	51.1%	418.0	41.0%
2002	9.6	34.3%	0	-- ^b	277.0	27.1%
2003	22.0	78.6%	16.4	96.4%	844.0	82.7%

^a Lentil production started in early 1990s in Kindersley

^b Total crop loss

Source: Data obtained from: Ministry of Agriculture (2010b).

As reported by the PFRA, in the Kindersley area, dugouts, which are the main source of water for agriculture producers (Wittrock and Wheaton, 2007), were completely dry during 2001-2002 (Table 5.7). It was also reported that the pasture growth during the same period was very poor in Kindersley, as shown in Figure 5.10. In fact the entire west-central Saskatchewan had very poor pasture growth, affecting livestock production in the region.

Table 5.7 Precipitation during 2001-2002 and effects on pasture and dugouts (Relative to average climate normal of 1971-2000)

Particulars	Remarks
Precipitation during the growing season 2002 relative to Historical Average (1971-2000)	<40-85%
Precipitation during the growing season 2003 relative to Historical Average (1971-2000)	<60-85 %
Pasture Growth 2001-2003	Poor
Dugout levels 2001-2003	Dry

Source: Environment Canada (2010)

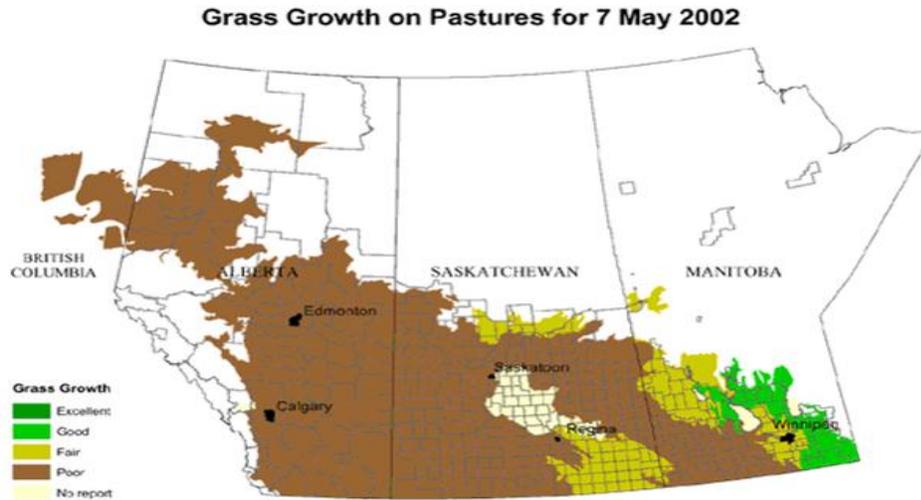


Figure 5.10 Pasture growth in the Prairie Provinces in 2002
(Source: Wheaton, 2008)

5.7 Sensitivities / Impacts of 2001-2003 Drought in Maidstone

On account of location and soil type, Maidstone never faced total crop failure in the instrumental record period. Based on recorded yields of various crops, the 2002 drought reduced crop yields for almost all crops, as shown in Table 5.8. For example, spring wheat yields were only 29.5% of the historical average. Other crops, such as canola, oats and peas were similarly affected.

Table 5.8 Impact of 2001-2003 droughts on agricultural yield (RM Eldon)

Year	Canola		Spring Wheat		Oats		Peas	
	Yield (bu/acre)	Percent of Historical Average						
Historical (1971-2000) Average	24.2		29.5		55.5		28.6	
2001	24.6	101.7%	30.7	104.1%	40.0	72.1%	30.2	105.6%
2002	16.9	69.8%	8.7	29.5%	37.4	67.4%	6.5	22.7%
2003	14.4	59.5%	17.8	60.3%	33.1	59.6%	21.9	76.6%

Data source: Saskatchewan Ministry of Agriculture (2010b)

5.8 Summary and Concluding Remarks

Historical records indicate that drought is a recurring event on the Canadian Prairies, with at least five decades since settlement having experienced major droughts (Quiring and Papakriakou, 2005). Furthermore, there is significant evidence that the climate of the Prairies has been unusually wet since the era of settlement. The tree ring data suggests that droughts were more severe and persistent in the 17th and 18th centuries than even the longest drought in the last century (Sauchyn and Skinner, 2001). Also, IPCC assessment reports indicate that anthropogenic-induced climate change can increase the probability of drought in the near future (IPCC, 2007). Thus, it must be recognized that the potential exists for future droughts of increased severity following a climate shift attributable to both natural and anthropogenic factors. To understand how these stresses have affected residents in the community, and what remedial measures were undertaken by them requires further investigation. This was done using semi structured interviews, as reported in Chapter 6.

Chapter 6

Community-Based Vulnerability Assessment

In Chapter 5, using droughts indices for the two study communities, it was concluded that the drought over the 2001-2003 had an adverse impact. However, this conclusion was based on biophysical impacts only. As social and ecological systems are interlinked (Holling, 2001), this chapter extends this conclusion by exploring the interaction between biophysical and social factors. Emphasis is on vulnerability and / or adaptive capacity of the respondents. In addition, governing institutions also play a critical role in the management of natural and social resources, which is also included in this assessment. The analysis of current exposure, sensitivity and adaptive processes employed by residents in the study communities has the potential to shed some light on the ability of these communities to adapt to more intense climate exposures predicted for the future¹⁴ under various climate change scenarios.

As reported in Chapter 3, most respondents in the two study communities are farmers, engaged in three basic types of livelihoods: dryland crop farming, mixed farming, and ranching. Dryland farming is totally dependent on rainfall and moisture from snow melt. Furthermore, crops do not receive any supplemental water (such as that through irrigation). Crop farmers were the dominant type of respondents in Kindersley, whereas in Maidstone majority of respondents were mixed farmers¹⁵. This is a method of raising cattle for beef production purposes, which also provides diversified sources of income.

Adaptive capacity assessment was undertaken through the lens of the “determinants of adaptive capacity.” The determinants of adaptive capacity are frequently employed as an analytical tool in sustainable development literature and in efforts to understand resilience thresholds for extreme climate hazards (Diaz et al., 2003). In this study, adaptive capacity was analyzed in terms of five types of capital

¹⁴ Prediction of future climate extremes is discussed in Chapter 7.

¹⁵ Mixed farming involves both crop production as well as livestock production. Calf-cow operations are common in this area.

resources that assist producers to adapt under drought conditions. These include: natural capital, technological capital, financial capital, institutional capital, and social capital.

The summary of the results is presented in Table 6.1, which provides the highlight of current exposure, sensitivities and adaptive strategies. This table can be viewed as a guide to develop future adaptive measures, but not an exhaustive list of vulnerabilities of the two study communities.

6.1 Past Exposure and Sensitivity to Climatic and Non-Climatic Factors

6.1.1 Biophysical Factors

“Water is the biggest limiting factor for our operations, and farming is gambling, farming is the stupidest thing, by June all of the risk is on your shoulders and you sit and wait and hope you get the crop off” (KD13).

Agriculture production and ranching in the area is highly dependent on timely rains and spring runoff from snow. According to interviewees, durum wheat, barley, canary seeds, lentils and canola are the dominant crops in the study communities (Based on responses by interviewees). After, the 1988 drought, direct seeding¹⁶ was extensively promoted to conserve soil moisture.

The majority (100%) of the crop farmers in study area typically start their farming activities in mid-April with a process called “burning off”. In this process, farmers use pre-seeding herbicides to control a broad range of weeds. Seeding time is generally between the last weeks of April to mid-May. As agricultural activities in the study area are more dependent on weather, this section explores the biophysical exposure and sensitivity in the two study communities. Before specific climatic events are examined, the optimal range of weather that the respondents reported to prefer is discussed for contrasting purposes in the following subsections.

¹⁶“In direct seeding, soil is not tilled in the spring before planting. This is to conserve soil moisture in the seedbed. Any fall tillage must leave the soil surface compact and level to preserve soil moisture”. For detail see Alberta Agriculture and Rural Development (1999).

Table 6.1 Summary of current exposure, sensitivity and adaptive capacity to drought/ climatic exposures

Particulars	Nature of Impacts
Exposure	
Biophysical	Water and soil moisture shortages, Non-contributing area with limited surface runoff, Soil erosion, Fire risk, Pests and diseases, Excessive moisture, Frost, Delayed seeding, Spotty rain, Poor water quality, Lowered groundwater level
Socio-Economic	Decrease in farm income, Local economy dependence on the agricultural industry, Remote location, Aging population, Depopulation, Economic Leakage, Lack of employment opportunities, Lack of infrastructure and health care
Current Adaptations to drought	
Farming practices	Minimum tillage, Drought tolerant crops, Continuous cropping, Diversification of crops, Grazing management
Information	Research, Weather forecast, Best management practices, International market, New technology
Financial Resources	Off-farm jobs, Value added crops
Institutional Support	Crop insurance, Hail insurance, Agri-Stability, Agri-Invest, Agri-Recovery, Farm and Ranch Water Infrastructure program, AESB Office, Saskatchewan Watershed Authority, RM office
Social Networks	Community-based lobbying efforts, Experience sharing, Help from neighbours
Others	Past experience, Forward-thinking mindset, Proactive leaders

The timing of the rain is very important to get a good crop. Producers in the study area mentioned that snowfall in the early part of the calendar year (January-March) matters as this is the source of spring runoff. This runoff is important for soil moisture and dugout recharge. Although different crops need different amounts of moisture to grow, germination of all crops needs moisture. Rainfall is needed in the early growing season (April-June) for germination and initial growth and during the late growing season (July-August) for continued growth and maturation.

The majority of the producers mentioned that timely rains are guarantee of a good crop year. The harvesting time in the area is generally late September, and rainfall during that time period is not favorable for crop yield. Producers mentioned that any rainfall in the fall is also important to provide moisture in the early spring of the next year. This rain, because of low temperatures during that time period, freezes in the ground until the spring thaw.

Temperature is another factor for crop production. The double digit temperature (10°C to 15°C) in last week of April is ideal for thawing the ground and for moisture availability to crops. Producers prefer a temperature around 27°C in June and in early July. A little cooling off in the middle of July is good, so that crops can finish without the heat stress. Often the wind dries the moisture out of the stems as well as the soil. For this reason strong wind is not preferred during the growing season. Producers mentioned that severe cold in winter is good for agriculture because moisture will freeze and would be available in the spring when temperatures are in positive digits. If winters are on warm side, then soil can soak up the water, thereby reducing the soil moisture available to crops (KD10, KD1, KD12, KD26; MD4, MD10, MD22).

Ranchers in the area also emphasized the importance of timely rains to get the grass and hay growing. In summer, a little moisture is sufficient to keep the grass growing. However, during haying season, rains can be a problem, as moisture can encourage growth of molds in bales. The mild temperatures are good for cattle growth too. If temperature is high (i.e., above than 35°C), it can cause heat stress in Black Angus and other cattle breeds. Warm temperature is also related to increased pest population. For example, flies are a problem for cattle on hot days. If early winter months

are mild, ranchers can extend their cattle grazing time, which can result in reduction of feed costs. For these reasons, ranchers prefer mild winters.

Good spring runoff is also important for cattle producers. Local spring snowmelt is important for both soil moisture and dugout recharge. With little spring runoff, dugouts do not fully recharge, and ranchers can run into stockwater shortages on grazing parcels during the latter part of the year. Adequate moisture is required during the spring for grass establishment growth. The lower snow cover during the 2001-2002 had implications beyond soil moisture for livestock producers, since cattle spend the majority of the year out in pastures where main sources of water are dugouts and sloughs. Grazing is generally rotational, meaning that stockwater supplies must be available throughout the pasture areas. During the 2001-2002 droughts in Kindersley, because of low snow fall, dugouts and sloughs were completely dry. Agriculture and Agri-food Canada data indicate that dugouts in the RM 290 - R.M. of Kindersley were generally dry by September 2002 (PFRA, 2002).

6.1.2 Drought

“Weather really shapes our everyday living; our first morning thought is about weather all year around; it impacts our daily activities, seeding, spraying, haying, and harvesting.....” (KD6)

It is important to understand how people define drought and how it impacts their lives. Town residents define drought as *“lack of water for their daily activities”* (MD2), although some of them use visual aspects to define drought. They identified drought as *“when everything turns brown due to lack of moisture”* (KD9). As the livelihood of the town people is not weather dependent, they therefore, were found to be less aware of the droughts in the area.

Drought is well understood by farmers and ranchers. Many of them defined droughts on the basis of timing of moisture availability. They identified drought as lower than average rainfall during the growing season. The most common definition provided by respondent was *“lack of rainfall to saturate soil for cropping, accompanied by high temperatures and strong winds”* (KD23, KD10, KD15, KD32; MD17, MD21). Many

respondents also identified lack of winter snowfall as the possible cause of drought. According to them, if they received less snow during the winter, their susceptibility to droughts increases. As a result, they plan their cropping activities accordingly (KD12, MD21). Farmers with many years of experience defined droughts as three years of low run-off from the snow and below average rainfall in the growing season, accompanied by high summer temperatures. They identified high temperatures as the cause of increased evapotranspiration, which can lead to drought conditions (KD24). In contrast, young farmers defined drought as below average rain for three or four consecutive months during an agricultural year (KD29). For the farmers who started farming after 1988, 2001-2002 years were huge multiyear disasters for them. Some producers also related increased population of grasshoppers, gophers or dust storms to droughts. Others characterized drought on the basis of activities they were involved in during dry years, such as reducing herd size, transportation of cattle to neighbouring provinces, and buying feed from other provinces, among others.

From the interviews it became evident that most respondents identified drought as below average rainfall during growing season. All respondents reported less snow for the area as compared to the past. For example, a statement such as *“Yeah there’s less snow I think then there was when I was growing up, there was more snow but I think that it could return to that. I think it cycles sometimes I think it can be 20 to 30 to 50 year cycles”* (KD12) were commonly made. The majority of the respondents (82%) did not identify global warming or climate change as the cause for less snow. They identified the change in snow volume as a cyclical process and hope for the return of snow. One farmer said *“when you’re totally dependent on soil moisture, you think next year it’ll be better. He defined farmer as ‘a perpetual optimist - that’s a farmer”* (KD14).

Although the residents of the Town of Kindersley were not able to provide details on droughts, they identified drought with water rationing. A few respondents remembered 2002 as a drought year when the town put a ban on watering lawns. In the town of Maidstone, residents experienced significant water shortage during 2002. The town, during this time period, was dependent on open water reservoir (called Maidstone Lake). The water levels in this lake were significantly lower than normal, resulting in some people hauling water from nearby water wells.

Although in both Kindersley and Maidstone residents' livelihood was not directly dependent on water, local businesses were indirectly impacted by bad years for farming. During 2001-02 droughts, some of the people involved in grain transportation business went out of business. Also agriculture related businesses (such as equipment dealership and agricultural input companies) faced financial challenges. Equipment dealers reported that they could survive after the 2001-02 droughts because they got machinery repair jobs from the farmers (KD3).

When respondents were asked to recall their experience with droughts, those from Kindersley area mentioned that every six years they are getting one bad year. The old age respondents identified 1988 as the most difficult year in their farming career. In 1988, the combination of drought and high interest rates forced many farmers to get out of business. In contrast, for young farmers in Kindersley, the 2001-2002 multiyear droughts were drastic. Both crop and livestock producers felt the negative impacts of these droughts. Although during the early spring of 2001 there was adequate moisture for germination, crops such as wheat, canola and lentils, require continued moisture availability to mature. One producer noted that:

"We start praying through the end of June. Without early growing season moisture or sustained moisture throughout the growing season, yields and crop quality declined. For crop farmers, this meant either taking an income hit or drawing on crop insurance" (KD12).

In Kindersley, the majority (66%) of crop farmers reported that during the 2001-2002 droughts, there was a total crop failure, as they had not combined anything during those years. During the spring 2002, Western Canada was the driest region in over a century (Environment Canada, 2002). During this period, crop farmers needed 60% more precipitation than average to replenish ground moisture and other water supplies (Environment Canada, 2002). In 2002, feed grains availability was already low, and cash crops were severely impacted by the compounding stress of the grasshopper epidemic. One mixed farmer explained:

"I had up to 2 to 3 inches of dead grasshoppers on the grass, you couldn't see the grass anymore, drought you can deal with, you know you can

maybe save grass here and there, and you know we saved some here and two days later the grasshoppers went through and there's nothing. Grasshoppers were terrible those years. I hope I never see that again" (KD1).

For farmers who were affected, this “double whammy” of drought and grasshoppers meant having to import feed, in many cases, from out of the province. Livestock producers bought hay from Manitoba (including north of Winnipeg region) during these drought period, although some of the respondent felt that these shipments were of low quality and very expensive.

In Maidstone, all respondents identified 2001-2003 as their first experience of drought. They mentioned that according to their parents, even in 1930s that area was not so dry. People from other part of the province moved here to survive through dry years elsewhere. But 2002-2003 were exceptionally dry years for Maidstone. One respondent indicated that “*I have forty-four years of farming experience in the area, I've put in a crop, and I've never seen it this bad*” (MD30). An older producer said that “*it was worse than the 1930s because then they had lots of snow in the winter, and it filled the potholes. There were no potholes anymore anywhere - just dry, dry*” (MD30). Other studies (Wheaton et al., 2005) also noted the shifting of droughts northward. The Maidstone area had many below average yield years, but the 2002 - 2003 droughts were the worst in history of farming in this area. Many respondents noted that although the study area has undergone drastic changes in farming practices to conserve soil moisture, the 2001-03 droughts were indicative of the vulnerability of the Canadian prairies to this natural hazard.

In Kindersley, besides recurring droughts, early frost during the harvest season (August) and excessive moisture were also recognized as a problem for farming. Early frost can damage the quality of grains; many farmers identified 2005 as a year when they faced losses because of early frost in August. Recently in 2010, on account of excessive rain during crop germination time (May - June), some respondents lost their already seeded crops (Figure 6.1).

In Maidstone, hail storms were a big concern for crop producers. Many farmers mentioned complete wipeout of the crops because of hail in 2005. Early spring and late frost can also add to the hardships. In 2005, Maidstone received a large amount of rainfall. This event happened on August 23rd 2005, when a total of 120 mm of rain was received in a single day (Environment Canada, 2005). The town's Mayor declared a state of emergency when the sewage station began to backup. The heavy rainfall flooded many basements and swamped croplands. Many producers lost their crops. The town water system was not able to supply water to 1,200 Maidstone's residents for one day on account of this event.



Figure 6.1 Seeded crop area under water in 2010, a farm near Kindersley

Source: Researchers' personal album

During the study period (August 2010), there were excessive rains in Maidstone. Many respondents said that these “rains are funny and very unusual for the area”. As a result, some respondents mentioned its effects on crops, including crop diseases, such as powdery mildew, a fungus on pea crop (as shown in Figure 6.2), and insect infestation such as Bertha Army worm and Diamondback moth affecting the canola crop.



Figure 6.2 Powdery mildew on Pea crop because of excessive moisture in 2010

Source: Researchers personal album

6.1.3 Sensitivity to Non-Climatic Factors

In addition to climatic hazards, non-climatic factors, such as high input cost, low commodity prices and global markets, were at the top of the list of farmer's concerns. The predominant threat has traditionally been referred to as the *cost-price squeeze*. Until recently, the prices available for the commodities produced by farmers have remained relatively unchanged. Respondents recalled that they got the highest price for their cereal crops in 1975, which did not bounce back until 2005. The realized net income¹⁷ of farmers in Canada has not shown an increase since 1970s (Figure 6.3), partly because of increasing input cost (Martz, 2004). The Canadian farm input price index illustrated an increasing trend in operating expenses between 2000 and 2005. For example, over this period, fertilizer and fuel prices increased by approximately 35% and pesticides by 19% (Statistics Canada, 2006). In comparison, the consumer price index on all items was increased only by 12.2% (Statistics Canada, 2006).

¹⁷ Net realized income is determined as a difference between gross revenues (from sales of crop and livestock products) and cost of production.

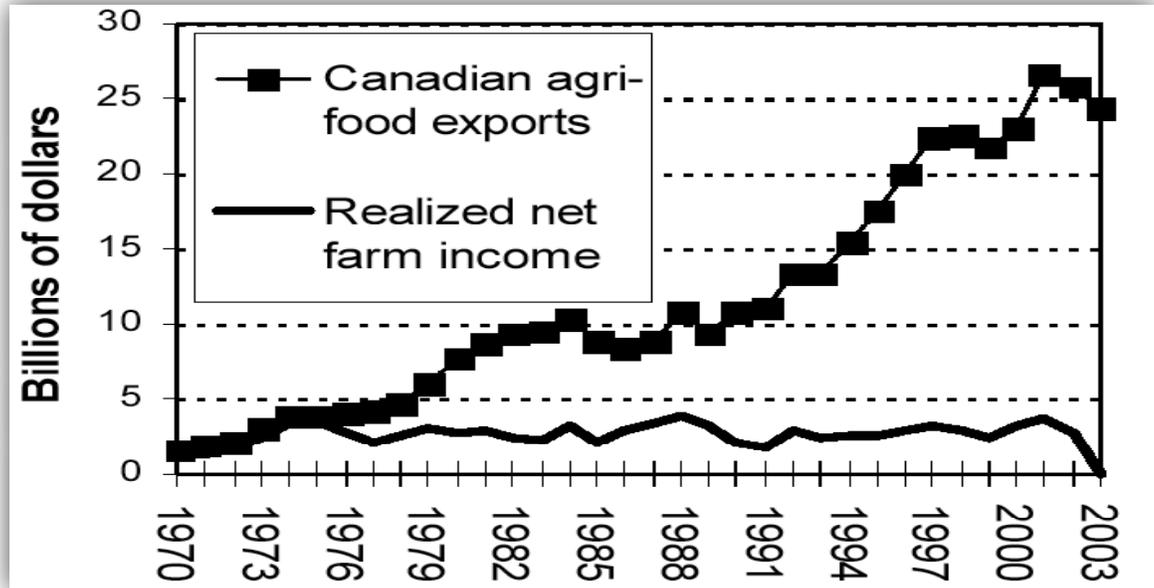


Figure 6.3 Trend in agricultural exports and realized net farm income of Canada, 1970-2003.

Source: Martz (2004)

Farmers, whether trying to build up their enterprises or winding down, identify the combination of low commodity prices and high input prices as the greatest challenge for farming (Smithers et al. 2005). In addition, net farm income is also affected by outbreaks of diseases for cattle as was the case in 2003-2004, where the Bovine Spongiform Encephalopathy (BSE), commonly known as mad cow disease, caused a significant decline in livestock producer's income (Mitura and Pietro, 2004).

The profit margin for producers has remained marginal or negative for decades. As a result of such poor economic conditions, many farmers increased the size of their production unit, or engaged in off-farm jobs to sustain their family farms. Extreme climatic events, such as drought, early or late frosts, hail, or excessively cool or hot growing seasons, can exacerbate the already economically precarious circumstances faced by many producers.

Sustainability of farms and services related to agriculture are sensitive to combination of climate and non-climate risks. Both the study communities are facing both climatic and economic factors at the same time. This has increased their vulnerability to current as well as future droughts. A number of respondents stated that a production unit already suffering from severe economic stress would be less resilient to drought than a production unit with greater economic resources. Higher resilience could be a result of higher equity, access to credit or high paying off-farm employment.

Farmers were well aware of the impact of international markets on their business. If farmers in other parts of the world, such as China, India, Pakistan, Australia and Argentina, have good crops, it has strong impact on the price of agriculture products in Canada. Because prices are determined in the world market place, farmers have no control on the price of their products; they can only passively take the price markets offer to them. Farmers in the Prairies have started producing cash crops that have high demand, such as lentils, peas, and canola. This has resulted in a reduction of production of traditional cereal crops.

Associated with price of product is currency exchange rate which also impacts the income of the farmers. As the value of Canadian dollar changes, it affects the competitiveness of the Canadian agricultural products. When the value of Canadian dollar increases, it makes Canadian agriculture products more expensive to importers, relative to the imports from other countries. As a result, the demand for Canadian products decreases. This situation makes producers as passive actors who have no control over price of their own produce. In the words of one respondent “in agriculture business, everybody is trying to make money, except for original producers, it doesn’t make sense when we have no control at the price of my own product” (KD11). Such statements may be one of the reasons for the decrease of number of farms on the Canadian Prairies. From the 1971 census to the 2006 census the number of farms in Saskatchewan decreased by 57 percent (Statistics Canada, 2006).

The majority (78%) of the respondents considered Canadian Wheat Board (CWB), which has the monopoly in marketing of cereal crops, as a hindrance to their marketing ability. The CWB was established in 1935 as a single desk marketer for all

grain products. Many respondents believe that they may be able to market their grains more efficiently. In response to the demands made by many Prairie farmers, the Canadian government dismantled the monopoly of CWB in October 2011. Now farmers have a choice to sell their grain products in open market or through the Canadian Wheat Board.

The decrease in government funding to support agriculture was another issue on farmers' minds. Between 1991/92 and 1999/00, government spending on agriculture dropped by 52% from the peak of over \$6.1 billion in 1991/92 to approximately \$2.9 billion for 1999/00 (Dale, 2001). According to the National Farmers Union (quoted by Swanson and Venema, 2006), no other policy decision has had a greater negative impact on western farmer's income than the ending of the Crow Rate benefit, which subsidized shipping costs. According to study respondents, cost of moving grain to port for exports is currently borne entirely by the farmer, which is about 25 per cent of the total cost of the farm operation on average. The National Farmers Union claims that eliminating the Crow Rate has devastated grain farmers' gross income, lowering that by as much as 40% through increased rail costs. Simultaneously, the rural rail network has been greatly tightened resulting in fewer grain delivery points. Since the beginning of the 1999-2000 crop years, the number of licensed primary and process elevators located in western Canada has fallen from 1,004 to 416, a reduction of 59%. Although the railways have captured significant efficiency gains with record profits, farmers have been forced to pay increased costs for trucking as a result of consolidation of primary grain collection points.

In Maidstone, government policy changes, such as removal of Crow Rate and consolidation of grain elevators, were problematic for many farmers. Now the farmers have to haul their grains to nearby big centers, such as North Battleford or Lloydminster, which has resulted in increased transportation cost for the farmers. In the words of one farmer,

"Government policies are moving us backward. I've got to haul every bushel of grain; I've got now 22-40 miles. They (parents) used to haul it 2

miles. Shipping cost for our grain is \$39.00 a tonne. It used to cost my dad a nickel a bushel. So I mean that's gone up 500 times" (KD14).

Because of high input cost and low profit margins, many respondents said that agriculture is not a viable business for them. In addition, to start farming is very expensive. This situation is faced by young farmers. Some of these farmers have to do many jobs in nearby towns to support their farm. One bad year can be economically hard for the young farmers, who are under a high debt load.

In terms of social factors, declining population in the rural municipalities was expressed as a concern. Because of narrowed profits margins in agriculture, many of the respondents do not want their next generation to be involved in agriculture. Instead, they wish their kids to have a secure source of income. Most of the young generation moves to big cities to acquire educational qualification in order to secure better jobs. Many of the farmers (27%) interviewed for this community were in the age group of 55 years or more. This demographic trend in agriculture community is a concern for future viability of family farms in both Kindersley and Maidstone.

6.2. Current Adaptive Capacity

As noted above, assessment of adaptive capacity of respondents in the two study communities was undertaken using five types of capital resources. Each of these is described in this section.

6.2.1 Natural Capital

Natural capital to support agricultural activities in the Kindersley area includes soil, rainfall, and snow. Kindersley is located in the brown soil zone, which is low in organic matter content (Environment Canada, 2008). The average rainfall in the area is 250 mm annually. According to respondents there is a decreasing trend of snowfall for the area. In term of topography, Kindersley is located in the plains and natural capital is

more evenly¹⁸ distributed, relative to Maidstone. The series of droughts over the last three decades have impacted dryland farming in the Kindersley area significantly.

6.2.1.1 Natural Capital of Kindersley Area

The Kindersley area lacks the surface water sources that would facilitate irrigated agriculture. Similarly, local surface water sources have proven to be inadequate for supplying water for the whole town. As stated in Chapter 4, lack of reliable high quality surface and groundwater inspired the town of Kindersley and the neighboring community of Eston to construct a pipeline to the South Saskatchewan River (SSR). In the case of Kindersley, the distance to the SSR is not so great as to rule out a pipeline solution. However, the potential for constructing a pipeline to the SSR to support the irrigated agriculture did not emerge in the discourse related to drought mitigation.

Similar to the Maidstone study area, the Kindersley area has exploitable deposits of natural gas and oil that contribute significantly to the area's economy. This industry provides a secondary income source for many respondents in the Kindersley area.

6.2.1.2 Natural Capital of Maidstone Area

The Maidstone study area was unique, given its far less frequent experience of severe drought after early part of century till 2002. This area falls outside the Palliser Triangle in a fertile belt which lies to the north, east and west of the Palliser Triangle. This community lies in the Aspen parkland eco-region. Annual rainfall for the area is 450 mm, which is higher than that in semi-arid Prairies (Environment Canada, 2013). Maidstone lies in the North Saskatchewan River watershed. North of Maidstone, topography changes into hilly areas characterized by small creeks and gullies. South of the town, there is the Maidstone Lake, which was a big water reservoir for the area until 2001. As noted previously, many respondents from this region indicated that the drought of 2002 was the first serious drought episode they had experienced in their farming career. This considerable advantage in natural capital (especially when combined with good soil conditions) is somewhat offset by the relatively higher lease rates paid for farmland in the Maidstone study area. For example, Farm Credit Canada (2011)

¹⁸ However, there are variations in soil type and productivity between agricultural production units.

reported that in 2011, native pasture land in RM #51 of the Maple Creek was selling for as little as \$129 per acre, as against a value of \$800 per acre in the Maidstone area.

6.2.2 Technological Capital and Infrastructure

Dryland farmers in the Kindersley area have embraced conservation tillage (minimum tillage or zero tillage) technology following the severe droughts of the late 1980s. Minimum tillage is a farming practice of direct seeding without turning the soil, which helps to conserve soil moisture. Farmers in the Kindersley area have adopted modern direct seeding technique, which is followed by chemical fallow and regular fertilizer applications. The majority (87%) of the grain farmer respondents reported practicing minimum tillage. The practice of summerfallowing has decreased in the study areas. The respondents (13%) who still practice summer follow reported an average yield during the drought of 2001-02, whereas farmers practicing minimum tillage reported below average yields.

Residents of the Kindersley area, both urban and rural, have been able to take advantage of the water pipeline infrastructure originally built to service the communities of Kindersley and Eston. Adjacent small urban communities and farmers have been able to connect to the pipeline to secure domestic water demand and water for livestock.

The advances in farm technology associated with minimum tillage have been widely adopted by producers (90%) in the Maidstone area. Continuous cropping is common, and producers in the area have diversified their crop varieties well beyond the cereal grains - a landscape that dominated their production portfolio a few decades ago. Water supply infrastructure for the Maidstone was redeveloped in response to the drought of 2002. However, there were other issues associated with this infrastructure as well. The supply infrastructure was quite old and reaching the limits of its expected life. In addition, it included a clay-asbestos pipeline that has been targeted for replacement if and when major problems arose. But problems with the quality of water supplied by the Waseca wells has meant that the Maidstone Lake supply is still required to improve potability of available water through mixing it with Waseca water.

6.2.3 Economic Capital

6.2.3.1 Availability of Economic Capital

Availability of financial resources is an important determinant of adaptive capacity. Agriculture producers in the Kindersley area have been impacted by the long-term cost-price squeeze in agriculture in addition to recurrent droughts. This, according to the majority of the farmers has resulted in a general fall in their capital resources. This has resulted in less help for the starting young farmers into agriculture, something that was common in earlier periods.

In response to droughts and market uncertainty, farmers have diversified into variety of agriculture products. In some cases they have added value-added activities on the farm, as well as income diversification through non-farm employment and entrepreneurial activities. This diversification has provided the cushion to farmers in bad farming years.

Crop diversification in the Kindersley and Maidstone areas was accomplished through replacement of traditional cereal crops (such as spring wheat, oat and barley) by a variety of new crops, such as lentils, peas, and canola. The change is prompted by two factors: (1) drought tolerance; and (2) high demand in international markets. This diversification of crops has helped farmers economically. For example, if output from one crop is ruined by weather, market or disease, then another crop could secure some income to producers.

Availability of off-farm jobs provides another source of income in both Kindersley and Maidstone communities. More than 60% of respondents reported non-farm jobs contributing nearly 50% to their family income. According to Statistics Canada (2011), nearly one-half of Saskatchewan farmers reported working off farm. This trend showed a 44% increase in 2001 over 1996. In majority of cases, women worked in the service industry, such as school, library, agriculture companies and hospitality industry, in order to support family income. Most men worked as seasonal workers; a majority of them were employed in the oil and gas companies during winter period, while others were engaged in snow removal and driving trucks. In some cases the farmers, with some

technical skills, were self-employed. As an example, one respondent stated that he was operating a repair shop for heavy truck and trailer on his farm (KD23). Some people, who owned medium or small farms, were engaged in off-farm jobs that helped them to secure household income. As an example, another respondent mentioned his involvement in real estate business and farming (MD12). These off-farm jobs were helping the owners of medium and small size holdings. Some of these producers may lack the capital to expand their units to a more viable size. Their major means of continuance in farming was the additional source of income. When economic and climate conditions are optimal, the farm production may earn a profit. When profits were small or the modest losses the off-farm employment sustained both the family and the farm. One respondent explained the situation of off-farm jobs as an adaptation to climatic and non-climate pressures in the farming sector,

“They drive a truck or do something because you have to have ... just a straight grain farmer nowadays ... if you can straight grain farm and not have an off the farm job, I give you credit because it’s pretty tough. The cash flows are so bad with grain farming and with livestock too - you only get paid once a year for it, so most guys have an off the farm job and I can’t think of any farm wives that don’t work now” (KD 13).

The mixed farming farmers in the area did not have time to engage in off-farm jobs. According to them, keeping cattle is a full time job. Mixed farming is kind of income diversification for them. In Kindersley area, the 2001-2002 droughts and the occurrence of BSE forced many farmers to quit livestock production. During this period, these farmers reported dependence on sales of crop products and selling hay. According to these farmers, it was more economical and less laborious for them to sell hay instead of keeping animals. Statistics Canada (2011) also noted a shift away from livestock-based operations to crop-based farms in 2011 agriculture census. The trend of moving away from mixed farming and coupled with financial hardship can make many farmers vulnerable to droughts in long term.

Off-farm employment opportunities cannot be availed by all age groups. Young and middle aged farmers use off-farm employment as an adaptive strategy. At the same

time farmers, the over 55 years of age farmers possess fewer sources of income, and rely solely on farming. One reason behind this phenomenon could be the lack of technical skills, such as knowledge of computers. Another reason could be health issues in this age group, which can limit their options for off-farm jobs. Distance to commute, particularly during the winter season, to an off-farm job could also be another constraint for people in this age group.

Presence of oil and gas exploration companies in both communities was noted to be a big source of economic capital. Farmers reported not only getting revenues for the oil lease at their holding, but also being able to secure an off-farm job (48%). In the words of one Kindersley respondent:

“We’re really lucky in this area because the oil and gas has given a lot of off the farm jobs to people. Most of the guys around here are working in the oil field or something and places like Rosetown that doesn’t have that are starving because there’s just no extra money for these guys. Around here we’re lucky because there are so many jobs here. Even my job I do off the farm here is probably related 50% to oil and gas because a lot of the trucks we work on are oil trucks” (KD23)

The oil and gas sector also contributes to the economic diversification for the Town of Kindersley. According to some respondents, the town’s prospects over the past few decades as an agricultural service hub would probably not have been as bright as they have been without oil and gas activity. Not surprisingly, Statistics Canada (2007a) reports the unemployment rate for the RM of Kindersley at zero. Concerns about the impact of oil drilling on water resources or any other social problem were rare in this study community.

6.2.3.2. Constraints for Securing Financial Capital

In view of the already tight economic situation resulting from the first year of the 2001-2002 droughts, many farmers were not able to make payments on their loans. As a result, farmers had to request banks to consolidate their loans or to sell their

machinery to pay off debts. In bad years some farmers were not able to upgrade their machinery. They had to change their operations to limit equipment use, which made their operation less productive. According to a grain producer from Kindersley, “*it is hard to build financial resources, we are just like a person who survive on “pay cheque to pay cheque”, drought and markets affect our income and it is hard to move forward economically” (KD, 30).*

Determining economic vulnerability in association with drought conditions in 2002 is a complex exercise, because it involves gaining an appreciation of the financial circumstances of diverse individual production units. This drought resulted in a total crop failure for most Maidstone area producers. The impacts of crop loss were accentuated by the fact that majority of them did not carry crop insurance. For example, a well-established producer with a minimal debt, some oil well surface revenues and cash reserves, could conceivably recover more easily than a younger producer carrying a larger debt load. Yield losses and crop failures due to other climate hazards, such as hail, late and early frosts, or excessive moisture, are not uncommon in the area. Respondents were familiar with crop losses due to such disasters.

Many consecutive years of crop yields higher than the provincial average may indeed provide some producers in the Maidstone area with greater economic resilience than producers in some other areas of the Palliser triangle. However, as noted earlier, higher yield areas are associated with higher land lease rates and are also often dependent on higher rates of fertilizer application. A crop failure on expensive land that receives expensive inputs would be a major challenge for any producer in this community.

6.2.4. Institutional Capital

Historically, government institutions have provided safety nets to offset the negative socioeconomic impacts for agricultural sector from extreme climatic events (Wittrock et al., 2005). Institutions are important vehicles to adapt to both current and future droughts (Diaz et al., 2003). In Canada, drought risk management programs have been initiated by federal and provincial governments.

Institutional support can be classified into two broad categories: Educational programs and Business Risk Management (BRM) programs. Educational programs aim to transfer technical skills to farmers, which help them to operate the farm successfully. BRM are offered by federal and provincial government to assist farmers in case of production loss by climatic and non climatic hazards. The BRM program includes four different types of programs: (1) Agri-Stability, (2) Agri-Invest, (3) Crop Insurance and (4) Agri-Recovery Program. The main goal of all these programs is to help farmers gain financial stability during periods of declining farm incomes (Agriculture and Agri-Food Canada, 2012a). The Majority of the respondents in Kindersley area participated in BRM, whereas, less than 50% respondents in Maidstone area made use of these programs (Table 6.2).

Table 6.2 Respondents' participation in the BMR

Kindersley		Maidstone	
Yes	No	Yes	No
96 %	4%	48%	52%

Of the four programs in the BRM category, Agri-Stability program is the most relevant one in the context of hazards. This program aims to protect farmers in case of large income decline caused by low prices, rising input costs and other related factors. Farmers, who participate into this program, receive payment when their current year production margin falls 85% of their reference margin¹⁹ level (Agriculture and Agri- Food Canada, 2011a).

Crop insurance and Agri-Stability were designed to work together. For example, farmers who intended to get a benefit from Agri-Stability need to participate in a Crop Insurance program. Crop Insurance has the potential to provide income stability to the farmers when climatic and non-climatic hazards impact their income. For example,

¹⁹ A reference for a given year is calculated by taking allowable income minus allowable expenses for that period. The reference margin is then decided based on the production margin of past average three years from last past five years, excluding highest and lowest production years.

farmers who have previous three or four years of good yield in a row can make use of this program. Agri-Stability program guarantees good coverage for bad years.

Given the importance of BRM programs, respondents were asked about their satisfaction level with these programs. Most of the respondents in the two communities suggested that the Agri-Stability program has many shortfalls (Figure 6.4).

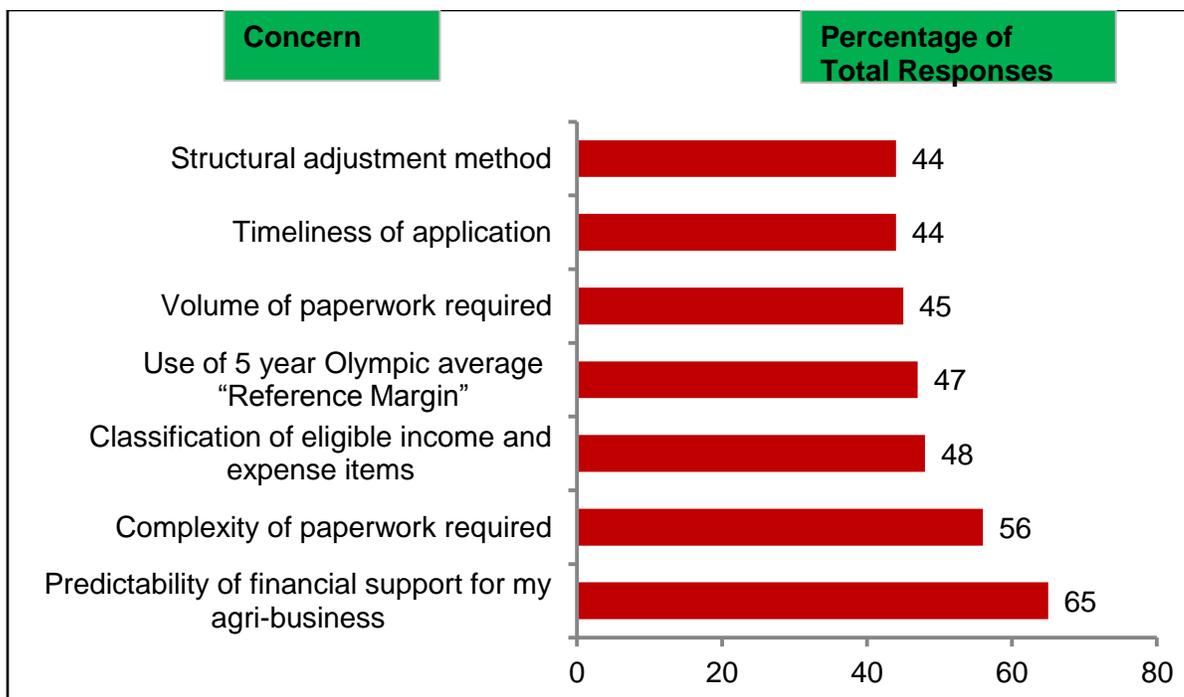


Figure 6.4 Respondents' concerns about Agri-Stability

These shortfalls can be classified as; complexity, predictability, timeline issues, and additional financial burden. Complexity of the program was identified in several features of the program - conceptual as well as in terms of its implementation. Comments such as this were made by several respondents: "*The AgriStability application is so complex, that many of us have to hire accountants, and sometime we don't know what we will get from this program*" (KD1, KD22, KD23, KD31, KD34; MD7, MD10, MD12, MD21). According to the respondents, the calculation of Agri-Stability was very complex. For example, a university degree holder (very few in the study areas) reported the difficulty in understanding the terms and conditions of the program. The structural adjustment method of Agri-stability program was a concern for respondents. In

simple words structural adjustment mean formula for calculation of Agri-stability benefits payment. Benefit payments are calculated based on the previous five years margin. According to respondents in case of continual disaster such as drought of 2001-2003, Agri-Stability did not trigger payments. Moreover, the income margins are calculated based on the whole farm, which was a concern for diversified farmers. According to respondents, the current method of margin calculation penalizes diversified farms.

Several examples of complexities were also noted. The allowable and non-allowable expenses were the puzzle for many. For instance, livestock producers spend money for cattle grazing on community pastures, but this expenditure is not included in allowable expenses. The land lease payments are also not included in farmers expenses. As a result young farmers, who are paying for the land, see the Agri-Stability program as disadvantageous for them. Another issue is the uncertainty of the amount of payment from the program. Producers pay an average of \$1984 to file an application by hiring financial experts (KD 31, KD 11). In spite of this, there is no guarantee that the application would be approved by the program auditors. According to a respondent,

“Agri-Stability..... It’s supposed to be if your income is down or whatever, they top it up. Well, we fill out all the forms every year, year after year, and ... Very seldom get anything out of it” (KD10).

Farmers are not sure what they will get at the end, therefore they are unable to present Agri-stability payment as a guarantee to banks and credit unions to get immediate cash loans. The following comments from respondents were typical.

“Now they have Agri-Stability which is a joke, as the formula is based on five year floating average, minus your highest and lowest production year. If I have two below average years and one high yield year, Agri-Stability will not pay me anything, because they don’t count high yield year which can top up my average. It looks good on paper, but it worth nothing for us. Farmers need immediate cash in case of income decline.....to pay the bills, not five years after the financial problem” (KD18).

The timing of receiving benefits from Agri-Stability is a concern for many respondents in the study area. Additionally, some respondents mentioned the poor customer services offered by the program. One respondent mentioned that he contacted Agri-Stability representative to inquire about his claim, but his emails and phones were transferred back and forth between different officials without any action. He stated,

“I’ve tried and tried to find out and I’ve written emails to government officials. I sent them one and it was over a month and I wrote them another one saying are you going to reply to this or not. Finally they wrote back and said that’s not our department. You have to contact crop insurance. So, that’s the kind of answers you get” (KD10).

In both communities, respondents mentioned the strong sense of alienation with the Agri-Stability program. This program does not work for mixed farmers, as they may face significant losses in crop production, but since the program is based on total income (where losses from crops are compensated by gains in livestock income), there is no payout from the program (KD10, KD22, KD23, KD28; MD6, MD8, MD11, MD27).

Agri-Invest program is another pillar of institutional risk management program (Agriculture and Agri-Food Canada, 2010). Agri-Invest is like a saving account. Farmers can contribute annually, and government matches dollar for dollar. The interest accumulated on money assists farmers in the situation of small income declines. This program offers user flexibility - money can be withdrawn whenever they need cash. However, only a few people in the study area reported the use of this program. One respondent commented for the program as follows:

“Yes, there’s Agri-Invest. It’s a little bit different I think. I think it’s the one where you’re eligible to put so much money in and the government matches it which when you’re getting money from the government, I guess it’s a help, that’s true, and it’s based on sales, not necessarily a bad year or a good year, but the one that’s supposed to bump you up when you go down ...” (KD27).

In comparison with Agri-Stability, the terms and conditions of Agri-Invest are farmer friendly. Many farmers view this program as beneficial for big farmers, whereas, small farmers cannot afford to maintain a saving account. Only some respondents indicated that they can save their extra dollars in this program, and take in the benefits in case of any risk,

Agri-Recovery is a disaster relief program, which aims to provide “a rapid financial response to assist with immediate recovery from a disaster situation enabling short- term actions to minimize \ contain the impacts of the disaster on producers” (Agriculture and Agri-food Canada, 2012b). The cost of the program is shared between the federal and provincial government on 60:40 ratio. A vast majority (64%) of the respondents criticized the delays in receiving assistance under the program. For example livestock producers after the BSE disaster in 2003 received assistance payments after a year. Similarly, grain producers stressed the delays in financial assistance under Agri-Recovery program. According to a respondent,

“If drought happens in this year spring, Agri-Recovery will not pay us anything till next year spring, luckily if we qualify for anything....it is worth very little for our business. I don't think Agri-Recovery is the solution” (KD 32).

Another frustrated producer stated,

“I know every government is announcing and making election promises to support agriculture community...., but it's not good enough ... No offence, but I have no faith in the government at all” (KD16)

As reported by respondents, the Crop Insurance, the most popular government sponsored BRM program, is a safety net for farmers to protect them against yield loss in case of climatic hazards such as droughts, flood, strong winds or pest infestation. Until 2004, crop insurance had offered spot hail coverage. However, currently farmers have to depend on private companies to insure their crops against hail spot damage. Crop insurance is a federal-provincial cost shared program, where the producers only pay 40 percent of the premium, while remaining 60 percent is shared between the federal and

provincial governments. Producers can select coverage at 50, 60, 70 and 80 percent of their average yield based on their need (Saskatchewan Crop Insurance Corporation, 2011). In Kindersley, a majority of the respondents carry crop insurance; however, many of them were not satisfied with the program (Table 6.3).

The main concern was high premiums and a low guarantee for loss coverage. Nonetheless, many indicated that crop insurance provides minimum revenues, which is based on their previous yields. This helps them to continue farming in the next year. However, in Kindersley during 2001-2003 multi-year drought, crop insurance did not provide any compensation. If the crop yield is decreasing, farmers get lower payments in each year.

Table 6.3 Respondents' concerns regarding Crop Insurance

Responses	Study Area	
	Kindersley	Maidstone
Not set for multi-year drought	96 %	NA
Low coverage high premiums	88%	89%
Early deadlines to apply	45%	NA
Removal of spot coverage	10%	55%

With respect to the crop insurance, one respondent mentioned:

“Your insurance is based on your past growing average crop and we can get three or four poor years, of course our average is dropping, dropping, so we’re being guaranteed less and less money which is the fault with these programs, basing it on your average. If years are all good we’ve got a high average and have one year bad, then that works, but if you have three or four, your average is down so low, we’ve lost a whole pile of revenue and it’s not really our fault if it’s dry years” (KD21).

Almost 100% of grain growers reported the same concern as “Crop insurance doesn’t work as good for multiyear drought; your premiums gone up and your guarantee has gone down”. As a result it acts as a barrier for farmers to adopt the program.

Furthermore, the deadline for applying for crop insurance is early as March 1. As such it is difficult for farmers to decide area and crops to be insured (Saskatchewan Crop Insurance, 2011). Most of the farmers in the study areas suggested a modification of these deadlines. Although crop growers have crop insurance, there are not many programs to offer safety nets for livestock producers. While Agri-Stability and Agri-Recovery components of the federal-provincial Agricultural Policy Framework were criticized as inadequate, Saskatchewan Crop Insurance was somewhat popular. As compared to Agri-Stability, many respondents did not view crop insurance premiums as a worthwhile investment. In fact, in Saskatchewan the number of crop insurance customer in 2012 dropped from 34,000 to 28,200 (Saskatchewan Crop Insurance Cooperation, 2012).

Although crop insurance is a popular program, its uptake has not been as high in the Maidstone area. Nonetheless, many respondents here acknowledged that Crop Insurance does provide a minimum level of revenue support that can assist producers in staying in business until the next growing season (following a bad year). Similarly, as compared to Kindersley, Agri-Stability was not viewed as an effective support program in Maidstone. For example, under the Olympic averaging system for triggering payments under the program, a single year drought like 2002, regardless of how severe it might have been, would not necessarily trigger any financial support.

Respondents suggested that agricultural risk management plans in Saskatchewan need continuous review according to the climatic variability of the province. For example, in the case of flood of spring 2011 in Manitoba and Saskatchewan (Agriculture Agri-Food Canada, 2012b), farmers could not decide the size of their cultivation without the knowledge of climate variation. This suggests that eligibility criteria for the Crop Insurance need to be reviewed in response to stakeholders needs.

Although Crop Insurance is generally viewed as business risk management strategy, some producers have different point of view. According to them crop insurance has encouraged stubble cropping in the province. One respondent stated that:

“Stubble cropping is far too common in this part of the world because of crop insurance and other programs.....but if there were no safety nets like Crop Insurance or Agri-Stability, you can bet your bottom dollar that there would be less stubble cropping. If you actually had to survive on what you grew, people would not be so greedy, they would not push it so hard, in my opinion”(KD34).

Gardner et al. (1992) have suggested that adaptation measures, like disaster payments and crop insurance, encourage producers to grow ‘high return - high risk’ crops on marginal lands, which results in increased level of vulnerability to climate change. This will make the Crop Insurance expensive to afford and may increase self-reliance in the future.

Recent multiyear droughts highlighted the continuous vulnerability of the Prairie Provinces and the possibility for reoccurrence in the future (Sauchyn and Kulshreshtha, 2008). According to one respondent point of view, Canada still lacks the long-term policies and risk management efforts to deal with extreme climatic events, such as droughts. Despite the enormous impacts droughts could have on the economy, environment, and society, drought research in Canada has been fragmented and often carried out in response to severe drought occurrence (Stewart et al., 2011). Participants of this study also conveyed the lack of long term planning, as evident in the following statement:

“I think when that happens (droughts) a lot of those government people are running scared. Is there really a long-term plan for this? I don’t think there is. When it’s dry like that, there’s enough pressure and it depends on how much pressure is put on them from different producers, say the livestock producers or the grain producers and I think they come up with plans willy nilly just to get over that year. I don’t really believe there is a long-term ...” (MD24).

Lack of political will for long term planning was also raised as an issue or constraint on adaptive capacity to extreme climatic events on local scale. Respondents noted a change of policies and programs with a change in political parties,

“Well that government program has had three or four names, they changed so quickly. Each government seems to change it a bit and call it something different, but none of them, as far as we’re concerned, none of them have really addressed the problem that well” (KD10).

Despite women’s involvement²⁰ in both on-farm and off-farm income to sustain family farms, there are very few policies or programs geared towards farm women in Canada. A spate of federal agriculture programs that focus on farm women were created through the 1980s. The Farm Women’s Advancement Program was created in 1988, followed by the Farm Women’s Bureau which was introduced in 1981. The mandate of the Bureau included consultations with farm women’s organizations as part of the policy making process. According to Gerrard et al. (2005), it was established as a unit within the AAFC. Unfortunately these programs were eliminated through the 1990s, with 2003 marking the elimination of the Farm Women’s Bureau. Lack of attention by policy makers to farm women increased the vulnerability of women for climate change and increased the pressure on women’s labor capacity to meet with the challenges of climatic variability.

Farmers were also asked about the role of institutions in building the adaptive capacity to deal with droughts. The AAFC plays a leading role in helping farmers to make informed decisions in managing their production unit. It has developed a website called “drought watch” to inform farmers about growing season weather conditions. This website provides daily, weekly, and monthly moisture and precipitation conditions across the different parts of the country, which can potentially help farmers to plan their activities accordingly. Only (29%) of the respondents indicated the usage of the AAFC website for their farm activities planning. The majority of respondents reported distrust of the information provided on this website with respect to moisture and precipitation predictions.

²⁰ As noted above, women are playing a major role in maintaining farm sustainability or in adaptation to climatic variability. During 2001 and 2006, the number of female farm operators increased by 16% (Statistic Canada, 2007c).

Community pastures are another resource provided by the federal government for ranchers. Ranchers can use community pastures to sustain their herd under extreme climatic conditions. These pastures are operated under the quota system where ranchers are allowed to send a specified number of cattle to graze. Federal community pastures have served 2,540 producers with 73,000 Cattle and 72,000 calves, per annum on average (Kulshreshtha and Pearson, 2002). These pastures also provide a model for pasture management, where farmers can learn about rotational grazing and water management. As well they promote sustainable land use practices and contribute to soil conservation in the prairies. In 2012, the federal government had announced it was winding down the federal community pasture program and transfer was the land back to the province. The Saskatchewan Government is now considering selling or leasing the land to interested groups (Saskatchewan Ministry of Agriculture, 2013). This transition of community pastures may potentially cause a problem for livestock producers in the area (Hart, 2013).

The PFRA has a long history of building adaptive capacity to droughts in Prairies (Swanson et al., 2007). This institution was established in 1935 in response to 1930 droughts. The PFRA provides technical and financial help to build the water resources on farms to promote beneficial farm management practices (KD36). Many respondents stated that the PFRA has played an important role in providing the technical and financial support for the construction of dugouts and managing community pastures.

The Saskatchewan Ministry of Agriculture extension staff is another institutional resource for local farmers to access information on improved farming practices. In the Kindersley area, many farmers mentioned that it is nice to have Saskatchewan Agricultural staff in the community *“if we ran into trouble, such as diseases or any concern related to varieties, we can access them easily and they are very helpful”* (KD2). Until recently, many communities were lacking in-person service with Saskatchewan Ministry of Agriculture extension staff. The New Democratic Party (NDP) government significantly reduced the number of extension offices in the province in 2004. However, there is some improvement in this respect under the new government. For example, Kindersley office was reopened by the Saskatchewan Party government in 2009 (KD16).

During interviews, respondents were also asked to estimate their ability to deal with future drought. Many respondents predicted the inability to withstand three years of severe drought by most of the production units. Their predictions were based on the occurrence of drought under the current set of government supported BRM programs. Across the Kindersley and Maidstone study areas, respondents demonstrated a sense of alienation with senior governments. The BRM programs were viewed as window dressing-programs that gave the appearance of support without actually providing any. In these communities, there is a sense that senior government institutions are not committed to sustaining family farms in the region.

While the relationship of area residents with senior government institutions are strained, there are thriving local institutional networks and prairies-wide producer organizations. Indeed, the Southwest Drought Committee, created by local producers and municipal governments in response to drought conditions from 2004-2009, contributed to the creation of two of the more popular senior government responses to drought. These include:(1) Farm and Ranch Water Infrastructure Program, which assists producers with the development of community wells, shallow bury pipelines and dugouts; and (2) Tax Deferral program, that allows cattle producers, who sell off breeding stock due to drought, to forego paying tax on the sale of cows, enabling them to use the full amount of sale proceeds to purchase replacement animals when the drought abates.

6.2.5. Human Capital and Local Networks

Many of the farmers interviewed attributed their decreased vulnerability to drought to a lack of adoption of effective farm management skills. Farmers who were incapable of applying appropriate agronomic and business practices in their operations were simply less capable of withstanding the combined impacts of recurrent droughts, high input costs and low commodity prices. Good farm management combined with the safety net provided by crop insurance and the ability to generate non-agricultural income were seen as the avenues for sustaining production units in the study area.

Social capital in the Town of Kindersley area included informal networks, such as church groups, youth and cultural group, and recreational and sport facilities typical to other study area communities. However, in the farming community, many respondents noted the deterioration of social capital. This decline was attributed to expansion of farm size resulting in few owners. While off-farm work is seen as a key to sustainability of a production unit, it draws human resources away from social activities and organizations. The Kindersley area has a Farm Club which has a mandate to share technological information, but only few of respondents were members. Respondents stated that their reliance on external institutions, such as seed, chemical companies and financial organizations, has affected their local links. Farms in the area can be considered as individual businesses; as one farmer stated *“we are in a competitive relationship”* (MD1) Kindersley has a drought committee but its level of activity has dropped off since 2002. For example, one member of the committee indicated that they met only once after 2002. The committee appears to operate in a reactive manner, i.e., response to extreme drought, rather than for developing resources to plan for future climate events.

The drought of 2001-2002 severely impacted the Kindersley area. The local town administration put enormous effort into upgrading its water system and enhanced its capacity to deal with future water related stress. As farming in the area is moisture dependent, any future multi-year moisture deficit could limit the agriculture production in the area. A majority (83%) of the farmers claimed that two consecutive years of drought was the threshold for withstanding drought impacts; any longer period droughts would create problems for the viability of many production units. Precipitation always has been a constraint in dryland farming. Farmers in the area have been able to mitigate its impact through using better technology, better varieties, and better management programs. Nonetheless, a lack of timely rains has a negative impact on crop yield. One responded noted that,

“There are lots of things we have done to offset the moisture related problems to an extent but at the end of the day the big one is weather, if it rains too much or too little we have problems. But we live with it because that is part of the business” (KD34).

Respondents in the Maidstone area reported a lack of enthusiasm for collective action among farmers. Many respondents noted that, the town had lost the grain elevators because of a lack of effective lobbying. Some respondents wondered why the town and RM were not successful in lobbying for a similar pipeline to the river when they faced a water quality problem in 2002, while Husky Oil was able to pump fresh water from the North Saskatchewan River for its operations. Maidstone is home to many community-based service clubs such as the Kinsmen and the Canadian Legion, which are slowly fading out due to fewer number young people in the community and their engagement in off-farm jobs.

6.3 Summary

This chapter documented the results from interviews conducted in the two study communities. The main purpose was to identify the residents' exposure to drought, their response to drought, and constraints on their adaptive capacity. The study communities (Kindersley and Maidstone) faced economic losses during 2001-2003 drought years. Results indicated that vulnerability to drought is not only a climatic factor and cannot be fully understood on the basis of just scientific facts, such as extent and frequency of drought. There are many contextual factors which are affecting producers' vulnerability to droughts. The most quoted ones were increasing cost of inputs, price fluctuation in international markets, tight profit margins and less supportive government policies.

Chapter 7

Future Exposure to Climate Change and Droughts

7.1 Biophysical Factors

Historical observation of geophysical and weather related events based on instrumental record indicates that the number of weather related events has increased after 1970s (Figure 7.1). All regions of Canada have experienced weather related extreme events, but the Prairie Provinces (Saskatchewan, Manitoba and Alberta) have a history of weather related disasters. For the Prairie Provinces, these include droughts and floods. As previously mentioned that drought has caused financial hardships for the Prairies. In fact, in Canadian history droughts are the most costly and recurrent natural disaster (Table 7.1). Six of the top ten most expensive natural disasters in Canada were Prairie droughts.

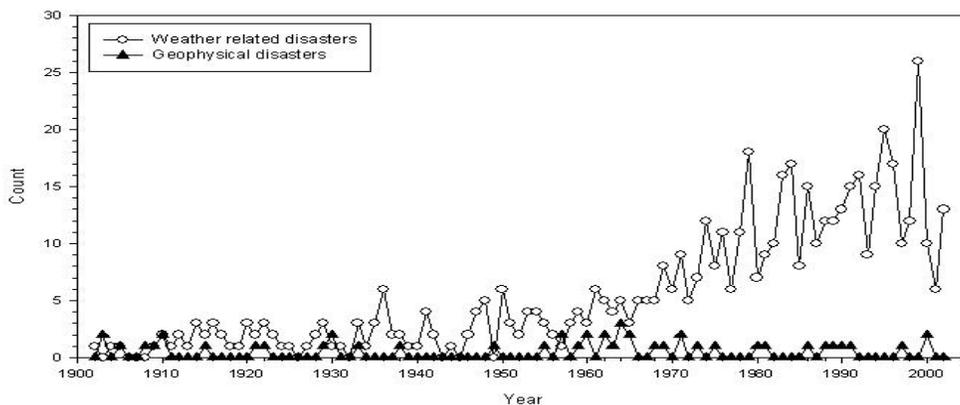


Figure 7.1 Historical trend of geophysical and weather related disasters in Canada (1900-2002)

Source: Koshida (2010)

Most global climate models project increased continental interior drying during summers and a greater risk of droughts for the 21st century (Watson et al., 2001). Based upon expert judgment, there is a 66% probability of an increase in the area

affected by drought (IPCC, 2007). The Canadian Prairie region is considered to be particularly vulnerable to the effects of climate change (Sauchyn and Kulshreshtha, 2008). Climatologists suggest that global warming is the anticipated shift in the climate due to greenhouse effect (accumulation of heat in the lower atmosphere through the absorption of long wave radiation from the earth's surface), which will cause the Canadian Prairies to experience higher temperatures and more frequent and extreme droughts. These effects are predicted to become increasingly evident within the next 50 years (Hengeveld, 2000; Clark et al., 2002).

Table 7.1 Top ten weather related natural disasters in Canada

Disaster	Year(s)	Location	Estimated total cost(Billion\$)
Drought	2001\2002+\-	National	\$ 5.8
Freezing Rain	1998	Ontario to New Brunswick	\$ 5.4
Drought	1988	Prairies	\$ 4.1
Drought	1979	Prairies	\$ 3.4
Drought	1984	Prairies	\$ 1.9
Flood	1998	Saguenay, Quebec	\$ 1.7
Flood	1950	Winnipeg, Manitoba	\$ 1.1
Drought	1931-38	Prairies	\$ 1.0
Drought	1989	Prairies	\$ 1.0
Hailstorm	1991	Calgary, Alberta	\$ 1.0

Source: Dotto et al. (2010)

7.2 Climate Change Scenarios

The climate change scenarios used in this study were based on the second version of the Canadian Global Coupled Model (CGCM2). CGCM2 is developed by Flato and Boer (2000). CGCM2 are computer models used to make quantitative projections of future long term climate change given various greenhouse gas concentrations (Table 7.2). These scenarios were measured in terms of change in temperature and precipitation over the normal period (1961-1990). The changes would be Moderate (felt by 2020), Strong (felt by 2050) and Extreme (felt by 2080).

According to these projections, the annual average temperature is predicted to increase²¹ by 1.05, 2.02 and 3.26°C respectively, by 2020s, 2050s and 2080s, while the average precipitation was forecasted to increase by 0.016, 0.116 and 0.186 mm/day, respectively, under the same three periods. According to the extreme scenario, temperature would increase on the Prairies in all seasons, but the major increase will occur during the winter season (Table 7.2). Whereas precipitation increases slightly in all three periods, under the extreme scenario the precipitation will increase by 0.186 mm/day (Table 7.2).

Table 7.2 Climate change scenarios for Canadian Prairies

Scenarios	Change in Temperature (°C)					Change in Precipitation mm/day
	Yearly	Winter	Spring	Summer	Autumn	
2020s	1.046	1.037	0.852	1.140	1.149	0.016
2050s	2.19	4.61	1.60	1.62	1.91	0.116
2080s	3.26	4.95	3.21	3.26	1.95	0.186

Source: Afshin (2010)

These changes may result in increased evapo-transpiration, resulting in decreased availability of soil moisture. In fact, these projections might be a more accurate and realistic predictions, as the Prairies are one of the driest regions of

²¹ Estimated temperature change were calculated by subtracting the annual mean of each climate variable in 1961-1990 from the annual mean of each certain averaging period (2020s, 2050s and 2080s).

Canada. Sauchyn and Kulshreshtha (2008) have also predicted moisture deficits for this region; specifically precipitation cannot offset water loss by evapo-transpiration as summer time high temperatures in the Prairies means more dry conditions on the Prairies.

It is important to downscale these regional predictions to a community level, as communities on the Prairies have different topographies, and thus different levels of change in temperature and precipitation. This study has adopted data from the larger project report “Rural Communities Adaptation to Droughts” (RCAD, 2012) that highlight predicted future climate for the study area.

In this study two sets of data were selected: One data set based on Medium emissions scenario (A1B) and the other on High emission scenario (A2). These scenarios are based on a different set of assumptions, as shown in Table 7.3. The medium emission scenario was based on very high GDP growth, low population growth, rapid technological changes, a mix of fossil fuel and new technology, and very high energy use. In contrast, the high emission scenario was based on very high GDP growth, low population growth, high energy use, rapid technological changes, and use of non-fossil fuel sources. On the basis of these two scenarios, temperature and precipitation were predicted for the period 2020s, 2050s and 2080s.

These predictions were then compared with the normal temperature and precipitation for the period of 1971- 2000. Under both medium and high emissions scenario, there are deviations in temperature and precipitation from normal period. Under the medium emission scenario, temperature and precipitation is likely to increase in all seasons (i.e., winter, spring summer and fall). The annual temperature by 2080s for Kindersley and Maidstone will likely increase by $3.6^{\circ}\text{C} (\pm 1)$ over the historical average (Table 7.4a). Although temperature increase occurs in all season, the significant increase will likely occur in the winter season, where an increase of $4.6^{\circ}\text{C} (\pm 1)$ for Maidstone and $4.5^{\circ}\text{C} (\pm 1)$ for Kindersley area by 2080s would be the result. In summer, temperature increases for the study area are estimated around $3.4^{\circ}\text{C} (\pm 1.3)$ for both communities. This increase in temperature would translate into higher evapotranspiration, which will probably cause a moisture deficit for the area by 2080s.

Table 7.3 Indicators of medium and high emission climate change scenarios

Scenario Group	A1B (Medium Emissions)	A2 (High Emissions)
Population Growth	Low	Low
GDP Growth	Very High	Very High
Energy Use	Very High	High
Land Use Change	Low	Low
Oil/Gas Resource Availability	Medium	Medium
Technological Change/Efficient Technology	Rapid	Rapid
Change Favouring	Balanced (mix of fossil fuel/technology)	Non-Fossil Fuel

Table 7.4a Climate change temperature predictions for Kindersley and Maidstone based on medium emission scenario (A1B)

Maidstone, SK					
°C	Annual	Winter	Spring	Summer	Fall
1971-2000	1.8	-14.3	2.9	15.9	2.6
2020s	3.0 ± 0.4	-12.8 ± 0.6	4.0 ± 0.5	17.0 ± 0.4	3.7 ± 0.4
2050s	4.3 ± 0.7	-11.1 ± 0.9	5.1 ± 0.9	18.3 ± 0.8	4.9 ± 0.7
2080s	5.4 ± 1.0	-9.7 ± 1.3	6.0 ± 1.2	19.3 ± 1.1	6.0 ± 1.1
Kindersley, SK					
°C	Annual	Winter	Spring	Summer	Fall
1971-2000	2.2	-14.0	3.4	16.6	3.0
2020s	3.4 ± 0.4	-12.6 ± 0.6	4.4 ± 0.5	17.7 ± 0.4	4.1 ± 0.4
2050s	4.8 ± 0.7	-10.9 ± 0.9	5.6 ± 0.9	19.1 ± 0.8	5.3 ± 0.7
2080s	5.8 ± 1.0	-9.5 ± 1.3	6.4 ± 1.2	20.0 ± 1.1	6.4 ± 1.1

Source: RCAD (2012)

Precipitation is also expected to increase for the two study areas. Under the medium scenario, 2080 level of annual precipitation for the Maidstone is predicted to increase by 7.6 - 64.8 mm. The change for the Kindersley under the same scenario will likely be 6 - 51 mm by 2080s (Table 7.4b). It is important to note that significant precipitation increase will likely occur during spring, when 17.3 mm for the Maidstone and 14 mm for Kindersley area is predicted (Table 7.4b). Precipitation increase during the summer months will likely to be 2.1 mm for Maidstone and 1.8 mm by 2080s for Kindersley (Table 7.4b). The predicted increase in temperature and insignificant increase of precipitation in the summer months for the study area could be problematic for agriculture sector. Farming in the study area depends on the timely rains and suitable temperatures. Departures from normal temperature could negatively impact crop production in the study areas.

Table 7.4b Climate change precipitation predictions for Maidstone and Kindersley based on medium emission scenario (A1B)

Maidstone, SK					
mm	Annual	Winter	Spring	Summer	Fall
1971-2000	424.8	52.9	89.2	210.4	72.3
2020s	437.7 ± 14.1	55.2 ± 3.1	93.5 ± 5.2	215.8 ± 10.7	73.6 ± 4.8
2050s	449.1 ± 20.1	58.0 ± 4.2	101.0 ± 9.5	211.6 ± 14.3	76.0 ± 6.0
2080s	460.6 ± 28.2	59.5 ± 5.4	106.5 ± 13.3	212.5 ± 19.2	78.9 ± 7.9
Kindersley, SK					
mm	Annual	Winter	Spring	Summer	Fall
1971-2000	339.4	34.8	72.2	179.9	52.5
2020s	349.7 ± 11.3	36.3 ± 2.1	75.6 ± 4.2	184.5 ± 9.1	53.5 ± 3.5
2050s	358.8 ± 16.0	38.1 ± 2.8	81.7 ± 7.7	180.9 ± 12.2	55.3 ± 4.3
2080s	367.9 ± 22.5	39.1 ± 3.6	86.2 ± 10.8	181.7 ± 16.4	57.3 ± 5.7

Source: RCAD (2012)

Climate change related temperature and precipitation predictions under high emission scenario are reported in Table 7.5a & b. Under the high emission scenario, 2080s annual temperature increase of 4.1°C(±1) and 4.2°C(±1) for Maidstone and Kindersley, respectively, is predicted. Summer temperatures would probably increase by 4.1°C(±1) for both study areas. Associated with this would be an increase in amount

of precipitation of about 1.2 mm and 1.1 mm , for Maidstone and Kindersley, by the 2080s (Table 7. 5b).

Table 7.5a Climate change temperature predictions for Kindersley and Maidstone based on high emission scenario (A2)

Particulars	Change in Temperature over Normal in degree C				
	Annual	Winter	Spring	Summer	Fall
Maidstone					
1971-2000	1.8	-14.3	2.9	15.9	2.6
2020s	2.9 ± 0.3	-12.9 ± 0.6	3.7 ± 0.4	16.9 ± 0.5	3.7 ± 0.3
2050s	4.2 ± 0.6	-11.3 ± 1.1	4.9 ± 0.7	18.3 ± 0.6	4.9 ± 0.6
2080s	5.9 ± 1.0	-9.4 ± 1.5	6.3 ± 1.2	20.0 ± 1.1	6.6 ± 1.0
Kindersley					
1971-2000	2.2	-14.0	3.4	16.6	3.0
2020s	3.3 ± 0.3	-12.7 ± 0.6	4.2 ± 0.4	17.7 ± 0.5	4.1 ± 0.3
2050s	4.6 ± 0.6	-11.1 ± 1.1	5.3 ± 0.7	19.0 ± 0.6	5.3 ± 0.6
2080s	6.3 ± 1.0	-9.2 ± 1.5	6.7 ± 1.2	20.8 ± 1.1	7.0 ± 1.0

Table 7.5b Climate change precipitation predictions for Kindersley and Maidstone based on high emission scenario (A2)

Particulars	Level of Precipitation in mm				
	Annual	Winter	Spring	Summer	Fall
Maidstone					
1971-2000	424.8	52.9	89.2	210.4	72.3
2020s	440.7 ± 20.4	55.8 ± 2.5	95.5 ± 9.6	215.9 ± 12.6	74.0 ± 4.8
2050s	445.9 ± 23.9	57.4 ± 4.9	101.3 ± 13.1	209.6 ± 12.8	75.9 ± 6.7
2080s	466.6 ± 29.2	62.4 ± 5.8	108.4 ± 13.8	211.6 ± 19.1	80.3 ± 10.3
Kindersley					
1971-2000	339.4	34.8	72.2	179.9	52.5
2020s	352.1 ± 16.3	36.6 ± 1.6	77.2 ± 7.7	184.6 ± 10.8	53.8 ± 3.5
2050s	356.2 ± 19.1	37.7 ± 3.2	82.0 ± 10.6	179.2 ± 11.0	55.1 ± 4.9
2080s	372.8 ± 23.3	41.0 ± 3.8	87.7 ± 11.2	181.0 ± 16.3	58.4 ± 7.5

Source for Table 7.5 (a and b) in RCAD (2012)

According to both medium and high emission scenarios, more precipitation will likely be available during the spring season. On Canadian prairies, snow melting occurs in spring months, which could cause spring flooding in parts of the study area.

The projection of increase in early spring temperature means a longer growing season, but the elevated temperature and humidity could also increase the probability of pest and diseases both in plants and animals (Nyirafa and Harron, 2002). Diseases such as leaf spotting diseases in cereals, *Ascochyta* blight in chickpeas and lentils, as well as *Sclerotinia* in canola are going to have significant impacts on crop productivity (Saskatchewan Ministry of Agriculture, 2010). These changes would likely increase the vulnerability of farmers in the future.

Besides future climatic risks, changing cultural practices may also play a role in contributing to vulnerability and / or adaptive capacity. In order to achieve economies of size, in the study area farmers have increased their cultivated land area. This is accompanied with the use of more chemicals to get a decent yield every year. The shift from summerfallow to continuous cropping, on one hand, has increased the yield of many crops, but on the other hand it has increased farmer's reliance on chemicals and fertilizer. This may have increased producers vulnerability to any climatic extreme.

During interviews, respondents were asked about their ability to deal with the projected climate change impacts, i.e., more frequent and severe droughts. Many respondents from Kindersley study area indicated that they are used to recurring droughts in this area. Based on their previous experience, they stated that they can withstand two years of drought. Droughts of three or more years will be out of their coping range. Therefore, most producers' degree of vulnerability will increase after two years of drought, particularly under minimal institutional support.

Chapter 8

Conclusions

This chapter provides the summary based on key findings from community based vulnerability assessment. Future research opportunities are discussed to conclude this chapter.

8.1 Purpose of the Study

The main purpose of this study was to gain insight into the socio-economic and biophysical vulnerabilities related to drought in the study communities, and the process of adaption to such event. The study has identified that drought has caused significant financial hardships for agriculture and livestock producers in the area. Institutions have played a major role in helping producers in the hard times, and building their capacity to deal with climatic events. However, respondents have identified many shortfalls in the available business risk management programs (BRMP).

8.2 Response to Objectives and Key Findings

Results for each of the objectives of the study (per Chapter 1) are summarized in this chapter.

8.2.1 Drought Characteristics in Study Communities

Using data for 1901 - 2005, the frequency and intensity of droughts in the two study communities were examined. Droughts are a recurring phenomenon in Kindersley, whereas, 2001-2003 drought was the first multiyear drought for Maidstone community. Results indicate that Maidstone area was exposed to multiyear drought during 1914 -1919, but many respondents did not have any memory of that drought. In this community, many respondents compared their 2001-2003 exposure of drought to the 1930s drought episode and indicated that the Maidstone area was not severely

affected in 1930s. In fact observations of many people from other parts of Saskatchewan moving to Maidstone during this period were made. In Kindersley droughts are common and respondents from this area noted many dry years in their farming career. The most quoted ones were the 1988 drought and followed by the 2001-2003 droughts. According to the Kindersley respondents, 2001-2002 was the first multiyear drought after 1930s.

8.2.2 Impacts of Droughts on Study Communities

Agriculture productivity was impacted by the 2001-2003 droughts. Both Maidstone and Kindersley faced yield losses as a result of these droughts. In the Kindersley area, in 2001 spring wheat, canola and lentil yields decreased by more than 46% than the average (1971-2000), and dropped by almost 100% in 2002 for canola. According to the Maidstone respondents, this area never faced total crop failure in the instrumental record period. In this area, the 2002 drought impacted crop yields for spring wheat and peas. The spring wheat yield was 70% lower than the average for a normal (1971-2000) period. The pea crop yield was also 93% below normal. Even 2003 was a below average year for all major crops in the region.

Drought did not impact the Kindersley water supply during 2001-2003, whereas, in Maidstone water level in the Maidstone lake became low due to the 2002 drought. As a result of the experiences of the 2002 drought, town of Maidstone decided to build a pipeline for underground water from nearby village Waseaca. During interviews urban municipal officials in Kindersley and Maidstone were optimistic about their current potable water source for their communities. Their optimism is based on the only slight increase in population and economic development, not on the basis of climate variability and future predictions.

In addition to droughts, excessive moisture was also identified as unusual and problematic for the study area. Such an event took place during June - August 2010. In Kindersley area, some respondents lost their already seeded crop because of flooding. In Maidstone, hail damage and crop diseases were major concerns.

8.2.3 Adaptation Strategies Adopted in Response to Drought

In response to droughts and farming in the semi-arid area, respondents have adapted to drought by changing their farming practices. According to several respondents, they shifted from conventional tillage to no tillage practices after the 1980 drought. This shift has helped to conserve soil moisture and reduce wind erosion. Before 1980s, many respondents were practicing rotations including summerfallow²²; now continuous cropping (where crops are grown every year) is common in the study area.

Respondents reported the challenges of farming in a semi-arid area. Water is the biggest limiting factor for farming in the study areas. According to them, as farming is not a reliable source of income, many (about 60%) of them had a second source of income as an adaptive strategy and at least one respondent indicated most farm wives work. Both study communities have high level of natural capital (through oil and gas mining activities). Oil and gas companies provide many off-farm jobs in the area, which had helped respondents to survive during the 2001-2003 droughts.

8.2.4 Comparison of Kindersley and Maidstone on the Basis of Adaptive Capacity

Kindersley and Maidstone lie in two different ecoregions. Kindersley is location in the brown soil zone which is accompanied by less average rainfall making this area vulnerable to more frequent droughts as compared to Maidstone. Rich soils of Maidstone make this area more suitable for agricultural activities. During 2001-2003 both communities were exposed to severe drought conditions, but in Maidstone crop yield losses were of smaller magnitude as compared to Kindersley, perhaps because of this difference.

Technological capital is high in both communities. Farming practices have changed from tillage to zero till practices to conserve soil moisture. Respondents from both communities indicated the use of relatively new machinery for better farming

²² Summerfallow is also called as fallow cropland, where land is purposely left with no crop to restore soil moisture and nutrients for the next crop year. This farming practice was common on Canadian Prairies.

practices. In term of economic capital, Maidstone respondents are in a better position because of less frequent droughts until 2002-2003. But in the contemporary agriculture sector many respondents from both communities are involved in off-farm jobs. Both areas are rich in oil resources. Oil and gas exploration companies provide jobs and business to many residents of the study communities. Both communities also developed better water infrastructure to handle any future pressure on their water sources.

Agriculture activities in both areas are moisture dependant; there is no irrigation system to support agriculture. In Kindersley many farmers in rural surrounding area of Brock and Netherhill have access to secure source of water, whereas, in Maidstone area the water is available only to town residents. There is no extension water pipeline in the surrounding rural municipality.

On the basis of comparison of social capital, Kindersley seems to have an advantage of being a bigger community. In Kindersley all the big companies are present and farmers have easy access to government representatives from agriculture extension staff. Whereas, Maidstone is a small sized community and agriculture related businesses and government agriculture representatives were not available in the town. Another example of Maidstone's social vulnerability was the absence of grain elevators in the town. Farmers in the area had to transport their grain to nearby towns. This transportation cost is an extra financial burden for the residents of Maidstone. In Kindersley farmers have easy access to grain elevators and other agriculture related businesses. In summary, although Kindersley area is not so blessed with fertile soils, but being a big size community, has higher social capital and is rich in institutions that can help people with adapting to droughts.

8.2.5 Effectiveness of Government Policy Measures

Institutional help, in the form of business risk management programs (BRM), are also available to farmers in the two study communities to offset impact of drought and other natural disasters. BRM programs identified by respondents were crop insurance, Agri-Stability, Agri-Recovery and Agri-Invest. In Kindersley 96% of respondents were participating in BRM during 2001-2002 drought, whereas in Maidstone only 48% of respondents reported being involved in these programs. Low rate of involvement in the

BRM programs by Maidstone farmers could be attributed to infrequent droughts in the area till 2001-2003.

Many of the respondents who are participating in BMR were not fully satisfied. The most criticized programs were Agri-Stability and Crop Insurance. All the respondents from both communities believe Agri-Stability has many shortfalls. These shortfalls included: complexity, predictability, timeline issues, and additional financial burden. In Kindersley, a majority of the respondents carry crop insurance. However, many of these respondents were not satisfied with the program. The main concern was high premiums and a low guarantee for loss coverage. In Kindersley during 2001-2003 multi-year drought, farmers observed that crop insurance was not setup for such natural hazards. If crop yield is continuously down, it means less and less payment for farmers. Many respondents (52%) from Maidstone area did not consider Crop Insurance as useful for them. Thus, it appears that the two study communities are relatively weak in terms of institutional capital. Results indicated a strained (with a strong sense of alienation) relationship between agriculture producers and senior government agencies.

8.2.6 Future Climate Related Risks for Study Communities

Future climatic risk predictions for the Maidstone and Kindersley communities were identified for the period ending 2080s. Predictions were noted under two scenarios: Medium emission scenario and High emission scenario. These predictions included a high probability of increase in temperature and insignificant increase in precipitation.

For both Kindersley and Maidstone, mean annual summer temperature increase is projected to be $3.4^{\circ}\text{C}(\pm 1.3)$. There are predictions of a slight increase in amount of annual precipitation for the area. Mean annual precipitation in the future is expected to increase as compared to average (1971- 2000), particularly for the summer months. During these months by the 2080s, precipitation is predicted to be between 17.2 - 21.4 mm for Maidstone and 14.6 - 18.2 mm for Kindersley. The predicted increase in temperature and insignificant precipitation increase in the summer months for the study area could be problematic for the agriculture sector. Farming in the study areas depends

on the timely rains and suitable temperatures. Deviations from normal temperature could negatively impact crop production in the study areas.

Some study respondents indicated some degree of disbelief regarding the projections of climate change and their foreseen impacts on the local communities. Communities and individual take proactive measure only when they perceive risk. If the communities are not considering drought as a threat, then chances of taking proactive adaptive measures are very low. Creation of this awareness is a prerequisite for any proactive planning. More research is needed to explore different ways to improve public awareness since social acceptance of climate change phenomenon would lead to effective adaptive measures to such climatic extremes.

Many respondents stated that their threshold level to cope with the drought is less than three years. Most producers believe that, following two years of drought, neither they nor their neighbors could remain solvent. The two to three year drought survival window assumption assumes that the current suite of government risk management programs, commodity price levels and input cost regimes remain relatively constant. The conclusion one can draw is that without a massive injection of government support and relief from debt obligations, three years of severe drought would threaten the continued viability of agriculture in the study areas.

8.3 Identification of Non-Climatic Stressors

Besides climatic factors, respondents perceived many non-climatic factors as constraints on their ability to deal with droughts. Institutional factors coupled with social factors, such as changing government policies, shortfalls in available risk management programs, depopulation, lack of social networks, and declining profit margin in agriculture, have contributed to their vulnerability to extreme climatic events. The combination of economic stress along with inadequate government risk management programming translates into a very narrow window of sustainability for producers who could face a severe multi-year drought in the future.

8.4 Study Conclusions

This study highlighted the linkage between social and biophysical factors that can enhance / constrain respondent's ability to deal with droughts. In climate change

adaptation literature, there are number of studies that have developed quantitative indicators to measure adaptive capacity of communities. Although these quantitative indices are helpful in identifying the most vulnerable areas, they are unable to provide details on the context and sources of vulnerability. This study contributed to this field of study by conducting participatory vulnerability approach. In this approach, respondents identified causes of their own vulnerability to natural hazards, such as a drought. By using this approach, a better understanding of actual actions undertaken by farmers under drought conditions was generated.

Results from this study indicated that both Kindersley and Maidstone were sensitive to drought conditions during the 2001- 2003 period. However, the study also found that a drought is not the sole cause of vulnerability of respondents in the region. There were number of economic and social factors, such as increased cost of inputs, debt load, inadequate government safety networks, access to agriculture extension workers, and lack of proper farm management skills, all of which contribute to their vulnerability to droughts. For most producers, the main adaptive measures undertaken in response to drought included seeking off-farm jobs, change in farming practices, and participate in Business Risk Management (BRM) programs.

Availability of off-farm job opportunities did help producers during periods of low farm incomes, which is so typical of drought conditions. The second adaptation practice, change in farm practices, was adoption of “No tillage” cultural practice. This resulted in conserving soil moisture on one hand, but on the other hand increased respondents’ dependence on chemicals and machinery suitable for the no-till practice. As a result, most respondents are spending more money to grow crops, and to buy new machinery. This had resulted in an increase in their economic vulnerability to climatic risks, such as droughts. The third major response to drought was participation in BRM programs. These programs have provided respondents a financial cushion in case of one year drought. However, due to operating rules and regulations, some producers did not participate in these programs. According to few respondents these programs had also encouraged cropping on marginal land, which can increase farmer’s vulnerability to predicted drought conditions in the study area.

This study found that several types of changes would help respondents to improve their adaptive capacity to cope with droughts. These changes include, but are not limited to, revision of BRM programs to make it easier for respondents to participate in them, greater access to agriculture extension education to promote effective farm management skills, easy access to grain transportation facilities, creating awareness related to climate change impacts on agriculture, and more opportunities to increase farm earnings. Such changes would assist producers to cope with future droughts in the region.

8.5 Study Limitations

There are three major limitations of this study. These include: (1) scope of research, i.e., only two communities (2) method of data collection (3) possible respondent bias. The first limitation of the study is that it was limited to study of only two communities in Saskatchewan. Some may consider this to be too limited for generalizing results for the Prairie region. In terms of the data collection process, much of the data pertained to respondents' views and expectations about the available institutional support to deal with droughts. The survey was based on ethnographic methods in which respondents were allowed to express their views. However, this method does not permit any quantification of results. Furthermore, there is also no possibility for any verification of the responses. These types of data may also contain some exaggerations of some facts.

8.6 Future Work

Based on the results of the study and their limitations, a number of areas deserve a mention for future research. These include:

- The past as well as current research on climate change and its impacts has mainly been based on large scale global climate models. Such results are not very pertinent in the context of a smaller area, such as a rural community in the Canadian Prairies. Further study of smaller communities in a rural would be useful.

- The manner in which projected climate variability will affect local communities has not well studied. The issue of climate change and its impact on local communities is complex and fraught with uncertainty. As physical and social characteristics of a given community contribute together to the resilience or vulnerability, it is crucial to understand them at the local scale.
- The threat of drought is real for the Canadian Prairies as it is for many regions worldwide. The extensive societal hardships experienced in regions affected by droughts are known all too well and have been demonstrated repeatedly. In order for governments to address management concerns and move forward in developing effective drought mitigation strategies, the policies must be based on well-founded scientific knowledge.
- Further research is needed to improve the BRM program for the producers. Respondents have suggested several problems with these programs. It is hoped that this study findings can contribute to improving BRMP in order to meet the needs of producers facing natural hazards.

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Appendix A

Interview Guide

Basic demographic questions:

- Can you tell me a little bit about your background?
- Do you mind telling me your age?
- What do you do to make a living?
- What is the size of your household? Who are living with you? Do the kids help in the farm?
- What is the main source/balance of sources in your household?
- What is the last grade you have attended?

- Farmers
- How big (how many acres) is your farm?
- What kind of crops do you grow? What are their percentages?
- Can you describe the sorts of practices you use?
- Does anybody irrigate here? What kind of irrigation method do you use?
- What type of equipment do you use?
- Do you have any livestock? What type of livestock do you have? How many?
- Would u replace your source of income when _____?
- Do you owned most of your land? Do you also leased/rented? How about your machinery?
- Is it a family farm or it is incorporated?
- Others
- Could you talk briefly about your duties as a _____?

- Can you talk about the existing water management measures, saying what's good about it? In what way or ways you think it is deficient? In your opinion, what should be done?

How do people live/livelihoods?

- How long have you been working/living in this field/area?
- Have there been changes? What are they? Why there are such changes?
- How did you manage through?
- Was there anything that has helped you?
- Why did you decide to act in this way? Who helped you decide to act in this way?
- Would you done something differently?
- What in your opinion is the worst problem faced by the community?

How do they use water?

- Does the livelihood of your household depend on water? How? How much?
- Do you haul your drinking water? From what sources do you get your drinking water?
- On average, how much water do you use?
- Is your livestock operation comes from the same source?
- What is the quality of the water you get? Do you treat all your sources?
- Have the source always been reliable (quantity and quality)?
- Does the source change seasonally/throughout the year?
- What did you do when you had no water? How much supply do you have if anything happen?
- How are you dealing with current problems?
- What helped you decide to take these actions?
- How do you ensure the security of the supply?
- Do you anticipate problems in quantity and quality of the sources? Why?
- Would you live differently if there were more secure access to water?

- Would you be willing to pay more for water to enhance the security?

How does weather influence what they do?

- What kind of weather do you need for good production?
- Can you describe a good year/bad year?
- What do you do when there aren't ideal conditions? What do you do when there are?
- How does the timing of water availability influence what happen?
- Is too much water/precipitation ever a problem? How does this affect you?
- Is too much water ever managed with consideration given to the next drought?

What has happened in drought situations in the past?

- Recent droughts - when were they? How long did it last? How bad were they?
- What did you do?
- When has this happened before, how long did it last, how severe was it?
- What was done to get through it?
- What (if anything) was done to prepare for the next drought?

What are some of the things that worked, didn't work, barriers, incentives?

- How well did things work in the past?
- In your opinion, what strategies were particularly effective?
- How long would these have continued to work?
- Would they work for other people in similar situations?
- What was tried and less successful? Why?
- Was there any institutional involvement?
- Did you participate with any support programs?
- What was successful about the experience, how could it have been better?

- Would you participate in those programs again?
- Did you have any friends that help you out on the farm? How did they help you?
- What would have made the drought more manageable last time?
- What would you like to see available in the next drought?
- What would you do in the next drought?
- What sorts of information do you need to help you manage through a drought better? Who should provide it?

Are there future considerations?

- If agricultural background
- Do you see your children farming? Why, why not?
- What will they have to do to stay viable?
- Did the last drought (or bad year) change how things were done? Did the last good year change how things were done?
- If there's a drought how long would you be able to make it through?
- What if you had a four-five-six year drought?
- Are you planning for changes in water quantity and quality?

What can be done at the institutional level to build more adapted communities?

- What can be done to ensure that the communities can cope better?
- What do they need from the province, federal government, and local government?
- What are the price points that enable participation in existing programs?
- If you need assistance with programs where do you get the info?

Last questions

- Is there anything I should have asked you about water and drought that I missed?
- Is there anybody else you think would like to participate in this study?

APPENDIX B

Information Sheet

Rural communities adaptation to drought: Case Studies of Kindersley and Maidstone Saskatchewan

You are being invited to participate in the 'Community-based Assessment of Vulnerabilities and Adaptive Capacities related to drought, study that is being conducted by Saima Abbasi (M.E.S candidate, School of Environment and Sustainability, University of Saskatchewan) under the co-supervision of Professor Suren Kulshreshtha (Professor, Department of Bioresource Policy, Business and Economics, University of Saskatchewan) and Elaine Wheaton, Distinguished Scientist, Climatology, Saskatchewan Research Council. Your participation in this study to help us gain a better understanding of how the local people of rural Saskatoon perceive their ability (adaptive capacity) to deal with climatic changes, such as droughts.

INFORMATION ABOUT THIS RESEARCH STUDY

Title of the study: Community-based Assessment of Vulnerabilities and Adaptive Capacities related to drought in Saskatchewan: Case Study of Kindersley and Maidstone

Researcher:

Saima Abbasi

MES Candidate, SENS

Room,338 Kirk Hall,

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Purpose of the study:

This proposed study focuses on social vulnerabilities resulting from changes in the environment facing humans. Using the vulnerability approach, research will focus on rural residents' exposure and adaptation to drought impacts in two rural communities in Saskatchewan (Kindersley and Maidstone). The goal of this research study is to develop a systematic and comprehensive understanding of the process that shape the impacts of drought on rural communities and livelihoods, and the present and future conditions and strategies that enhance or constrain adaptive capacity to water shortages.

Consent Form Information:

Benefit of the study: There is no guarantee that you will personally benefit from your involvement in the study. But the research will be beneficial for community and provincial leaders to assess their strengths and weakness in different sectors to deal with natural climatic hazards especially droughts. The main contribution of this research is to strength the development of comprehensive local approaches to develop longer-term planning for adapting to drought.

Research Procedure to be followed:

I will conduct guided conversation (semi-structured interviews) to get the information about, respondent experiences, views and opinions about the drought impact. Information will be collected on your past experience of dealing with drought. What measures you took, was they effective or not.

Interviews will be conducted by the graduate researcher (Saima Abbasi), either at the participant home, or at any location convenient to the participant. Interview analysis will take place at the University of Saskatchewan.

Risks and Right to Withdraw:

We do not anticipate any risk or discomfort with this research; however, if any discomfort should arise you may withdraw at any time. Your participation in the study is completely voluntary.

Confidentiality:

Your anonymity and identity will be protected, and steps will be taken to ensure that your name and any other identifying information will remain confidential. Prior to your participation, and following an initial agreement to partake in the study, you will be asked to sign a consent form. After the consent form is signed, your identity will be referenced by random pseudonym. The information you provide, and consent to, will be converted into counts or averages to be used in the final report.

Data collected, in the form of transcribed interviews, will be stored in electronic form after being encoded and paper copies of data will be stored in a locked file cabinet located at a secured office of the project headquarters at the University of Regina. All paper materials will be destroyed after five years after the completion of the study. All information with names will be deleted with numbers or pseudonyms being replaced in the electronic copies. Every effort has and will be made to protect the privacy and confidentiality of participants.

Use of Information Provided:

Upon signing the consent form participants agree to allow information gathered in the study to be reported in journal articles, conferences presentations, or funding reports. The information will contain no reference to you or the remarks made by you. It will then be communicated broadly, including, but not limited to, briefing and presentation to the communities.

Contact:

If you have any questions or future concerns about your participation within this study, please contact the Ethics Office at the University of Saskatchewan (306)-966-2084.

Ethics Approval:

The research study was reviewed and approved by the University of Saskatchewan Research Ethics Board on June 29, 2010.

Appendix C

Consent Form

I have read the information regarding this study focusing on assessment of Assessment of Vulnerabilities and Adaptive Capacities related to droughts in Saskatchewan. I have been given the opportunity to inquire for more information about the research, and acknowledge that I may withdraw my participation in this research study at any time. I am providing my consent to participate in this study. A copy of this consent form has been provided to me for my own records.

Signature of participant: _____ Date: _____

Signature of Interviewer: _____ Date: _____

Other Points:

The researcher/interviewer would like to use an electronic recording device during the interview, and, with your consent, would like to create an audiotape of the session. Please be aware that the audio tape can be shut off at any time at your request.

Do you agree to the use of an electronic recording device during the interview?

_____ Yes

_____ No

Please mark below how you would like your information to be identified within research study?

_____The research may use my first name in their study from the interview information.

_____The researcher may NOT use my name in their study from the interview information.

_____ I would prefer the use of fictitious name of _____

Do you want to review the transcript of the interview prior to analysis of the findings?

_____ Yes

_____ No

Thank you,

(Signature of participant)

(Date)

(Signature of researcher)

(Date)

Appendix D

NVivo Coding Guide

I ATTRIBUTES

1) Gender

- Male
- Female

2. Occupation

What are the livelihood categories that apply to the respondent?

- Farmer

A producer whose operation involves crop production, with no livestock other than hobby animals or pets.

- Mixed farmer

A producer whose operation includes both crops produced for market as well as commercial livestock.

- Rancher

A cattle, sheep, bison or horse producer who does not typically produce crops for market, but may raise some crop for her/his own use as livestock feed.

- Other Agricultural (This would include certain other agricultural livelihoods such as intensive livestock operations - hog barns, feedlot, dairy, poultry, etc.)

- Self-employed

A self-employed professional or business operator.

- Employed

Earns a salary or wage

- Retired

A person who is primarily retired but may still assist in the family business or farm

- Other (town residents who are not classified in previous categories, store owners, etc.)
- Unemployed, student , disabled, etc.
- Unknown

3. Community

The rural-urban Centre that serves as the major farm service Centre or hub community in the respondent's neighborhood.

- Kindersley
- Maidstone

4. Watershed

Name the watershed where the respondent resides

5. Age

Intervals

- (0-18), (19-30), (31 -50), (51 - 65), (65-75), (75 and over)

6. Marital Status

- Married
- Single
- Divorced
- Widowed
- Common law
- Unknown

7. Number of people in the household (including respondent)

- Number
- Unknown

8. Residence

- Town
- Out of town (farm, ranch or acreage)

9. Water Source (primary -domestic)

- Personal well
- Municipal/town supply
- Cistern/hailed water
- Other (spring, creek, dugout)

II Nodes

1. Tree Node LIVE LIVELIHOODS (livelihoods- how people live)

1.1 LIVED LIVELIHOOD DESCRIPTION

- How does the respondent earn a living/what are the sources of income?
- What is the balance e.g. farm and off-farm?
- How long has the respondent been involved in her/his current occupation(s)
- How many family members/employees participate in the operation?

1.2 LIVEGR -- LIVELIHOOD GENDER ROLES (sharing workload and income earning responsibilities)

- How is gender reflected in the sorts of income generating activities different family members are engaged in?
- How are management responsibilities and workload share?

1.3 LIVEVC -- LIVELIHOOD VULNERABILITIES AND CHANGES

- What are the livelihood sensitivities and vulnerabilities faced by the respondent?
- How is livelihood threatened by drought, low income, rising costs etc.
- What, if any, have been the changes in the way the respondent and her/his family have made in the ways they earn a living, and why were those changes made i.e. what issues trigger changes?
- Would they continue to work off-farm if their farm income situation improved?

2. Tree Node WATERU -- WATER USE (How does the respondent use water?)

2.1 WATERUDU -- WATER USE DOMESTIC - URBAN

- How does the urban respondent/community obtain and use domestic/household water? What sorts of water quality and quantity concerns does the respondent have?
- Does the respondent have an idea of what her/his use rates are?
- What sorts of changes are they making or would they make if they could?

2.2 WATERUDF -- WATER USE DOMESTIC - FARM

- How does the non-urban respondent obtain and use domestic/household water?
- What sorts of quality and quantity concerns does the respondent have?
- Does the respondent have an idea of what use rates are?
- What sorts of changes are they making or would they make if they could?

2.3 WATERUL -- WATER USE FOR LIVESTOCK

- How does the respondent obtain and provide water for livestock (e.g. wells, dugouts, pipelines, solar pumps, grid electric, hauling)?

- What sorts of quality and quantity issues, if any, does the respondent have?
What sorts of changes would they make if they could?

2.4 WATERUI -- WATER USE FOR IRRIGATION

- Does the respondent irrigate?
- What crops are irrigated?
- How is the water allocated, obtained and used e.g. pivot or flood, once per year or twice)?
- Is the irrigation system performing satisfactorily or are there issues?
- What sorts of changes would they make if they could?

2.5 WATEREE -- WATER USE OTHER

- Do the respondents or their communities have other significant uses for water? (e.g. oil and gas extraction, the town's golf course, farm field sprayer use.)
- Is supply quantity and quality satisfactory for these uses?

2.6 WATERSPORT -- WATER SOURCE PROTECTION

- How does the presence or absence of a watershed group affect source water protection, allocation and use in the respondent's neighborhood?
- How is watershed planning managed in the respondent's community: what is the process, how are decisions made? Who is involved, are plans revisited, changed?
- How is water quality issues addressed locally? (e.g. how is wastewater managed by the respondent/community, are there concerns about pollution from oil and gas operations or intensive livestock operations?)

3. Tree Node CIMES -- CLIMATE EXPOSURES AND SENSITIVITIES

3.1 CLIMPR -- CLIMATE PREFERRED

- What is the optimal or normal range of climate/weather, snow, rain etc. that the respondent either relies on or would prefer?

3.2 CLIMDR -- CLIMATE EXPOSURES AND SENSITIVITIES - DROUGHT

- How does drought impact respondent's lives and livelihoods
- What are the characteristics of drought
- At what times of year does drought sensitivity arise
- How frequently do they experience drought and associated impacts?
- Can the respondent recall specific years of serious drought; especially recent events e.g. 1988, 2001, 2002

3.3 CLIMEW -- CLIMATE EXPOSURES AND SENSITIVITIES - EXCESS WATER (too much water or moisture at the wrong time)

- How, if at all, has the respondent been affected by excess moisture or flooding

3.4 CLIMO -- CLIMATE EXPOSURES AND SENSITIVITIES - OTHER

- What other climate exposures besides drought excess moisture and flooding are respondents sensitivities to (e.g. low snow fall and run-off, cold spring weather, early or late frosts)?

4. Tree Node ADAPTS ADAPTIVE STRATEGIES

What adaptive strategies have respondents employed to improve resilience and mitigate the impacts of vulnerability to drought and other climate hazards, and challenges to water supplies?

4.1 ADAPTS -- ADAPTIVE STRATEGIES FOR DROUGHT

What sorts of adaptive strategies have respondents and their communities engaged in to improve resilience to drought, and challenges to their water supplies:

4.1.1 ADAPTSDC -- ADAPTIVE STRATEGIES FOR DROUGHT AT COMMUNITIES' LEVEL

- What adaptive strategies have respondents' urban communities employed to obtain and sustain optimal quality and quantities of water (e.g. drill new wells, dams/reservoirs, conservation/rationing,, improved treatment, wastewater management)
- What government programs have respondents taken advantage of to secure water and or mitigate the impacts of drought and water management and delivery challenges
- Have respondents lobbied government for programs or assistance to improve resilience, or finance infrastructure
- How have these strategies changed over time
- What plans are in place or being designed to deal with hazardous exposures in the future

4.1.2 ADAPTSDP -- ADAPTIVE STRATEGIES FOR DROUGHT - AG. PRODUCERS (AND OTHER

RURAL RESIDENTS/BUSINESSES)

- What adaptive strategies have respondents employed to obtain and sustain optimal quality and quantities of water for domestic and agricultural use (e.g. drill new wells, dams/reservoirs, irrigation, improved treatment)
- What have producers done to conserve soil moisture and prevent drifting?
- What do they do to conserve water for livestock and protect sources?
- What government programs have respondents taken advantage of to secure water and or mitigate the impacts of drought (e.g. Crop Insurance, AgriStability, FRWIP, PFRA programs, etc.)? Why or why not?
- Have respondents lobbied government for programs or assistance to improve resilience?

- How have these strategies changed over time?
- What plans are in place or being designed to deal with hazardous exposures in the future?

4.2 ADAPTSO -- ADAPTIVE STRATEGIES FOR OTHER CLIMATE HAZARDS AND WATER STRESS

- What sorts of adaptive strategies have respondents and their communities engaged in to improve resilience to climate/weather challenges other than drought that can impact their livelihoods and water needs (how do they deal with issues like floods, threats to water quality?)
- How have these strategies changed over time?
- What plans are in place or being designed to deal with hazardous exposures in the future?

5. Tree Node ADAPTC -- ADAPTIVE CAPACITY

What are the assets available to respondents and communities that support their capacity to adapt to drought and water problems?

5.1 ADAPTCT -- ADAPTIVE CAPACITY - TECHNOLOGY

- What is the level of access that respondents have to the technologies that could help them deal with drought and water management issues - is it readily accessible - is it affordable?
- What sorts of technological innovations have respondents invented or adopted to help them adapt?
- Are technological advice and solutions available locally, through governments, or private industry?
- What resources are available (e.g. PFRA offices, local suppliers such as well drillers and track hoe operators)?
- Are these resources available locally, are they affordable or cost-prohibitive?

- What level of technical capacity (knowledge, skill, machinery) do individual producers have?

5.2 ADAPTCI -- ADAPTIVE CAPACITY - INFORMATION AND EDUCATION

- Do respondents have access to the information and educational opportunities they require to deal with drought and water issues?
- How do they obtain the information they require (is it available locally, through government, via the internet etc.)?
- How does the availability of local/regional climate and water supply data affect adaptive capacity?

5.3 ADAPTCER -- ADAPTIVE CAPACITY - ECONOMIC AND FINANCIAL RESOURCES

- How do personal or community economic/financial issues impact adaptive capacity?
- What sorts of financial resources are available to assist producers in making adaptations (e.g. government programs, savings)?
- What is the relationship between resilience in the face of drought and water issues and general economic conditions in agriculture and business?

5.4 ADAPTCIN -- ADAPTIVE CAPACITY - INSTITUTIONAL SUPPORTS

- What sorts of institutions play a role in helping the respondent deal with drought and other water and climate related issues? (e.g. local irrigation associations, the RM, the province, federal government, banks and credit unions, watershed groups.)
- What roles do local, regional, provincial and federal institutions play in enhancing adaptive capacity?
- Which funding and program supports offered by government do respondents utilize?
- How do respondents perceive these institutions are they seen as cooperative, well-informed, obstructive etc.?

- How do respondents view the programs and services offered by institutions, are they beneficial, counterproductive, irrelevant etc.?
- Are there producer or community-based institutions that enhance adaptive capacity through planning and lobbying, such as the Stock Growers, Agricultural Producers of Saskatchewan, irrigation associations, cooperatives?

5.5 ADAPTCSN -- ADAPTIVE CAPACITY - SOCIAL NETWORKS

- What sorts of social networks are operating in the respondent's neighborhood and how do they affect resilience to drought and other climate and water related issues?
- Are local community-based lobbying efforts ever employed?

6. Free Node BAR -- BARRIERS TO ADAPTIVE CAPACITY

- What are the barriers to adaptation identified by respondents? (e.g. economic/financial; institutional intransigence; increasing frequency and intensity of exposure events; community decline; etc.?)
- Are their sufficient incentives or penalties in place to encourage change?

7. Free Node IMPIN -- IMPROVING INSTITUTIONAL SUPPORT

- What do respondents say about the ways local and external institutions could improve their performance and help individuals and communities cope better, and enhance their adaptive capacity?
- What could be done to improve institutions and programs that are not performing satisfactorily?
- Are new institutions and/or new institutional approaches required - have some institutions outlived their usefulness?

8. Tree Node FUTR -- FUTURE RESILIENCE

8.1 FUTRTH -- FUTURE RESILIENCE - THRESHOLDS

- What are the limits of drought/climate induced stress that the respondent believes he/she could withstand without incurring significant livelihood damage (e.g. the

insolvency of a farm or ranch operation, the need to move to a new community and/or occupation)?

- How many years of severe drought (1988 or 2001), for example, could the respondent's farm unit withstand and remain in business?
- What are the limits of drought/climate induced stress that respondents and community officials believe local watershed resources could withstand without incurring ecological and financial losses that exceed current adaptive capacity?
- Can the community sustain or encourage growth given the current state of its water resources?
- How much additional water related expenditure can the community incur without raising taxes to the point that its population can be sustained?

8.2 FUTRP -- FUTURE RESILIENCE - PLANS

- What sorts of planning activities are respondents engaged in to enhance their resilience?
- Have past exposures (droughts/floods etc.) changed attitudes, plans, and strategies?
- What range of conditions are people planning for?
- What are their plans?

9. Free Node GEN -- GENDER ROLES

- What are the gender related components of adaptation and sensitivity to drought and other climate and water related exposures?

10. Free Node WATERFM -- WATER FINANCIAL MANAGEMENT

- Does the community charge for water use or delivery?
- Is town water metered?
- Is rationing employed due to infrastructure or supply issues?

- How is new infrastructure financed - taxes; use or delivery fees; grants, or personally (for farmers)?
- How are irrigation projects managed and financed - grants, government/AESB operations, producer fees, cooperative producer arrangements etc.?
- Do respondents have the financial capacity to make the investments to meet their future and current water needs?

11. Free Node OTHER -- OTHER ISSUES AND RESPONSES OF INTEREST

- Any issues, concerns or items of interest and concern mentioned by respondents but not adequately addresses by the preceding NODES.

APPENDIX E

Transcript Release Form

I, _____, who was interviewed during Saima Abbasi's research study entitled "Community-based Assessment of Vulnerabilities and Adaptive Capacities related to drought in Saskatchewan: Case Study of Kindersley and Maidstone", have reviewed the transcription of my interview and have been given the opportunity to change, add or delete any information in the document to better reflect my interpretation. I feel will be handled correctly by the researchers.

I hereby authorize the use of this transcript to be used by Saima Abbasi to be used within the analysis of the research project, in the form I specified on my consent form. I have retained a copy of this transcript for my own records, and have received an envelope, pre-stamped, that will enable me to return a signed copy of this release form to Saima Abbasi.

If I have any further question or concerns about any area of the study, I am aware that I can contact, Suren Kulshreshtha, Professor, University of Saskatchewan through the number (306) 966-8413 or Elaine Wheaton, Distinguished Scientist at the Saskatchewan Research Council, through the number (306) 933-8179; or the Research Ethics office at the University of Saskatchewan at (306) 966-2084.

Participant Signature

Date

Researcher's Signature
(Saima Abbasi)

Date