Climate Action Initiative
BC AGRICULTURE & FOOD

BC Agriculture Climate Change Adaptation **Risk + Opportunity** Assessment

Provincial Report

Climate Action Initiative
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THIS PROJECT HAS BEEN INITIATED BY the BC Agriculture Council's Climate Action Initiative (CAI) to address the priorities identified in the *BC Agriculture Climate Change Action Plan.* The Action Plan is intended to guide the agriculture sector in adapting to a changing climate and mitigating greenhouse gas emissions.

The Action Plan is available at:
www.BCAgClimateAction.ca

This project involved contributions from many people in different capacities from its early stages through to its completion. The project management team assisted in developing, guiding and executing the project: Dr. David Connell (University of Northern BC), Jennifer Pouliotte (BC Ministry of Environment) and Allen James (BC Agriculture Council). In addition, Dr. Connell played a key role in developing the focus group design and providing background research. Rachelle Beveridge assisted with background research, focus groups, analysis of the interviews and development of Chapter 4 of the Provincial Report. Lauren Klose helped with background research and materials for the focus groups.

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The results of this project will be applied to two new Climate Action Initiative projects in 2012–2013. The *On-Farm Adaptation Practices* project will explore appropriate farm level adaptation practices for BC agriculture. The *Regional Agricultural Adaptation Strategies* project will pilot a collaborative adaptation planning process involving local and regional government and the agriculture industry organizations as partners.

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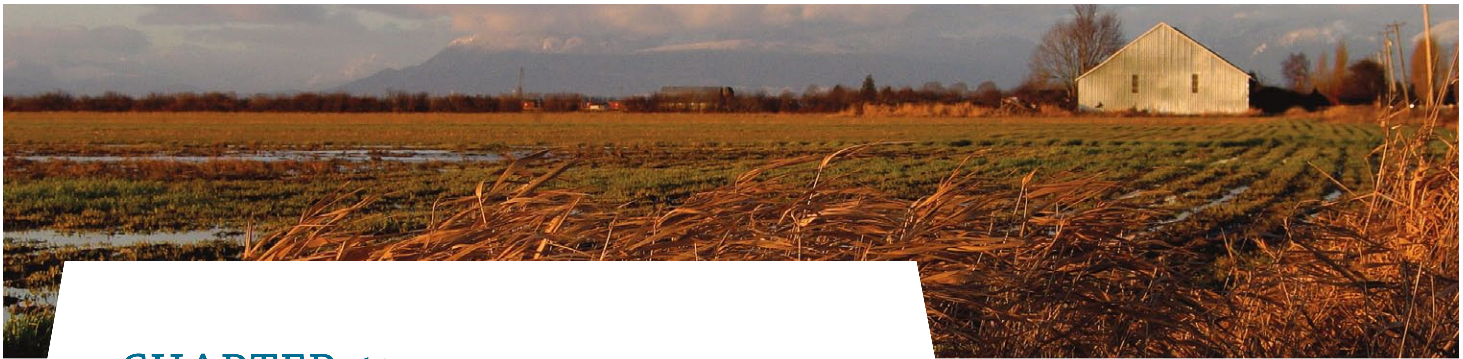


CHAPTER 1: Introduction

Managing through uncertainty & challenging weather is a common element of farming life and producers have developed many ways of adapting. However, the scope and scale of climate change is anticipated to exceed anything previously experienced. Patterns of "normal" weather will shift and the frequency of unpredictable and extreme weather events will increase. This will test the capacity of individual agricultural producers to respond through current approaches, practices and technologies.

This project was initiated, in part, to provide a baseline assessment of potential impacts of climate change for BC agriculture. Although agriculture-focused research has been conducted for the Okanagan, information on the implications of climate change for agriculture in BC as a whole, and for most regions and commodities, is very limited.

Project objectives

- → Increase knowledge/understanding of the potential impacts of climate change within the agricultural regions of the province
- → Identify the agriculture sector's vulnerabilities, adaptive capacities, risks and opportunities in the face of climate change
- → Document past, present and planned farm activities/practices that assist farmers to manage climate variations
- → Identify gaps in the information and resources available to support the agriculture sector with climate change adaptation
- → Maximize opportunities to align with related research and activity in the province

Project background

To begin to address these gaps and challenges, this project was developed in late 2010 by the BC Agriculture & Food Climate Action Initiative, on behalf of the BC Agriculture Council. It serves as a first step in addressing the priorities for climate change adaptation as identified in the *BC Agriculture Climate Change Action Plan*.*

This report provides a high level overview of the implications of climate change for the BC agriculture sector, including the key areas of risk and opportunity, and the factors that will influence the industry's ability to adapt and thrive. The project has been guided by agricultural producer perspectives of impacts, risks and capacity to manage through climate change. The research for this project has included: a review of related research and climate science, thirty-seven producer and specialist interviews and a series of twelve focus groups across the province. Project results have been compiled into this provincial

* *The BC Agriculture Climate Change Action Plan* was released in the summer of 2010. It outlines strategic direction and key activities to assist the BC agriculture sector to adapt to a changing climate and mitigation greenhouse gas emissions. www.bcagclimateaction.ca

overview report, as well as a series of regional/ commodity snapshot reports.

This report is just one step toward better understanding agriculture's risks and opportunities associated with climate change. The number of key actions identified in Chapter 7 is an indicator of how many gaps remain to be filled. However, climate change adaptation is about taking action with the best information available, despite its imperfections and gaps. To wait for all of the answers will leave the BC agriculture sector (and the province's food system) exposed to higher risk. Implementation of adaptation measures, practices and approaches will benefit and strengthen the overall resilience of the industry, even without consideration of climate change impacts.

Report structure

- Chapter 2 highlights the key resources that informed this report, as well as the overall approach and methods used.
- Chapter 3 profiles the BC agriculture sector, its major characteristics and context.
- Chapter 4 reviews the current capacity of the industry to adapt to variable and challenging conditions in a number of key areas.
- Chapter 5 provides an introduction to the climate science, including a review of provincial and regional level climate trends and projections.
- Chapter 6 outlines the major climate change impacts, risks and opportunities for the agriculture sector.
- Chapter 7 presents key actions to enhance adaptive capacity and resilience of agriculture in BC.

Each chapter builds on the information provided in earlier chapters, informing conclusions and findings in later sections. However, for readers with a particular interest in one area, each chapter may also be read on its own.

CHAPTER 2: Framework & Methods

A **great deal of related work**, in other jurisdictions and here in BC, has informed this study and helped to shape its content and structure. Some of the key areas of relevant research are highlighted below. A variety of approaches can be used to assess potential climate change impacts and adaptive capacity. Many studies (including this one) employ a range of perspectives and methods. To address the objectives of this project, a participatory risk-based approach was chosen. This chapter explains what this means, as well as the steps taken to complete this assessment. Further detail is available in Appendix 1.

Related research

The ability of the agriculture sector to adapt to climate change is of growing concern around the world, particularly as it relates to the stability of food production and supply. The global picture for impacts and adaptation in agriculture was reviewed in the International Panel for Climate Change (IPCC) report released in 2007.[1] In recent years, a number of jurisdictions have undertaken research and committed substantial resources both to support agricultural adaptation and to bolster food security.

Some of the jurisdictions conducting work in this area include Australia, New Zealand, the United Kingdom[2] and some U.S. states such as California and Washington.[3] Of particular relevance to this study is the extensive research completed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO)[4] and the government of Australia,[5] and participatory research conducted in eastern New Zealand to assess risks to agriculture.[6]

> *"The strong trends in climate change are already evident, the likelihood of further changes occurring, and the increasing scale of potential climate impacts give urgency to addressing agricultural adaptation more coherently.*
>
> — Mark Howden, 2007

Research on impacts to food systems in the developing world has also been undertaken through agencies like the FAO[7] (Food and Agriculture Organization of the UN).

Agricultural adaptation studies have been undertaken nationally and in parts of Canada. A series of reports generated through the Canadian Climate Impacts and Adaptation Research Network, which closed in 2007, brought producers, stakeholders and academics together to lay groundwork for enhancing agricultural adaptation work in Canada.[8] The national report *Climate Change Impacts & Adaptation: A Canadian Perspective* featured a chapter on agriculture, highlighting the potential impacts of climate change for the sector and initial considerations for adaptation nationally.[9] In 2007, an overview of research specific to adaptation for Canadian agriculture, and the main approaches to adaptation studies, was compiled in the book *Farming in a Changing Climate.*[10] In the Prairie provinces, researchers have used various approaches to evaluate past and current adaptive capacity, in order to promote resilience of the sector in the future.[11] Most recently, a national review of agriculture and climate change adaptation was prepared for the federal government in 2011, outlining challenges, adaptation options and policy & research gaps.[12]

Here in BC, extensive research has been conducted for the Okanagan region, including studies of climate change impacts, vulnerability and adaptive capacity,[13] water management and crop suitability[14] for agriculture (see the Regional variation section in Chapter 5 for more detail). A multi-year and multi-partner project to develop an agriculture water demand model was also developed in the Okanagan Basin.[15] This model is now being transferred to other parts of the province.[*] Some Regions in BC have undertaken studies on climate change projections and impacts, and some community adaptation planning has occurred.[16] However, work that is specific to agriculture in BC is still very limited, which is one of the reasons this study was initiated.

Conceptual framework

Why use a participatory risk-based approach?

Risk management is an approach that is increasingly used to address complex problems that require collective decision-making. Australia and New Zealand are particularly notable for developing risk-based decision-making supports for climate change across a range of sectors.

Risk-based approaches have a number of attributes that make them useful for climate change adaptation decision-making.[17] In particular, information is presented in ways that can be used to make decisions on the ground despite data constraints, limitations on predictability and degrees of uncertainty. Importantly, the approach allows for risks to be prioritized as a basis for defining both short and long term goals and actions. The risk management perspective can be used to communicate how climate change mitigation (reducing greenhouse gas emissions) and adaptation (managing the impacts of climate change) are both necessary to address different levels of risk over time.[18]

For information to be considered "useable" by decision-makers, it must be perceived as credible, relevant to their situation, and legitimate.[19] Both the content of this study and the process used in its development were designed to provide a practical foundation for stakeholders to begin integrating adaptation into decision-making.

Those most knowledgeable "on the ground" (agricultural producers, industry leaders and other specialists) were engaged in review of research design, engagement materials and reports, and were central to developing findings of this report. Climate science is of limited use to the industry until it is combined with applied knowledge. The participatory approach used in this project aimed to bring value to producers and the agriculture industry by providing useful climate information and engaging participants in a meaningful dialogue about its implications.

What is climate change risk assessment?

The basic definition of risk is the likelihood of an event occurring, combined with the severity of expected impacts. There are a variety of perspectives on what constitutes risk. Traditionally, in fields like engineering, risk has been viewed quantitatively; for example, whether an actual load may potentially exceed the manageable load for a piece of infrastructure.

When assessing risk to agricultural systems, a more dynamic and holistic view of risk is required because it involves so many components. In the field of disaster risk reduction, risk is thought of in quantitative terms as well as incorporating other factors such as knowledge, financial and social capacity and political will.

The approach that is used to characterize climate change risk in this study is illustrated in Figure 2.1. The bottom row refers to three factors: hazard, vulnerability, and adaptive capacity. ***Hazard*** refers to qualities of, and changes to, climate and biophysical variables. For example, amounts and timing of precipitation and how this affects snowpack, streamflow, runoff, etc. ***Vulnerability*** refers to the ways that humans come into contact with climate and biophysical variables. This includes exposure (coming into contact with a hazard) and sensitivity (the degree to which a system is impacted by that exposure).[20]

* Copies of the report, which includes a description of the methodology, can be found at www.waterbucket.ca under the "agriculture and water" community of interest

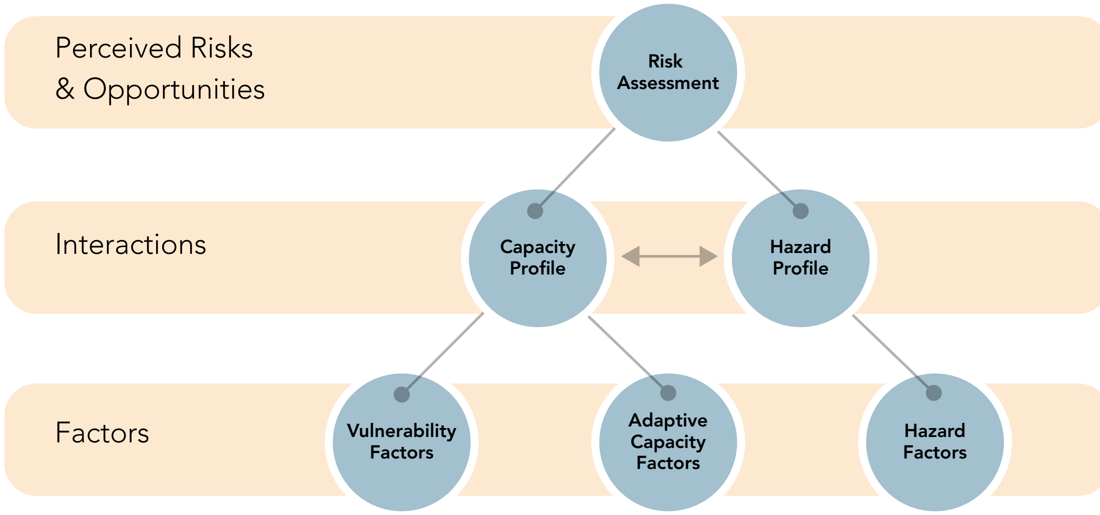


FIGURE 2.1. CONCEPTUAL FRAMEWORK FOR THE BC AGRICULTURE CLIMATE CHANGE RISK & OPPORTUNITY ASSESSMENT

Adaptive capacity is the presence of necessary resources and the ability to mobilize effective responses to climate change (including climatic variability and extremes) in both the immediate- and long-term.* This is not entirely distinct from vulnerability: having greater adaptive capacity reduces the vulnerability of the system. There is always a certain level of vulnerability in the system but we have the ability to make choices to manage climate change risks and enhance our capacity to adapt to a range of possible futures. Adaptive capacity is discussed in more detail in Chapter 4.

Scope of the report

The project scope includes five major agricultural regions and eleven commodity types (see Appendix 1 for details). Although these parameters mean that parts of BC's very diverse sector were not included in the research, this study provides the groundwork and impetus for more inclusive and detailed regional processes in the future. Regions and commodities were selected to strike a balance between representing key commodities in each of the major agricultural regions, as well as the breadth of production systems present across the province as a whole.

* Definition adapted from Stokes and Howden 2010

A key lesson from the interviews and focus groups across the province is that in spite of variations within the sector, there are many similarities with respect to key issues and opportunities. The provincial overview report and the regional/commodity snapshot reports have been designed to serve as a resource for all agricultural regions and commodities.

Methods

An advisory committee comprising experts from academia, the provincial and federal governments and the agriculture industry has guided this assessment from its early stages. Producer perspectives form the core of the study content and underlie the approaches selected. Numerous agricultural associations provided critical communication linkages to producers.

The approach and methodology for this study were developed based on a review of existing literature and resources (both agricultural and climate change adaptation). This was to draw on evolving best knowledge and practices for climate change adaptation assessment, leverage existing local knowledge and assets, and to ensure the relevance of the chosen approach in the BC context. The steps taken to complete of this study are summarized in Figure 2.2. Further details regarding the methods used are included in Appendix 1.

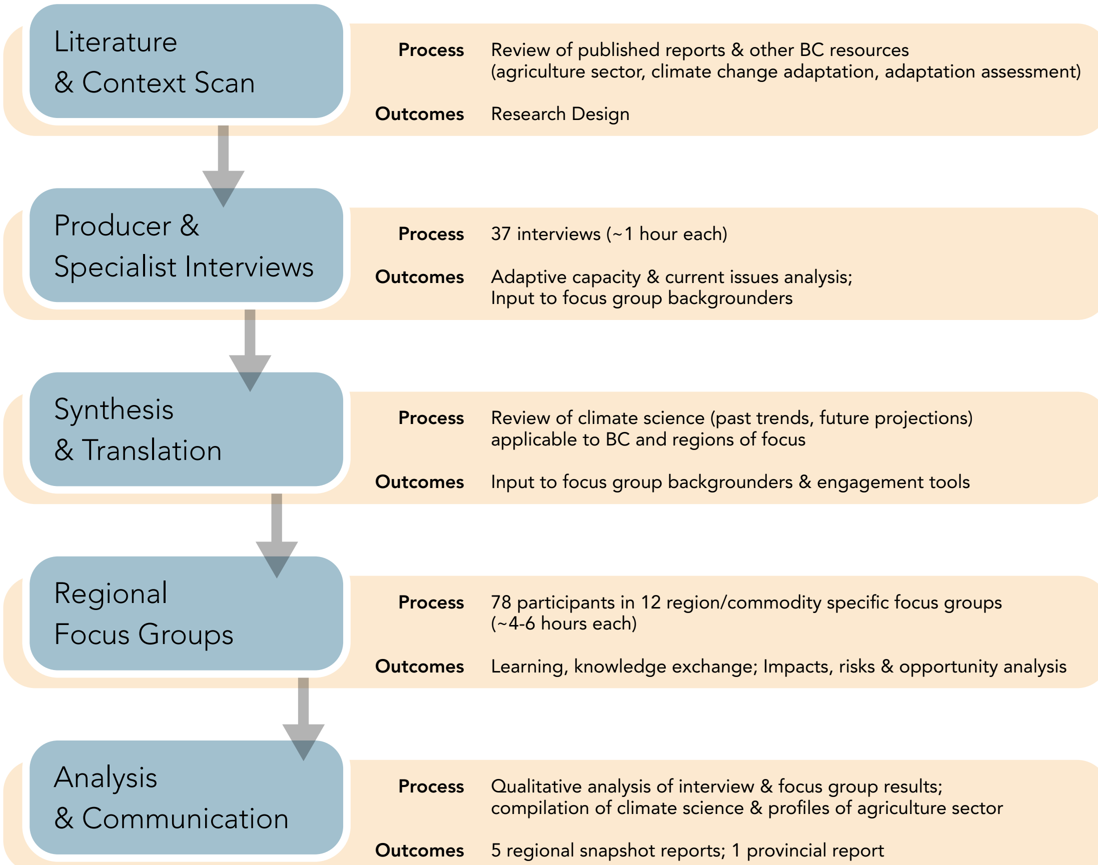


FIGURE 2.2. SUMMARY OF METHODS: PROCESS & OUTCOMES OF EACH STEP

Following the approach used in studies such as Belliveau et al. (2006) in the Okanagan, risk and opportunity in the 2020s climate scenario was evaluated relative to an assessment of *current ability to manage change and variability*. Adaptive capacity will develop in various ways between now and the 2020s, both intentionally and incidentally. This assessment is a baseline that identifies current strengths and weaknesses and key actions that could help to improve resilience to projected climate changes over time.

Thirty-seven interviews were conducted with producers and other specialists across the province. Interviews provided insight into the dimensions of vulnerability and adaptive capacity of agricultural production in the province.[21] Interviewees were asked about:

- Characteristics of agricultural operations in their area
- Recent experiences with weather and other factors determining good/bad years, and ways of managing change, variability and extremes
- Resources available to producers and the industry to manage change and variability
- Characteristics of the industry, especially processes of innovation and change

Interviews were the first step in engaging with producers and other specialists to gather an in-depth first hand perspective on the current ability of producers and the industry to adapt to change, challenging conditions and variability. The

TABLE 2.1. FOCUS GROUP REGIONS AND COMMODITIES

Region	Commodity	Number of Focus Groups
Peace	Grain	1
Interior	Cattle	2
Okanagan	Tree Fruit	1
Okanagan	Wine Grapes	1
Fraser Valley	Dairy	1
Fraser Valley	Poultry	1
Fraser Valley & Delta	Greenhouse	1
Fraser Valley & Delta	Berries	1
Fraser Delta	Field Vegetables	1
Vancouver Island	Mixed Farms	2

information gathered then fed into the development of the focus group design and materials.

"Snapshot" reports were produced for each region and commodity, and distributed to participants prior to each focus group. The documents were designed specifically as discussion tools — to provide climate trend, projection and impacts information in forms that were relevant and engaging for participants as a basis for discussion in the focus group.

Twelve focus groups were held in nine locations around the province (as shown in Table 2.1).

Focus groups began with a brief presentation summarizing the regional scan document and inviting participants into discussion. The presentation was followed by a structured and facilitated discussion with participants that covered the following topics:

- Questions about the climate science
- Potential impacts of the climate scenario for the 2020s for operations and industry; focused primarily on the on-farm implications, but also region and industry-wide implications
- Prioritization of top issues from this discussion
- Rating top issues in a matrix format, in terms of "degree of impact" and "manageability"
- Factors influencing ratings of these two variables, from an on-farm, industry and regional perspective
- Proposed actions and recommendations for industry, government, and others

Results are being communicated directly through this provincial overview report, along with a series of region/commodity snapshot reports. In turn, these results will be distributed and carried forward by a range of actors including the Agriculture & Food Climate Action Initiative and all of the project partners.

CHAPTER 3: Profile of BC Agriculture

To provide background for the risk and opportunity assessment to follow in proceeding chapters, this chapter provides a high level description of the BC agriculture sector and its surrounding context. This profile is further supplemented by Chapter 4, which explores the current overall resilience of the BC sector.

For most BC residents, the issues facing agricultural producers are not common knowledge, in part because of the rapid and massive shift of population away from rural communities and farming life. Table 3.1 below indicates the scope of this change.[22] This trend is not unique to BC, and many other changes have accompanied this transition. Contemporary production systems enable individual farms and farmers to produce much greater quantities of food and consequently the economics of production have shifted. Throughout North America, average farm sizes have increased and the number of farmers has decreased.

However, the BC industry is unusual in many respects and is embedded within a unique context. BC has an unusually limited agricultural land base, an uncommon level of diversity within the sector (with respect to geography and products) and a high proportion of relatively small family farms. These factors influence agriculture's current role in BC communities, economy and society as a whole. They have also strongly influenced the current state of the industry and consequently, the findings of this report.

Agricultural land base, soils & climate

Less than 5% of the province's land base is considered to be arable, although it is estimated that up to 15% has some agricultural potential.[23] The total land in crops in 2006 was just over 585,000 hectares.[24] Overall, BC farm holdings take up approximately 2.8 million hectares with 1.6 million hectares owned by producers, 300,000 hectares leased from other land holders and another 900,000 hectares leased from government.[25] The leased Crown Land is primarily used as range by the province's cattle ranchers. This represents a substantial land-based asset available to the sector.

Reflecting its diverse geology, climate and topography, BC has a broad range of soil types. Through the British Columbia Land Inventory, arable soils have been mapped and classified according to their potential and limitations for agriculture (utilizing a rating system of Class 1 to 7).* Approximately 1% of

* The highest soil classifications are for land with the greatest range of production potential. However, specific sites may suitable for particular types of agriculture but have relatively poor classifications.

TABLE 3.1 BC AGRICULTURE'S CHANGING NUMBERS

Census year	BC's population	Farm population	% of population farming
1891	98,173	22,000	**22%**
2006	4,113,487	60,765	**1.5%**

BC's land base is classified as prime farmland (within classes 1–3). As a point of comparison, Alberta's prime agricultural land is 17% of its land base.[26]

With some exceptions, much of the best farm land exists within close proximity to urban settings. This has placed considerable pressure on the province's agricultural land base and led to the creation of the Agricultural Land Reserve and Agricultural Land Commission in the 1970s. The pressure on agricultural land has also resulted in high agricultural land values (and prices). The average value of BCs farmland varies but is more than twice the Canadian average and considerably higher for farms close to urban areas.[27]

The climate in BC's farming communities varies considerably by geography. This is influenced by latitude, the mountainous terrain and proximity to the Pacific Ocean. The diverse topography means that precipitation varies widely, as do average temperatures, often within very small areas. Nonetheless, a few generalizations can be made about the climate within the agricultural regions incorporated into this study.

The ***Fraser Valley and Metro Vancouver*** have relatively mild temperatures and abundant rainfall, as well as long frost free periods. While annual precipitation in this area is substantial, the majority of rainfall tends to be concentrated in the period between October and March. ***Delta*** has less precipitation on average than communities further east in the Fraser Valley.[28]

Climate conditions vary across ***Vancouver Island*** but are generally mild due to maritime influences. A relatively long season of production is possible for central and south eastern Vancouver Island because of the number of frost free days. Precipitation varies within the growing regions but for much of the Island's productive area, a high proportion of the precipitation falls between October and March, with a relatively dry growing season.

The southern portion of the ***Central Interior***, around Kamloops is considered semi-arid with hot and dry summers and moderately cool winter temperatures. Further north toward Williams Lake, conditions are slightly cooler and there is more annual precipitation. Overall, the Central Interior has been severely impacted by Mountain Pine Beetle infestations and is prone to forest fires.

> *"The relationship between settlement patterns and the need for land suitable to provide for locally grown food resulted in many of our modern centres being built on the best agricultural land in the region.*
>
> — *Planning for Agriculture*, Barry E. Smith 1998

The ***Okanagan Region*** is warm and dry in the summer and cool in the winter with relatively long frost free periods. The Okanagan sits in the rainshadow of the Cascade and Coast Mountains and is classified as semi-arid. On average the precipitation in the region is the lowest in Canada and soil moisture deficits are common. This area has been impacted by Mountain Pine Beetle infestations and is prone to forest fires.

The ***Peace Region*** has a continental climate with long cold winters, short warm summers and moderate annual precipitation. The average annual precipitation in the Peace Region is moderate, and high rates of evapo-transpiration often create water deficits and dry soils in late summer, particularly in lowland areas.[29]

Characteristics of BC agriculture

Farm distribution & products

It is estimated that BC agriculture produces about 200 different commodities and there are approximately 19,800 farms in the province.[30] Although the province's agricultural products are diverse and every region includes a range of farm types, certain production systems tend to be concentrated (in part due to the natural attributes and historical growing conditions) within specific regions. Proximity to markets has also created competitive advantage for some regions.

The vast majority of the BC's grains, oilseeds and forge seeds are produced in the Peace Region. Some grain is also produced in the south east corner of the Kootenays.[31] Most of the province's cattle ranches are located in the southern and central interior, the Peace Region and the Kootenays.[32] The Okanagan producers are growing most of BC's tree fruits and grapes.

The Fraser Valley, Metro Vancouver, and southern Vancouver Island are home to a range of farm types including berry and vegetable operations and various kinds of livestock operations. Almost 70% of the dairy industry is located in the Fraser Valley.[33] Dairy is also an important economic contributor on southeastern Vancouver Island and in the North Okanagan-Shuswap area. The greenhouse industry is predominantly located in the Lower Mainland, as are nursery and mushroom operations. Poultry production is concentrated in Fraser Valley (80%) and about 10% of the industry is located on Vancouver Island.

The number of farms producing organically has been on the rise in BC over the past decade. Between the 2001 and 2006, the number of certified organic operations jumped from 319 to 452.[34] The majority of these farms were producing fruits, field vegetables and greenhouse products. Another 73 farms were in transition (to certification) in 2006 and more than 2,700 operations reported organic production without certification.

It is difficult to tell a single story about characteristics and trends in BC's agricultural production because of the dynamic nature of the industry. Statistics for the number of farms or land in production don't reveal the significant changes happening across commodities and within certain regions. Table 3.2 provides an example of changes that have occurred in horticulture crop in production in BC within a thirty year span (1976 census to 2006 census).

Substantial changes have also occurred in livestock and grain and oilseed production. These shifts away from, or toward, certain commodities are generally driven by profitability (or lack thereof).

Farms & farm operators

Although they range considerably in size, the majority of BC's farms are family businesses (68%) or informal partnerships (27%).[36] Due to the relatively limited agricultural land base, the types of agricultural production and high land values, BC has always had a high proportion of small farms. In 2006, almost 65% of BC's farms were less than 70 acres (27% were less than 10 acres).[37] In recent years there has been an increase in the smallest farms, as well as the largest, with the number of mid-sized farms in decline.

The overall demographic trends for Canadian farm operators show an aging population without sufficient new entrants into the industry to replace them. BC's trends are the most pronounced in the country with 45% (13,540) of farm operators 55 or over and only 6% (1,770) under 35.[38] These demographic shifts reveal the challenges with farm succession in the province, as well as costs associated with entering the industry in BC.

Farm revenues

The primary agriculture and food processing sectors in British Columbia generated $9.6 billion in 2010 with farm cash receipts for primary agriculture estimated at $2.4 billion.[39] The overall proportion of primary agriculture's contribution to the provincial GDP has been declining over the past decade from 0.83% in 2001 to 0.59% of the provincial GDP in 2010.[40] In recent years, net farm income in BC has consistently been negative, in part due to costs of production outstripping farm revenues.[41]

Table 3.2 Select Horticulture Crop Production Hectares in British Columbia[35]

Year	Potatoes	(All) Field Vegetables	Greenhouse Vegetables (square m)	Strawberries	Blueberries	Tree Fruit	Grapes
1976	4,374	7,464	No data	No data	No data	11,715	No data
1991	3,369	8,275	628,137	918	1,139	10,735	1,877
2006	3,439	6,957	2,523,522	439	1,638	7,057	4,775
Shift	**–21.4%**	**–6.8%**	**+301.7%**	**–52.2%**	**+43.8%**	**–38.9%**	**+154.4%**

Note: During this time, sweet cherry production increased substantially.
Major reductions in production of apples and pears occurred during the same period.

Commodities generating the largest revenues in 2010 included dairy, poultry, floriculture and greenhouse vegetable and beef. In 2006, 10.2% of the province's farms generated about 80% of the provincial gross farm receipts.[42] During the census periods of 1981 to 2006, an average of 64%-68% of BC's farms had gross farm receipts under $25,000. The national average for farms in this category ranged from 37%–51%.[43] While this partly reflects the broader trend of reliance on off-farm income,[*] for a range of reasons the average farm gross receipts in BC are consistently lower than the national average.[44]

Farm businesses in BC rely on sales through both export and domestic markets for their revenues. By far the largest export market for BC agri-food products is the United States, with a smaller proportion of exports going to Japan, China, Hong Kong and Korea.[45]

Government & BC agriculture

Agriculture is an industry that is influenced by, and interacts with, all levels of government. The policy, regulatory and programmatic environment in which agriculture is embedded is very complex and multiple levels of government are involved in many key areas. This complexity is highlighted in Appendix 2, which lists many of the government agencies and summarizes their roles in relation to agriculture. More detail surrounding some of these relationships will be highlighted in the chapters to follow.

There are dozens of policies, regulations and programs that affect the management decisions and day to day activities of farmers. Various aspects of agricultural production, marketing, processing, food safety and management of wildlife, range and environment are just a few of the areas touched by government regulations. Numerous federal, provincial and local government bodies are involved in oversight of the regulations. Responsibility for some regulatory areas (like food safety and environment) cuts across multiple government agencies. In addition to developing and overseeing regulation, the role of the federal and provincial governments also includes provision of various services and supports to the agriculture sector.

A unique element of the government and agriculture interface in British Columbia is the presence of the Agricultural Land Reserve (ALR) which shapes many of the policies and regulations surrounding the agricultural land base in BC. The Reserve is a land use zone encompassing 4.7 million hectares of private and public land defined as an area in which agriculture is a priority use (and non-agricultural uses are controlled).[**] The Agricultural Land Commission (ALC) is tasked with administering the Agricultural Land Reserve and with encouraging and enabling BC's farm businesses.

Local and regional governments also play a role in administering regulations and policies that impact farm businesses. Regional and local planning, bylaws, zoning and infrastructure management all factor into how farms businesses operate. In addition to Official Community Plans, many local/regional governments now have Agriculture Area Plans and some have Agriculture Advisory Committees to provide input on issues relevant to the sector.[***]

* In 2005, 48.4% of Canadian farm operators had an off farm job or business. In BC, 54.9% of farm operators had an off farm job or business.

** The Farm Practices Protection (Right to Farm) Act complements the ALR (which protects agricultural land) with the intent to similarly protect normal farm practices. The law came into effect in 1995 and is intended to protect farmers conducting "normal" farm practices from nuisance lawsuits/bylaws.

*** A list of local and regional Agriculture Area Plans, as well as links to the documents, can be found at: http://www.agf.gov.bc.ca/resmgmt/sf/aap/Status_of_Ag_Area_Plans_and_Strategies_19_Sept_2011.pdf

CHAPTER 4: Current Resilience & Adaptive Capacity

ADAPTING TO CHANGING & CHALLENGING CONDITIONS of all kinds is a constant element of agricultural practice, and producers have long been in the business of maximizing their resources to adjust to variability. This variability can occur in a range of areas including weather, markets, input prices and regulations. To effectively manage their operations farmers continually learn, change and adjust their approaches, as well as collaborate with a broad range of partners.

Adaptive capacity describes the ***presence of necessary resources*** and the ***ability to mobilize those resources*** to effectively respond to various challenging conditions in both the immediate and long-term. Resources may be at the farm or sector level, or a result of the broader social, biophysical, economic, or institutional context. In addition, the ability to re-organize and capacity for ongoing learning are critical to developing effective responses to climate change.[46] In part because future climate conditions may be unexpected or unprecedented, managing the effects of climate change requires, above all, flexibility to address a range of potential impacts and to change course as required.[*]

Figure 4.1 outlines many elements that factor into the agriculture sector's ability to adapt. These elements are expressed as five interrelated types of resources: financial, physical, human & social, knowledge and policy & regulatory.

Evaluating the approaches, resources and tools *currently* utilized by producers to manage through challenging or changing conditions, is a first step in exploring the resilience of the industry. For this reason, the interviews conducted with producers and other specialists focused on evaluating existing resources and tools employed to manage through variability or difficult conditions, as well as current barriers or challenges to adapting and overall resilience.

Some studies evaluate adaptive capacity through quantitative data. Various indicators can be used to measure the industry's capacity in certain areas.[**] This study does not employ a quantitative approach, in part because the BC sector's diversity does not lend itself well to this type of analysis. In addition, many elements of adaptive capacity cannot be meaningfully expressed in quantitative terms.

The analysis that follows highlights challenges, strengths and differences in a way that can only be done by speaking directly with producers and other specialists on the ground. The majority of the data that informs the analysis was drawn from the interviews with producers and other sector specialists; additional data was collected throughout the focus group sessions. The analysis is divided into the five categories of adaptive capacity identified in Figure 4.1, but with a focus the on specific issues and themes that emerged through the research.

* This framework for adaptive capacity was developed based on interviews with producers in BC, together with approaches presented in Belliveau et al. 2006; Smit & Wandel 2006; Reid et al. 2007; Yohe & Tol 2002; Smit & Pilifosova 2003; Stokes and Howden 2010

** An strong example of this type of analysis may be found in: The Prairie Climate Resilience Project: Indicators of Adaptive Capacity to Climate Change for Agriculture in the Prairie Region of Canada. http://www.iisd.org/pdf/2007/climate_adaptive_cap.pdf

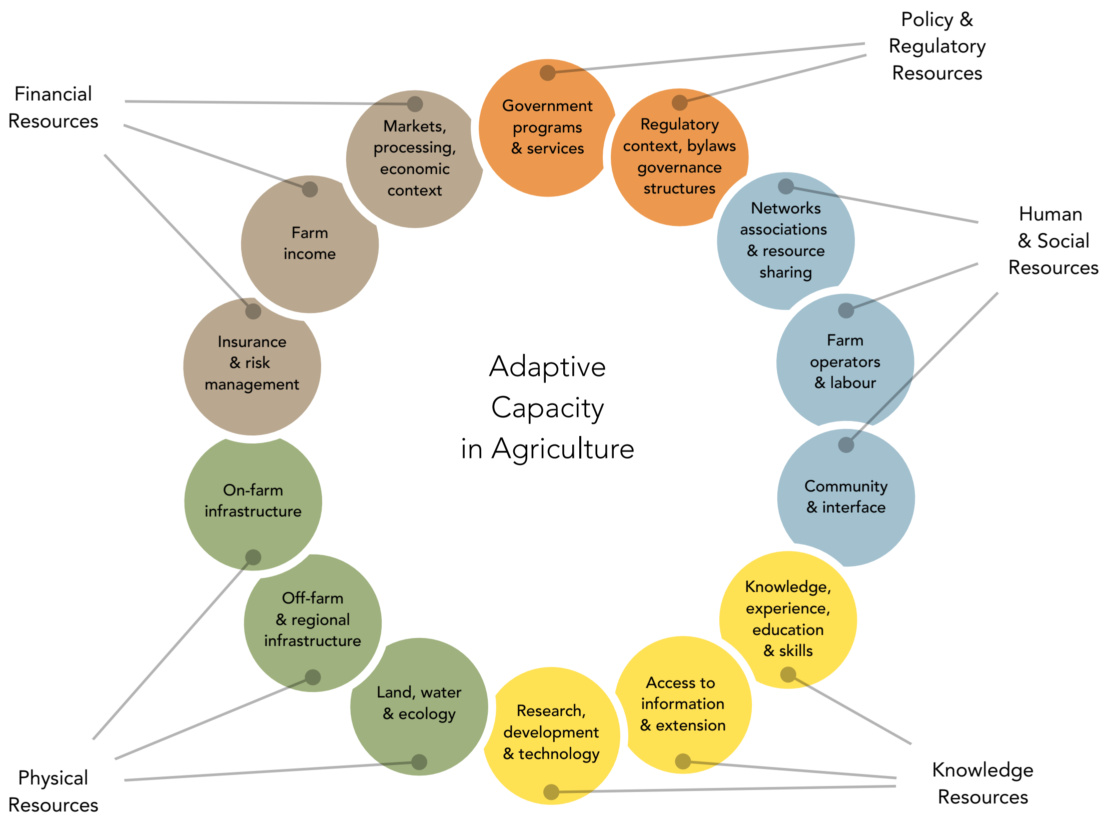


FIGURE 4.1. ADAPTIVE CAPACITY IN BC AGRICULTURE

Financial resources

The ability of the industry to cope with challenging and changing conditions is strongly influenced by the availability of sufficient and stable financial resources. The economic circumstances across the sector, and from one operation to another, vary considerably. Therefore, the financial resources available to support adaptation are similarly variable.

Farm income & income stability

Farm businesses struggling with marginal economic circumstances are not likely to prioritize investment in new approaches or technologies. The statistics (shown in Chapter 3) for gross farm receipts reflect a disproportionate number of operations with low farm revenues.

In addition to overall farm income, stability of this income also affects the ability to adapt. At present, the most stable operations in BC are predominantly those within the supply managed system (e.g., dairy, poultry and eggs). Operations with relatively stable income are in a stronger position to consider investments with longer payback periods and to test new approaches or technologies. Parts of the industry with stable income are also more able to undertake collective investment in industry development.

Periodic economic setbacks, such as extreme weather, can also compound and make upgrading, innovating and reinvesting difficult. Rising and fluctuating input costs are a common challenge for BC producers that destabilize net income. As well, the extent of exposure to global markets and variable or depressed commodity prices is a major contributor to unstable farm revenues. Other factors that impact overall farm incomes and their stability include the presence of off-farm income, the business model employed and the overall scope of the operation.

In order to increase farm revenues and to manage through a range of adverse conditions, farmers may adjust their business models in a number of ways. However, to implement these approaches generally involves some level of risk, at least initially, and the financial capacity, knowledge and skills to shift to a new business model, product and production system, and/or market.

Diversification of products, markets and income streams is a means for maintaining profitability when prices and markets fluctuate, as well as providing a buffer through challenging weather conditions. The BC sector is unusually diverse, both across the sector and within individual operations. A range of diversification approaches are employed including:

- Diversification of agricultural products
- Diversification of compatible on-farm income streams
- Diversification of markets and marketing approaches
- Augmentation of income with off-farm sources

While some agricultural businesses have opted for diversification, others have consolidated; accomplished by expanding their businesses through buying land, quota or production (often from those leaving the industry). Consolidation trends are notable within grain and dairy production systems as a means for increasing economies of scale and improving profitability. Like diversification, consolidation requires investment and the ability to take on business expansion.

Whether to manage through an immediate set of challenging conditions or to increase resilience over the longer term, producers sometimes opt to trim their production costs. In a particularly bad year, this may mean reducing inputs and costs to the greatest extent possible to minimize losses. While this approach does enable survival of businesses under financial stress, it is not a strategy that enhances flexibility or resilience over the longer term.

> *"If you can't afford to make changes, you don't do it. [You] work on those other objectives (like the environment) when you can afford to do it… A base level of economic wellbeing is needed.*
>
> — cherry producer, Kelowna

> *"In BC, the forage insurance program is yield-based, meaning that insurance takes average production and starts to kick in once production drops… But after several dry/drought years in a row, your average yield drops. So if consecutive years are bad as well, you can only get reduced coverage because [compensation is] based on average production over the past few years.*
>
> — cattle producer, Vanderhoof

Income stabilization, insurance & compensation supports

To manage through uncertain, changing or difficult conditions, some producers choose to participate in government Business Risk Management programs. A significant portion of the provincial and federal government funding available to assist BC's agricultural producers is earmarked as part of the Business Risk Management (BRM) portfolio.[47] BRM incorporates a number of funding and financial support programs intended to assist agriculture by stabilizing farm incomes or providing compensation when losses occur. A brief description of each of these programs is provided in Appendix 3.

The extent to which producers are able to participate in the programs varies and, ultimately, direct income stabilization programs do not replace self-sufficiency and stable profit margins. However, at present they are a substantial component of managing variability. In the 2010/2011 year, the Province's Business Risk Management Programs paid out $80 million "to producers whose businesses were affected by risks that were clearly beyond their control."[48]

While many producers view production insurance and additional emergency compensation (through Agri-Recovery) as providing important protection from losses, there is concern that the formulaic approaches utilized for compensation do not take into account the range of farm types in BC or the losses being experienced. When producers experience significant losses due to weather related events, the responsiveness and timing of compensation is critical. For repeated losses, due to either gradual changes or extreme conditions, compensation based on average yields may not be sufficiently flexible to respond to what is occurring on the ground. Compensation based on income margins can be similarly problematic in some circumstances.

> *"Also facing our industry is the age of our people… They're an aging population [and] they're almost to retirement… they're not really willing to change their methodologies so I think… if they're economically viable operations there will be young people moving in to take over, but it has to make sense. And the younger [producers], I think they're more willing to adapt to the changes or to try new things….*
>
> — grain producer, Peace Region

Human & social resources

The primary asset for enhancing the resilience of agriculture is farmers themselves. BC has thousands of knowledgeable producers with many years of experience. The province also has an unusual number of active and engaged industry organizations that provide a range of important services to producers. However, the current human and social capacity of the sector is being stretched and this is impacting overall ability to manage in difficult and changing conditions.

Farm operators

The challenges surrounding succession and the aging farm operator population were noted in Chapter 3. When difficult conditions arise that require new approaches and investments, producers contemplating retirement are more likely to maintain the status quo or to consider exiting the industry (which may be the more cost-effective option). Producers within a number of commodities raised the concern that the aging demographics of the sector are impacting its resilience, because younger producers (with a longer planning horizon) are more likely to adapt to change and adopt new technologies and practices. Those portions of the industry that are most profitable and financially stable are encountering less difficulty with this issue.

In addition to running their businesses, some agricultural producers participate regularly in consultations, planning processes and meetings. These individuals add critical value and adaptive capacity to their industry by keeping their associations strong and representing the sector in a range of contexts. These additional responsibilities take the time and energy of producers and take them away from their businesses. Yet the importance of the participation of farmers in government and community planning and consultation processes grows as the number of people with agricultural expertise and experience shrinks.

Securing farm labour has been a substantial challenge in some parts of the sector in recent years. The cost of labour for BC producers is higher than in many competitor jurisdictions. Yet securing local labour has become difficult in most regions of the province. Some farmers that require a large seasonal labour force participate in programs that provide temporary agricultural workers from jurisdictions outside of BC. Other producers have sought ways to minimize labour brought onto the farm. In either case, there is limited flexibility for producers with regards to farm labour and these constraints mean that producers are required to invest additional effort and time into securing labour.

Networks & organizations

Producers use informal networks and word of mouth to share information about daily issues, challenges and new approaches. These informal networks are particularly important for producers with smaller scale or more remote operations who may not participate in industry organizations.

Many producers receive a substantial quantity of information, as well as access to various services and resources, through industry organizations. The province has an astounding number and variety of industry organizations, which are a tremendous source of knowledge, skills and information. Some are commodity-based, some regulate marketing and distribution (marketing boards) and some support farmers within a particular geographic area (farmers' institutes) or production system (organics).

Some industry organizations also serve as the main interface between the sector, governments and the public. Industry organizations contribute greatly to the overall capacity of individual producers by addressing issues of collective importance to the sector. Industry organizations conduct research, share information and work with other partners to address immediate issues or to improve the circumstances of the industry as a whole.

As government has stepped away from providing certain supports to producers, the pressure on industry organizations to fill these gaps is growing and the resources of these organizations are being stretched. Many industry organizations have very limited staff resources and necessarily involve producers themselves to direct and maintain their operations. This is particularly true for smaller organizations. Those without sufficient funding and staff are unable to provide all of the necessary supports for producers. In addition, organizations with stretched resources are often required to focus on the most immediate and pressing concerns, rather than investing in projects to build longer term resilience.

Knowledge resources

At the root of all adaptive decision-making is knowledge and information. The knowledge and direct experience of BC's producers is a critical resource. At the same time, when producers encounter new or challenging circumstances, or wish to bolster their decision-making, they seek out information through a range of sources.

Information & extension

Web-based resources are increasingly drawn upon by producers for all types of information. Recently developed tools like the irrigation calculator* can be easily accessed and utilized on-line. However, for geographic or commodity specific information, most producers continue to utilize more traditional options, including educational workshops, field days, conferences or direct consultation with experts. Producers also share information with each other or seek it out through suppliers (of equipment, seeds, inputs etc). Where local information is not available, producers may seek out information from comparable jurisdictions. Cross-provincial and cross-border information sharing takes place within some commodities such as grain and berries.

> *"The education piece and extension is paramount and it doesn't have to be specific to climate… Maybe it's survival of the fittest but from a public standpoint we used to have a really strong extension program — engineering, soil management, nutrition — there was so much more available and some industries have been able to do that [for themselves] but many have not. The bottom half has slipped — the top half can maintain [itself], but we're losing lots of ground.*
>
> — industry specialist, Fraiser Valley

As the BC Ministry of Agriculture's role in extension has been reduced, many producers now pay for private consultants or rely on their associations to provide extension. For producers with limited financial resources or in more remote locations, access to extension is increasingly difficult. Parts of the industry with new entrants also have more pronounced extension gaps because producers starting out often lack the knowledge, experience and resources.

Research

Producers draw from research generated through a number of sources including government, industry organizations and the private sector (including equipment, seed, breeding and chemical companies). Industry organizations conduct a broad range of applied research, but with limited financial resources more pressing issues may take precedence over research. As a result, there are gaps emerging in locally relevant agricultural research and industry

* http://www.irrigationbc.com/

"[The] research that is done on a local basis for us… is a tool for us to use in the future to either pick or eliminate some of the crops which we can grow up here — but that research needs to be done now because you constantly have to look forward and you need to get enough years of research behind some of those varieties to draw conclusions.

— grain producer, Fort St John

organizations are challenged to fill these gaps. Innovative producers will also undertake trials or test approaches within their own operation to gain direct experience and immediate results.

Increasingly, producer organizations are also becoming engaged in collaborative research projects with various partners across government or within research centres. Often these collaborations can help to address more complex issues or to develop projects with longer timeframes. Recent examples of this type of collaborative research include the water supply and demand project undertaken in the Okanagan.*

The most common concerns regarding gaps in research, relate to emerging problems or issues — for example, the monitoring and management of unfamiliar pests or diseases, or the development of variety trials for crops better suited to changing conditions. In other cases, producers noted that although information is being collected, it is not available in a form that is accessible. This problem was raised regarding weather and climate information which in some cases is not available in a format for producers to use in planning and management.

Physical resources

The nature and condition of on-farm and surrounding physical resources plays an important role in the ability of producers to adapt to difficult conditions. This is particularly true with respect to variability and extremes in weather, which can challenge the existing infrastructure and available physical resources.

On-farm infrastructure: equipment, technology & farm practices

The condition and efficacy of on-farm physical resources is important for farm resilience and producers are continually investing in, improving and adjusting their equipment, technology and practices. Producers are able to provide dozens of examples of those types of changes.

In many cases, investing in certain technology or practices can help to reduce damage and losses associated with weather conditions including extreme heat, frost, wind, erosion and excessive moisture. In other cases, the technologies and practices adopted may also increase efficiency and reduce costs. Box A provides a number of examples of practices producers utilize to help manage through variable or challenging conditions.

Box A: Practices and technologies for manageing challenging conditions

- Water efficient irrigation technology and practices (drip & dual systems, water metering, soil management, cover crops, etc)
- Water storage
- Conservation tillage
- Wind machines (frost damage protection)
- Site selection & engineering
- Drainage management
- Variety trials & selection
- Conventional, IPM and organic pest and disease control measures

The extent to which producers are flexible with regards to investing in new technologies and practices is defined largely by other factors including: current knowledge, availability of information and financial resources and the willingness to alter current approaches. Many producers mentioned the value

* For more information, see http://www.obwb.ca/wsd/

of the cost-share incentives to support investment. The Environmental Farm Plan and Beneficial Management Practices Programs are currently the primary source of incentives for producers to invest in planning or changes to equipment, technology and infrastructure.[49] These programs provide both planning support and cost-sharing for a range of investments that increase resilience (e.g., efficient irrigation, riparian area restoration, conservation tillage equipment).

Local & regional infrastructure

Much of the physical infrastructure that farm businesses depend on is located beyond the boundaries of the farm. Regional and local infrastructure plays a central role in the ability of producers to manage through challenging and variable conditions. Some of the most important elements of this off-farm infrastructure relate to water management.

The pressures on water supply are widely acknowledged in British Columbia and, in part, have led to the current process to revise the province's Water Act.[50] Access to sufficient water is one of the greatest concerns of producers in a number of regions of the province, particularly in areas where supply is already stretched. While producers are improving irrigation efficiencies and some have developed on-farm storage, broader water availability, infrastructure and accessibility have a substantial impact on the ability to maintain productivity in adverse conditions and on the range of options available in the future.

How local and regional governments manage infrastructure also influences the degree to which producers are willing to invest in improving their own operations. For example, if the broader drainage infrastructure is not sufficiently managed, this impacts the functionality of on-farm systems and creates a disincentive for producers to invest in drainage improvements.

Patterns of land use and management have a significant bearing on agriculture's adaptive capacity. Changes that are made to the land base have both immediate and long-term impacts on agricultural production. In many parts of the province, the agricultural land base has been impacted by surrounding urban and residential development which alters hydrology, resource management patterns and the ecological systems upon which farms depend. Producers note that industrial activities like forestry and oil and gas are also affecting agricultural production systems by altering the landscape, hydrology, spreading weeds (onto farmland) and even altering micro-climates.

Policy & regulatory resources

The policy and regulatory framework shapes the interface between government and the agriculture sector. As was noted in Chapter 3, agriculture is embedded in a complex regulatory context including numerous government agencies. Each of the agencies has its own mandate which drives the policy and regulation that emerges. This can create a challenging and fragmented environment for producers managing through difficult or variable conditions. Producers pointed to two specific contexts in which regulations were not enhancing sector resilience.

The first context was the introduction of new regulations that reduced flexibility or decreased opportunities for agricultural producers. This is generally an unintended consequence of regulations that were meant to address another issue or problem. One producer described this approach as the "one size fits all approach" which does not sufficiently consider the range of potential implications across the sector.

Two examples provided were the Meat Inspection Regulation and the carbon tax. As an unintended consequence, the Meat Inspection Regulation is seen to have effectively reduced the ability of small scale livestock producers to sell their products in local markets, thus limiting flexibility with respect to markets and income streams (particularly for producers in more remote locations). The carbon tax, again as an unintended consequence, is perceived to have created a competitiveness disadvantage for producers by increasing their input costs without any associated benefits. Particularly for producers operating with thin margins in highly competitive markets, this was perceived to be a policy/regulation that impacts overall resilience.

The second challenge identified is policy and regulatory frameworks that constrain producers with respect to their management options, which in turn reduces their ability to respond to changing or difficult conditions. In this case, regulations are developed with particular objectives in mind but are experienced as rigid and limiting on the ground. Areas of particular concern were: drainage and ditch management, wildlife management and range access and management. In all cases, producers noted that these were areas where cross-agency and cross-jurisdictional cooperation is required, and where more flexible approaches that acknowledge management complexity would facilitate more resilient agricultural systems.

Summary

While parts of the BC agriculture industry have relatively strong and stable financial resources, the relatively low (average) farm revenues and negative net farm income across large portions of the sector is a limiting factor in the overall ability to manage through challenging conditions. While various strategies are employed by producers to improve their financial circumstances, these require access to resources that some producers may not have. Additionally, in some cases a strategy may be employed because it appears to be the only option available, rather than because it is the optimal approach for enhancing resilience.

Similarly, while government Business Risk Management programs are serving as a financial resource for some producers, supporting resilience requires a flexible system of financial supports that strikes a balance between bolstering industry self-sufficiency while ensuring efficient and effective compensation for losses. A more resilient agriculture sector begins with improved economic viability that also maximizes flexibility in a range of future conditions.

The overall demographics of BC's producers impact the planning horizons and options considered when managing through difficult conditions. Farmers nearing retirement are less likely to consider investing in new approaches or technologies. However, producers with clear succession plans are much more likely to contemplate the longer term resilience of their operation. A longer term orientation enables producers to consider the full range of potential approaches; even those that may take time to bear positive results.

> *"[Flooding] is not really an issue here — you can have an excess of rain [but] the intensity of the rain seems to be changing — up to four inches of rain in a day. A recent slide on the mountain took out one of the former dairy properties nearby. Logging activity is a real issue on the mountain and impacts on water supply — we have gravity water supply and this can be impacted by logging and major rain events.*
>
> — dairy farmer, Port Alberni Valley

Industry organizations are the primary means by which producers generate collective responses and develop collective solutions to challenges they are facing. At present the demands on these organizations are growing and they are increasingly stretched to meet the needs of the sector. The limited financial and human resources of industry organizations can lead to an "emergency response" orientation where immediate problems are addressed but longer term planning or investments are necessarily set aside. Much of the funding upon which industry organizations rely, is project-oriented and short term. This further limits the capacity of these organizations to develop strategies that support resilience.

At the farm level, a whole range of resources factor into the investment in adaptive practices, equipment and technologies. Once again, the financial circumstances of the producer impacts their flexibility to make changes or invest in new approaches, but the availability of informational and planning tools to guide producers in their decision-making is also important.

How local and regional physical resources are managed, including land, water and infrastructure, can have a substantial impact on the capacity of producers to adapt to adverse conditions, particularly in relation to variable and extreme weather. Decisions made beyond the farm can impact the availability and accessibility of water (fundamental for agricultural production) and can alter landscapes and hydrology in ways that create additional management challenges for producers. Evaluating infrastructure-related decisions with a lens of agricultural adaptive capacity would help to ensure that the physical infrastructure is supportive of a more resilient sector.

Finally, the policy and regulatory frameworks that producers exist within, impacts their ability to adapt and in some cases can have the unintended consequence of reducing sector resilience. Each government agency has a distinct set of priorities and a unique mandate. Producers note that an overarching policy commitment to supporting agricultural resilience would assist these agencies to evaluate the full range of potential outcomes and to avoid unintended consequences. Stronger coordination across government levels and departments and amongst existing policies and regulations would also create a more supportive policy and regulatory environment for the sector.

CHAPTER 5: The Climate Science

As noted in the previous chapter, managing through uncertainty and challenging weather is a common element of farming life and producers are constantly balancing this with the many other variables that influence their decision-making. Despite uncertainty about markets, weather and other factors, producers use their knowledge and experience to plan and to make effective decisions every day. Climate change science is another type of information that producers can incorporate into their decision-making to make more informed choices.

This study has used climate scenarios for the 2020s as a reference point to focus the assessment; however, this is just one period along a longer-term path of change. Conditions will continue to change in the proceeding decades, and decision-making will have to incorporate evolving information and conditions.

This chapter begins with a general introduction to climate change science. This is followed by an overview of observed trends and projected changes in the climate for BC as a whole, and variations by region. A glossary of terms is included in Appendix 4.

Weather, variability & climate change

If there's one thing farmers know, it's the weather. Weather is what happens on a particular day at a particular location. Farmers are continually required to adapt to weather conditions to effectively plan and manage their businesses.

In contrast, climate refers to long-term trends, patterns and averages over time. These are more difficult to observe through day-to-day or year-to-year experiences or records of weather. However, over a period of decades, recorded observations can be used to characterize the climate and identify changes.

Anyone who pays close attention to weather forecasts appreciates that predictions of weather are often limited in their accuracy. This is partly because of the many factors that impact climate systems (which in turn influence the weather we experience). In BC, we are familiar with the phenomena of El Niño and La Niña ("ENSO"), which dramatically impacts the average weather that we experience as it shifts back and forth every three to seven years (see Figure 5.1). Compared to La Niña years, conditions in BC during El Niño years are typically warmer and drier in winter and spring, and less stormy in southern BC.

Adding to the complexity, the Pacific Decadal Oscillation (PDO) is a known pattern that shifts over longer time periods (20 to 30 years) and this impacts temperature and precipitation conditions here in BC. It also has a warm and cool phase, and so it can either enhance or dampen the impacts of El Niño and La Niña conditions in a given year (see Table 5.1). BC may have shifted to a cool PDO phase around 1998.[51]

Figure 5.2 shows the difference between climate variability, oscillations, and climate change. The many factors that impact the weather create significant variation in what we experience from year to year. However, we are still able to chart averages over long periods of time. It is the patterns over these long periods that point to a changing climate. This means that as the average temperature increases in the future, variation above and below that average will still occur but the highs and lows will occur around a new mid-point.

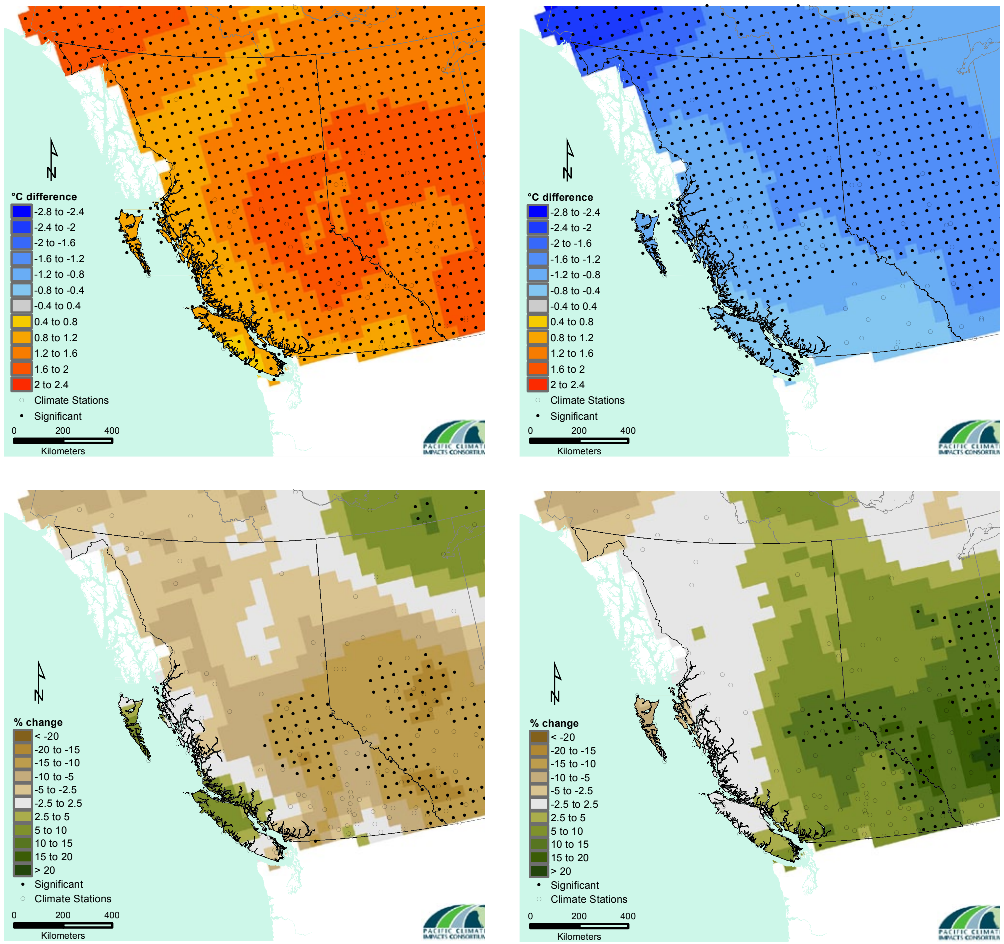


FIGURE 5.1. ENSO PATTERNS IN BC

The top two maps depict temperature differences (1900–2004) from the average during El Niño years (left) and La Niña years (right). The two bottom maps depict precipitation variations from average (again with El Niño at left, La Niña at right). Source: Pacific Climate Impacts Consortium, www.pacificclimate.org | Data source: Environment Canada CANGRID dataset

TABLE 5.1 MAIN CLIMATE VARIABILITY & OSCILLATION DYNAMICS FOR BC[52]

	Warm Phase	Cool Phase	Length of cycle
ENSO	▪ "El Niño" ▪ Warmer winter and spring	▪ "La Niña" ▪ Cooler and wetter than average in winter and spring ▪ Stormier in southern BC	3–7 years
PDO	▪ "Positive phase" ▪ Warmer winter and spring ▪ Wetter spring	▪ "Negative phase" ▪ Cooler winter and spring ▪ Drier spring	20–30 years
Interactions between ENSO and PDO[53]	▪ Both in warm phase → Strength and predictability of El Niño events increases → Potential for increased extreme weather	▪ Both in cool phase: → Strength and predictability of La Niña events increases — wetter conditions enhanced → Potential for increased extreme weather	In alternate phases: → Tendency to partially cancel out temperature and precipitation anomalies

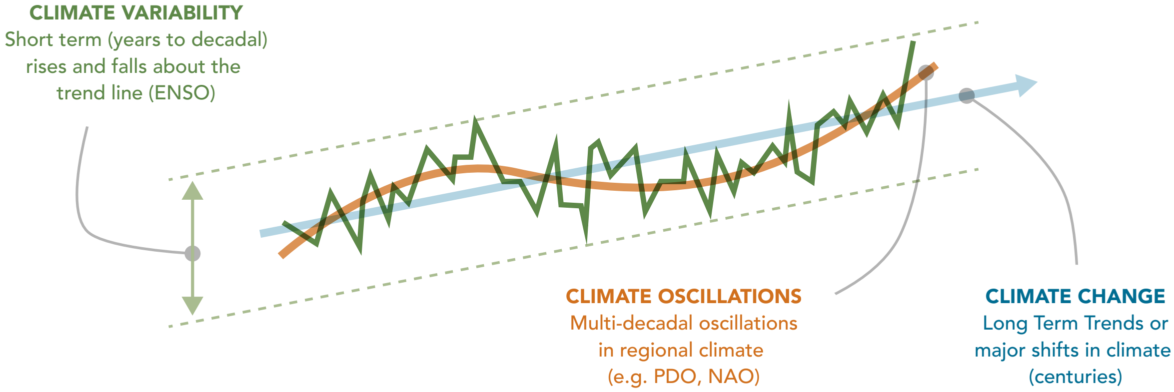


FIGURE 5.2. CLIMATE VARIABILITY, OSCILLATIONS & CHANGE

Diagram showing difference between climate variability, oscillations, and climate change. Adapted from original, courtesy of Pacific Climate Impacts Consortium, www.pacificclimate.org

The climate science

Scientists have been steadily improving the understanding of climate changes that occurred in the distant past, as well as what has happened since we began to keep written records. Based on extensive research, the past climate of BC is quite well understood. Coming out of the last ice age around 12,500 years ago, conditions were much colder and drier than they are now. This was followed by a period of rapid warming, leading to a subsequent period from around 10,000 to 7,400 years ago, that was 2°C to 3°C warmer than now. Around 4,400 years ago, the climate in BC began a period that was roughly the same as what we have experienced in the recent past.[54] As knowledge of prehistoric climate has grown, so has our understanding of more recent past trends and potential future conditions.

Since the early Intergovernmental Panel on Climate Change* reports, climate models have developed to be able to include more and more specific processes — this means that current models can approximate the actual climate system more closely than just a few years ago. A range of factors that influence climate can now be incorporated, such as: volcanic activity,

* The Intergovernmental Panel on Climate Change is an independent body that produces climate science assessment reports every five or six years. Hundreds of scientists around the world take part in preparing and reviewing these reports. The most recent IPCC report was released in 2007, and is available at http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1

BC climate science: key resources

The following are some key sources for regional climate information in BC:

- Pacific Climate Impacts Consortium
  www.pacificclimate.org
  - → Publications library
  - → Plan 2 Adapt tool
  - → Regional Analysis Tool
  - → Climate Overview 2007: Hydro-Climatology and Future Climate Impacts in British Columbia (updated 2009)
- From Impacts to Adaptation: Canada in a Changing Climate. (2007) Chapter 8: British Columbia
  http://www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/assessments/132
- Okanagan Water Demand Model
  http://www.waterbucket.ca/aw/?sid=44&id=195&type=single

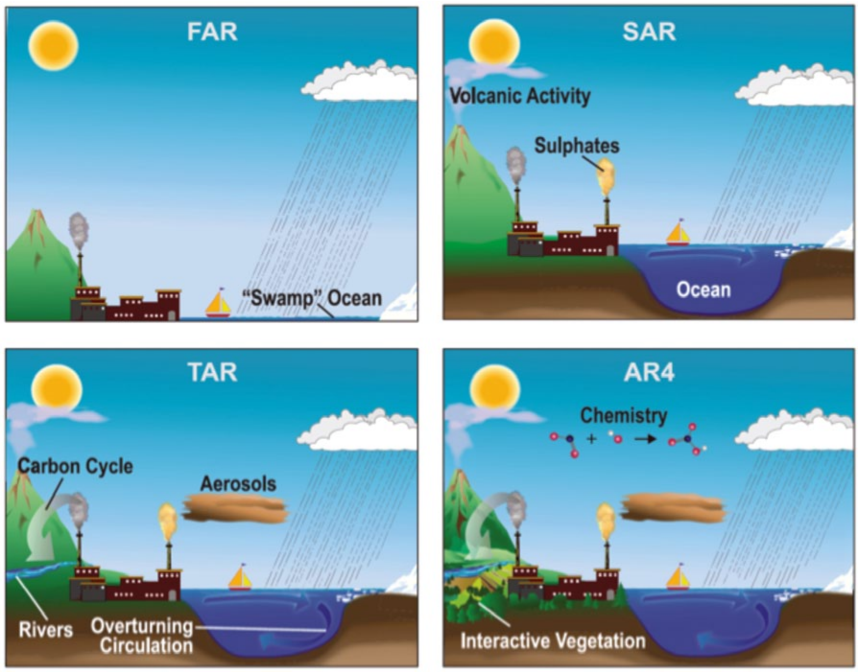


FIGURE 5.3 INCREASING COMPLEXITY REPRESENTED IN GLOBAL CLIMATE MODELS OVER TIME

(FAR = first assessment report; SAR = second assessment report; TAR = third assessment report; AR4 = fourth assessment report). Source: Solomon, S. et al. (Editors), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge United Kingdom and New York, NY, USA. [originally Figure 1.2]

hydrological systems, carbon cycles and interactive vegetation. Figure 5.3 shows how current global climate models capture much more of the complexity of the global climate system than earlier versions.

At the same time, methods for ***downscaling*** global climate models have greatly increased the ability to project future conditions at a regional scale, better reflecting local variations in climate.

For BC in particular, a great deal of work has been focused on developing reliable climate information to describe past trends and to understand what the future might hold in the various regions of the province. The amount of work done in BC to scale climate information down to the provincial and regional level is exceptional, as many places continue to rely on general data for the national or continental level as a whole. Any assessment of climate change impacts in BC does require a regional scope, in part because of how much the varied geography and topography influence weather and climate conditions in different regions of the province.

Climate change in BC: past trends, future projections

According to thousands of climate scientists analyzing climate data around the world, the evidence to date is unequivocal: the global climate is changing, and becoming warmer.[55] This does not, however, mean that conditions everywhere are becoming consistently warmer year after year. All of the variables that impact climate will continue to influence the weather in many different ways.

In BC for example, warming has primarily been felt in an upward shift in BC's coldest winter temperatures: winter average temperatures have been increasing more than summer average temperatures. In other words, BC has been getting less cold more rapidly than getting "more hot".[56] And changes will still impact each region of the province differently. So while the term "global warming" makes sense if you talk about the overall worldwide trend, at a regional level, "climate change" is a more appropriate way to describe what is occurring.

This section provides a summary of past trends and future projections of climatic conditions for British Columbia. It is based on data compiled from a variety of studies.[57] This discussion below is based on conditions in BC *on average* for the whole province, unless otherwise noted.[*] Tables 5.2 and 5.3 provide an overview of projected climate change for BC in the 2020s and 2050s.[**]

* For a detailed discussion of limitations to climate change data, please consult the BC Climate Overview produced by the Pacific Climate Impacts Consortium in Victoria, BC (Rodenhuis et al. 2009).

** From www.plan2adapt.ca: "The ensemble median ['average'] is a mid-point value, chosen from a standard set of PCIC-chosen Global Climate Model (GCM) projections. The range values ['range'] represent the low and high ends of the expected range (i.e., the 10th and 90th percentile of the set)."

Temperature

As noted above, the trend over the past century in BC shows that temperatures have been warming but that over the last century, average nighttime low temperatures have increased more quickly than average daytime high temperatures. The temperature increases observed for BC in the second half of the century were greater than the global average.

In the future, warming is projected to continue with greater warming occurring in the north of the province than in the south. Warming will also be greater in inland areas than in coastal areas (due to the influence of the ocean) and, on average, greater in winter than in summer.[58] In the future, the annual

TABLE 5.2. CLIMATE PROJECTIONS FOR BRITISH COLUMBIA IN THE 2020S

Source: Pacific Climate Impacts Consortium, www.Plan2Adapt.ca

	Time of Year	Projected Change from 1961–1990 Baseline	
		Range (BC)	Average (BC)
Average Temperature	Annual	+0.5 °C to +1.5 °C	+1.0 °C
Precipitation	Annual	+0% to +7%	+4%
	Summer	−4% to +5%	+0%
	Winter	+1% to +8%	+4%
Snowfall	Winter	−11% to +2%	−2%
	Spring	−55% to −7%	−30%
Growing Degree Days	Annual	+76 to +234 degree days	+163 degree days
Frost-free days	Annual	+6 to +16 days	+10 days

TABLE 5.3. CLIMATE PROJECTIONS FOR BRITISH COLUMBIA IN THE 2050S

Source: Pacific Climate Impacts Consortium, www.Plan2Adapt.ca

	Time of Year	Projected Change from 1961–1990 Baseline	
		Range (BC)	Average (BC)
Average Temperature	Annual	+1.3°C to +2.7 °C	+1.8 °C
Precipitation	Annual	+2% to +11%	+6%
	Summer	−8% to +6%	−1%
	Winter	−2% to +16%	+8%
Snowfall	Winter	−16% to +2%	−10%
	Spring	−70% to −20%	−58%
Growing Degree Days	Annual	+191 to +459 degree days	+305 degree days
Frost-free days	Annual	+12 to +28 days	+20 days

number of frost-free days and the length of the overall frost-free period are projected to increase. Annual growing degree days are also projected to expand, in some areas by over 200 growing degree days.

To illustrate the magnitude of projected changes, the average annual temperature by the 2080s is projected to increase by 2.8°C. This means that an average year in the 2080s will be as warm as the warmest years we have experienced in the past century.[59] While the 2080s might seem like a long way off, this change will occur in stages over the intervening period.

Precipitation

During the period of 1900–2004, precipitation increased an average of 22% for BC as a whole, but with significant variation by region. Most of the province experienced a relative increase in annual precipitation of between 10% and 50%, with some areas of the south coast showing a negligible increase or a slight decrease. The increase in precipitation has occurred mainly in the winter and spring, and has been greatest in the northeast while the southwest showed a slight decrease in some cases.[60] On average, BC has been experiencing more days out of the year with precipitation, and less consecutive dry days.[61]

The increasing trend in average precipitation in BC is projected to continue in the coming decades (e.g., 0% to +7% by the 2020s, and +2% to +11% by the 2050s), with the greatest increases in spring. In spite of the overall increase per year, precipitation is projected to decrease in the summer in most areas of the province, which could affect the length of the growing season.

Extremes

While average changes are of concern for the agriculture sector, extreme temperatures and weather events are likely be a greater risk in the near future. In the past few years in BC, producers in many regions of the province have experienced severe impacts due to extreme weather conditions.*

Examples of recent extreme weather conditions

- ***2007*** — Record drought conditions and resulting low crop yields impacted BC cattle producers in 2006. A portion of a $7.5 million Drought Assistance Program went toward assisting producers with losses.[62]

- ***2010*** — A series of drought years culminated in substantial financial losses in 2010 for both BC grain and cattle industries. $11.4 million in crop insurance compensation was paid for grain producer losses.[63]

- ***2010/2011*** — Extreme precipitation right before harvest resulted in substantial crop losses for vegetable producers in the Fraser Valley/Metro Vancouver. An estimated $6.3 million in crop insurance and Agri-Recovery was paid for compensation/return to production.[64]

The observed pattern of increasing extreme hot temperatures and decreasing extreme cold temperatures is projected to continue in the future.[65]

Extreme weather events are projected to occur more frequently in BC in the future, and studies have shown some specific trends already.[66] These include an increase in heavy rainfall events in the spring, and an increase in extreme wet and extreme dry conditions in summer. The intensity and magnitude of precipitation events is projected to increase in the future. For example, models focusing on the US Pacific Northwest region suggest that the area will experience more frequent extreme heat events, less frequent extreme cold events, increased extreme precipitation in the winter, and increasing rain-on-snow events accompanied by more severe flooding.[67]

Forest fires have become more frequent and severe in western North America, and this trend is projected to continue.[68]

* While it is not possible to attribute most individual events to climate change, more of these *types* of extremes are anticipated.

Hydrology

In addition to variations in precipitation, water supply is influenced by a range of factors including glacial melt, snowpack, soil moisture and streamflow. Streamflow patterns vary significantly by regime type (rain-dominated, hybrid rain/snow, snowmelt dominated, hybrid snow/glacial melt and glacial melt-dominated). Detailed studies are not available for all regions of the province, but some consistent patterns have been observed and projected.

Despite an overall increase in precipitation, the amount of snow falling in BC has declined by about one quarter since 1951, due to temperature increases. But there is variation regionally: in southern areas particularly, less precipitation has been falling as snow and more of it as rain, while northern BC has seen more annual snowfall since the mid-20th century.[70]

At the same time, glaciers in BC are receding, and trends in streamflow indicate that this process is likely quite advanced. Areas that rely on glacial melt as part of their water supply have seen a significant decrease in August streamflow since the mid-1970s.[70]

The combined changes in temperature and precipitation patterns and glacier dynamics affect the timing and levels of streamflow in the province. In general, fall streamflow is expected to increase due to an increasing portion of precipitation falling as rain rather than snow. Spring runoff has been occurring an average of 10 to 30 days earlier in snow-fed watercourses,[71] and in the future the amount of runoff is projected to increase while the peak flows in the spring will decline and continue to occur earlier.[72]

Decreasing contributions from receding glaciers and the conditions and precipitation patterns described above are projected to lengthen the period of dry conditions and low flows in the summer, and affect groundwater recharge.[73] As the climate warms, previously snowmelt-dominated or hybrid systems will transition to hybrid and rain-dominated regimes, which experience more unpredictable peak flows and increased risk of flash flooding in the winter.

Soil moisture is a key variable for production, and varies with streamflow patterns, evapotranspiration rates and exposure to conditions including wind, solar insolation, cloudiness and humidity. Despite its importance, there is little data available on soil moisture in BC. Based on a study of future conditions in the Columbia Basin, it is likely that earlier snowmelt in snow-dominated and hybrid basins will increase soil moisture in spring. How projected changes will influence summer and early fall soil moisture is more difficult to interpret, due to the many variables involved. This is an area where more research is required. Rain-driven systems tend to have their driest soil conditions in late summer and early fall.[74]

Sea level rise

Global sea level has risen more than 20 cm since 1899,[75] but this varies significantly by location due to land movement (rising or falling) and climate and weather variability. Future projections show that sea level rise will continue. Estimates for the BC coast over the next century suggest a probable sea level rise of 80 to 120 cm at the Fraser River Delta, and 50 to 80 cm at Nanaimo.[76]

Regional variation

While there will be overall changes for the province as a whole, there will be variation in the changes occurring at the regional level. The types and amount of information on climate projections and effects differs by region. The information presented here is based on available studies for the regional level. Tables 5.4 and 5.5 provide an overview of projected climate variables by region.

Peace

In addition to overall temperature increases, average winter low temperatures have increased more significantly in the Peace region than in other regions (by 5.3°C in Fort St John between 1951–2006), and this increase is projected to continue in the future.[78]

Precipitation is projected to increase in the Peace region overall, and in all seasons except the summer.[79] The amount of precipitation stored as spring snowpack is projected to decrease, and onset of the spring snowmelt may occur earlier.[80]

TABLE 5.4 CLIMATE PROJECTIONS FOR BC REGIONS IN THE 2020S

Source: Pacific Climate Impacts Consortium, www.Plan2Adapt.ca

Region	Average Annual Temperature	Average Annual Precipitation	Average Spring Snowfall	Growing Degree Days	Frost-Free Days
Provincial Average	+ 1.0 °C	+4%	−30%	+163	+10
Peace	+ 1.0 °C	+5%	−30%	+134	+9
Central Interior	+ 1.0 °C	+4%	−29%	+160	+12
Okanagan	+ 1.1 °C	+4%	−33%	+175	+15
Fraser Valley & Delta	+ 1.0 °C	+4%	−32%	+203	+14
Vancouver Island	+ 0.9 °C	+3%	−31%	+267	+9

TABLE 5.4 CLIMATE PROJECTIONS FOR BC REGIONS IN THE 2050S

Source: Pacific Climate Impacts Consortium, www.Plan2Adapt.ca

Region	Average Annual Temperature	Average Annual Precipitation	Average Spring Snowfall	Growing Degree Days	Frost-Free Days
Provincial Average	+ 1.8 °C	+6%	−58%	+305	+20
Peace	+1.8 °C	+8%	−56%	+241	+16
Central Interior	+1.8 °C	+6%	−55%	+306	+23
Okanagan	+1.9 °C	+6%	−57%	+369	+26
Fraser Valley & Delta	+1.8 °C	+7%	−56%	+394	+25
Vancouver Island	+1.6 °C	+6%	−53%	+476	+15

Data in Tables 5.4 and 5.5 was obtained using PCIC's Plan2Adapt tool. Values shown are a midpoint within the range of projections for each region. Plan2Adapt provides data at a regional district level. The areas used for each region are: Greater Vancouver (Fraser Valley & delta), Cowichan Valley (Vancouver Island), Cariboo (Central Interior), Okanagan-Similkameen (Okanagan), and Peace (Peace). Data for other regions and for the full range of projections, can be accessed at www.plan2adapt.ca

The Peace region is generally in transition to more of a combined rain-and-snow-dominated hydrological system, whereas most of the area's runoff has been snow-dominated in the past. Some areas, such as the Alberta plateau east of the Rockies, will have rain-dominated runoff in the future, while higher elevation areas in the northwest of the Peace will remain snow-dominated.[81]

Trends to date indicate that peak streamflow has been occurring earlier in May and June, and this shift is projected to continue in the future. That contributes to lower flows in August and September in some watercourses. Streamflow during the rest of the year is generally expected to increase.[82] Droughts are expected to occur more frequently during the summer and early fall.

Central Interior

The relative increase in precipitation in the Central Interior over the past century was more pronounced than in other regions, since the region was drier to begin with.[83] Looking ahead, both temperature and precipitation projections for the Central Interior are generally consistent with what was described for the province on average. The one exception is that this region is expected to see a greater decrease in precipitation in the summer than the provincial average.[84] Most of the region is projected to have

Table 5.6. Projected changes in growing degree days for the South Okanagan

Adapted from Neilsen et al. 2001.

	Baseline (1961–1990)	2020s	2050s	2080s
GDD (base 5°C)	1909	2225	2509	2860
GDD (base 10°C)	960	1183	1398	1666

approximately the same number of growing degree days in the 2050s, as Salmon Arm has now.[85]

The annual amount of precipitation is projected to stay the same or increase through the 2020s, but with slightly decreasing precipitation in summer and more in winter. Warming in winter and spring will mean that an increasing amount of that precipitation will fall as rain in most parts of this region, while less falls as snow (particularly in spring). But in the southwest area of the Cariboo-Chilcotin region, the amount of snowpack in spring is projected to stay the same or to increase.[86]

Streamflow in the Cariboo-Chilcotin region is dominated by the influence of snowmelt, resulting in a relatively predictable pattern of high flows in the spring, and low flows in fall and winter. Warming will shift streamflow patterns as less precipitation falls, or is stored, as snow. Projections for this region suggest an overall decrease in runoff, particularly in summer, which will contribute to lower soil moisture in the fall. Some models also show drier winter conditions in headwater regions of the Cariboo-Chilcotin.[87]

Okanagan

Temperature projections in the Okanagan are consistent with what was described for the rest of the province, but minimum and maximum temperatures for this region have increased more than the BC average.[88] Projections show a significantly greater increase in growing degree days in the Okanagan than on average for BC (Table 5.6). By 2080, the potential growing season is projected to be 1.5–1.7 months longer. These changes will impact budding and harvest dates, and crop suitability.[89]

The annual amount of precipitation in the Okanagan is projected to increase slightly through the 2020s, but there will be a progressive decrease in summer precipitation. Warming temperatures will mean that an increasing amount of that precipitation will fall as rain, while less falls as snow, especially in the spring.[90]

Over the past thirty years, a decrease in annual streamflow has been observed in the Okanagan, along with an increase in the average minimum flows and a decrease in average high flows. As the hydrology of the Okanagan is driven by snow, the projected shift to a more rain-dominated regime, and particularly the reduction in snowpack, will have significant impacts on streamflow and surface water. A decreased snowmelt in the spring will lower peak flows at that time, and the timing of spring peak flows will occur progressively earlier as a result. Overall, more variable timing of peak flows is expected, and annual flows are projected to decrease.[91] On the other hand, groundwater recharge is also expected to occur earlier in the year when evaporative demand is lower, which could result in a minor increase in groundwater reserves.[92]

Based on future projections and detailed modeling for the south Okanagan, studies have shown that an increasing evapotranspiration rate and longer growing season will increase crop water demand in the future. Increases of between 12% to 20% are projected for the 2020s, 24% to 38% for the 2050s, and 40% to 61% by the 2080s. To put this in perspective, conditions giving rise to what is considered "extreme" crop water demand today (occurring about 1% of the time in the historical record), would be the average by the 2050s (occurring about 46% of the time).[93]

Furthermore, the timing of high demand and low supply in the region tends to coincide, leading to potential supply shortages. Modelling suggested that areas drawing water from the main channel and lake system would likely have sufficient supplies, but those drawing from tributaries may not.[94] Projections suggest that, without measures to adapt, the total annual water demand for the Okanagan will be greater than available annual inflows by later this century.[95]

Fraser Valley & Delta region

Temperature projections in the Fraser Valley are consistent with what was described for the rest of the province. The annual amount of precipitation is projected to stay the same or decline through the 2020s. Much of this decrease in precipitation occurs during the summer. Warming in winter and spring will mean that an increasing amount of that precipitation will fall as rain, and less as snow. The Greater Vancouver region exhibits very similar trends to those shown for the Fraser Valley, with some exceptions. A greater decrease is expected in winter snowfall (e.g., between –41% to –6%, an average of –23%, for the 2020s). Projections indicate an increase of 275 growing degree-days by the 2020s, and +498 degree-days by the 2050s, and slightly fewer additional frost-free days than further up the Valley.[96]

A study of extreme rain events in the Greater Vancouver area[97] found that the number of high intensity rainfall events showed an increasing trend from 1950–2005. This study also showed that the intensity of rainfall events occurring in April, May and June has increased significantly. Short duration events (up to 2 hours) were particularly more intense. Other studies link such high intensity rain events to an increasing risk of more frequent landslides in southwestern BC.[98]

Projections to the 2050s suggest that annual runoff will increase by around +14% on the Fraser River at Hope. Seasonally, these projections show increasing flows in spring and decreasing flows in summer. Peak flows will occur slightly earlier in the spring than they have in the past.[99]

Projections for the Fraser delta region suggest a relative sea level rise of 80 cm to 120 cm by 2100.[100] This takes into account local land subsidence as well as rising ocean levels due to climate change. Currently, a storm surge combined with high tides in El Niño years could overtop existing flood protection infrastructure, even without additional sea level rise.

Vancouver Island

Vancouver Island is expected to warm as much, or slightly less, than the provincial average. This will translate into a greater increase in growing degree days for this region than the provincial average. Annual precipitation is projected to increase slightly, but with a notable decrease in precipitation in summer — this decrease is larger than the provincial average. Warming in fall, winter and spring will mean that an increasing amount of that precipitation will fall as rain, while less falls as snow.[101]

Trends show that while annual streamflow in streams along the south coast has increased, low flow levels have decreased.[102] Projections for the Campbell River watershed to the 2050s show an increase in runoff in the winter and fall.[103] As warming occurs, more precipitation will fall as rain and less as snow — this is especially pronounced in the winter when the amount of precipitation falling as snow is projected to decrease much more for Vancouver Island than in BC on average. For areas of the Island at higher elevations, the remaining snowpack will tend to melt more quickly, leading to an increase in spring runoff with peak flows that occur earlier. For areas at lower elevations, the diminishing (or nonexistent) snowpack means that spring runoff will decrease, while the potential for high flows driven by winter precipitation will increase.[104]

Projections for the Island suggest a relative sea level rise of 10 cm to 90 cm by 2100.[105]

Conclusion

This summary of the past trends and future projections in climate for BC and its regions provides a reference point for the analysis of risk and opportunity that follows. It may also serve as a source of data for consideration by producers and other decision-makers seeking a high level summary. The BC and relevant region-specific information was shared with producers and other agricultural specialists in regional/commodity focus groups to inform consideration of what these changes could mean for agricultural production in BC in the 2020s. The resulting assessment of potential impacts, risks and opportunities is presented in the following chapter.

CHAPTER 6: Impact, Risk & Opportunity Assessment

THE CHARACTERISTICS & DEGREE OF RISK or opportunity for the agriculture sector are a function of the types of changes that are projected to occur in the climate, together with the capacity of the sector to adapt. What might appear at first glance to be an opportunity for enhanced production in BC is in fact a great deal more complex. Potential opportunities have associated costs and risks, and the range of projected conditions poses increasing challenges for an industry that is already under pressure.

To assess the implications of climate change for BC's agriculture sector, the best available local and regional data on climate trends and projections (outlined in Chapter 5) was presented to producers in order to interpret how those changes would impact operations and to identify factors affecting the ability to manage potential risks and opportunities.

Data collected in the twelve regional focus groups was compiled and analyzed to produce an overview of impacts, risks and opportunities for BC agriculture as a whole. The impacts identified in the focus groups are summarized in Table 6.1, and discussed in detail in the following sections. These are *potential* impacts of projected climate change, based on expert judgment by producers and other agricultural specialists.

This chapter sets the stage for a series of key actions presented in Chapter 7.

Impacts, risks, opportunities

Each key issue in Table 6.1 is discussed below in terms of the *projected changes in climate conditions and effects*, together with the ***impacts to agricultural systems***. This description is followed by a list of factors that affect how manageable the projected changes are for the agriculture industry and producers (what factors make it easier or more difficult to manage).

Climate change impacts are the outcome of a variety of conditions, as well as their specific timing, frequency, magnitude and so on. Each issue identified includes a combination of changes, from the simple (e.g., increasing average temperatures) to the complex (e.g., a combination of snowfall, evapotranspiration rates, air temperatures and local hydrology determining adequacy of water supply in the late summer). These issues are presented in rough order from more direct issues like "increasing amounts and variability of precipitation" to compound issues such as "changing biological and ecological interactions," or "economic factors." The risks and opportunities have not been ranked.*

Increasing amounts & variability of precipitation

This issue is a central challenge for producers across BC, and is considered a limiting factor for production

continued in 2 pages

* Given the variation across regions, commodities and at a farm level, conditions that are not particularly troubling for one part of the province or production system can have more significant implications for another. Agreeing on the criteria for evaluating risk, and rating priority risks and opportunities are valuable next steps to be taken at a regional and/or commodity level.

TABLE 6.1 SUMMARY OF KEY ISSUES, CONDITIONS & POTENTIAL IMPACTS FOR BC AGRICULTURE, BASED ON EXPERT JUDGMENT OF REGIONAL CLIMATE SCENARIOS FOR THE 2020S

Issue	Changing conditions	Potential agricultural impacts
Increasing amounts and variability of precipitation	▪ Increased fall, winter, spring precipitation ▪ Increased overall precipitation ▪ Increased variability and magnitude of precipitation events	▪ Accumulation of moisture exceeding drainage capacity ▪ Water-logged soils, localized flooding ▪ Lower crop productivity and quality — crop damage & losses ▪ Increased difficulty planning for and managing planting and harvesting ▪ Changes to livestock grazing management ▪ Nutrient leaching, input losses ▪ Increased potential for regional water storage
Widespread flooding	▪ Increased storminess and precipitation-driven floodwaters ▪ Rising sea level ▪ Dike overtopping and/or dike breach	▪ Widespread inundation of farmland ▪ Crop and infrastructure damage and loss ▪ Relocation or loss of livestock ▪ Interruptions to supply lines ▪ Prolonged recovery time ▪ Salinated soils (in case of sea dike overtopping or breach)
More frequent extreme weather events	▪ Increased frequency of extreme heat events ▪ Increased storminess ▪ Increased frequency and intensity of extreme rainfall events	▪ Reduced quality and productivity (both crops & livestock) ▪ Damage to plants, crops, livestock and infrastructure ▪ Interruption of critical supply lines (feed, inputs etc) ▪ Damage to regional infrastructure ▪ Increased risk of flash floods, soil erosion, landslides ▪ Increased awareness of importance of local food supplies (within communities)
Seasonally dry conditions (and water supply effects)	▪ Reduced proportion of precipitation falling as snow ▪ Earlier peak flows ▪ Reduced runoff and soil moisture in summer ▪ Decreased summer precipitation ▪ Higher evapotranspiration rates and crop water demand ▪ Increased frequency of drought	▪ Water deficits ▪ Increased productivity/quality if irrigation is possible (depending on crop and within specific temperature range) ▪ Less costly and easier to harvest (in drier conditions) ▪ Reduced productivity/quality if moisture is inadequate ▪ Water restrictions leading to reduction in management options for extreme heat, sun scalding, frost and pests ▪ Reduced water quality and quantity for livestock watering ▪ Better hay production and longer grazing season ▪ Migration of salt wedge further upstream on the Fraser, cutting off irrigation earlier ▪ Increased overall demand for water use ▪ Reduced soil moisture, worsened in case of successive hot and dry years ▪ Substantial crop/financial losses with consecutive years of drought

Issue	Changing conditions	Potential agricultural impacts
Shifting range of conditions (affecting suitability of varieties, crops, livestock)	▪ Shifted average conditions ▪ Increased variability and extremes ▪ Increased temperatures and growing degree days ▪ Decreased summer precipitation	▪ Increased uncertainty, costs, loss and damage ▪ Improved productivity and quality ▪ Opportunity to switch to higher value products ▪ Opportunity to diversify crops and livestock ▪ Improved suitability for longer maturing varieties ▪ Increased number of harvests possible ▪ Longer *potential* growing season, but *actual* growing season limited by variability and extremes
Changes to biological and ecological interactions	▪ Milder winter conditions ▪ Changed climatic regime overall ▪ Increased spring rainfall and extreme rainfall ▪ Accelerated rate of change ▪ Increased variability	▪ Increased reproduction and survival rates of pests and diseases, and of beneficial insects (predators) ▪ Increased number of pest cycles in a season ▪ Establishment of new pests, diseases, other invasive species ▪ Increased survival and reproduction rates of some wildlife and bird populations ▪ Impeded pollination ▪ Lower productivity, crop damage and loss
Changing economic factors: input costs, consumer demand and markets	▪ Increased variability and extremes ▪ Warmer winter temperatures ▪ Warmer summer temperatures ▪ Climate change impacts in other growing regions	▪ Increased input and management costs ▪ Decreased heating costs ▪ Increased ventilation costs ▪ Increased feed costs ▪ Increased prices and demand for BC products ▪ More upward pressure on agricultural land values

in key agricultural areas.[106] Effective management is typically costly and complex, requiring coordination across geographic, regulatory and stakeholder boundaries.

The projected *increase in fall, winter and spring precipitation* across the province in the 2020s gives rise to a number of impacts for the agriculture industry. The overall increase in precipitation for this area is projected to occur along with a rise in *variability* of precipitation and *more frequent extreme* weather events.

The most commonly mentioned impact arising from these conditions is an accumulation of moisture (over an extended or short duration) that exceeds the local drainage capacity, resulting in ***water-logged*** soils and/or *localized* flooding. Depending on the duration of these conditions, the direct impacts range from ***lower crop productivity and quality*** or an ***inability to graze livestock*** in certain areas, to ***crop damage***, or even ***complete losses***.

The increasing variability of precipitation, and especially extreme rainfall, causes challenges with ***planning for planting and harvesting***, activities that are typically possible during a short window of time in spring and fall. Adjustments in timing can be made in some cases, but this increases risk and can cut into already slight margins. Field vegetable producers experienced this situation to an extreme in 2010, when unusually wet conditions made it impossible to harvest vegetable crops. $6.3 million in damages were claimed through production insurance and Agri-Recovery.[107]

These conditions also pose escalating risks around ***nutrient leaching and input losses*** (fertilizers, pesticides, seed, etc). Groundwater quality in the Fraser Valley is already an active area of research and management; projected conditions would exacerbate current pressures on water quality and managing inputs.

Compounding these direct impacts, water management is an inherently complex undertaking, and projections for increased variability and magnitude of precipitation events raises the ***level of complexity*** involved in developing and implementing effective management solutions. Potential solutions ***require coordination, negotiation and joint decision-making***.

While this issue was rated consistently as one of the largest challenges, there were also opportunities identified. In particular, increasing precipitation could potentially be ***stored regionally***, to use during drier summers. In the case of livestock, more spring rain may ***allow for harder grazing***. As well, the increasing frequency of extreme moisture events may lead to ***increased awareness and motivation*** to take steps to manage this. Often, producers that had recently or regularly experienced these types of challenges perceived a greater risk.

Factors impacting manageability — On-farm

- Location and characteristics of land & soils
- Ability to "wait out" wet conditions (dependent on production system)
- Flexibility of financial resources (many producers operating within small margins)
- Quality, condition and maintenance of existing drainage infrastructure (on-farm and linkages to ditch/drainage system)
- Previous experience, knowledge
- Tenure of land (for leased land there may be lack of incentive for either landowner or producer to invest in infrastructure)
- Costs associated with infrastructure upgrades/ adjustments (especially for infrequent impacts)
- Access to insurance programs (may provide buffer, but poorly suited to dealing with successive small events)
- Availability of supports/incentives for improvements and upgrades (e.g., EFP program)

Factors impacting manageability — Beyond the farm

- Quality, condition and maintenance of existing regional ditch, drainage and pump systems
- Degree of conflict with other stakeholders and water uses (e.g., fish habitat protection vs ditch maintenance)
- Degree of flexibility within regulatory systems impacting management
- Extent of flexibility within other parts of the food system (e.g., required timing for delivery to processors is presently not very flexible)
- Availability of management and technology options (currently exist but are costly)
- Reliability of seasonal forecasts and longer term projections as a basis for management and investment decisions
- Level of financial and political commitment to infrastructure improvements and maintenance
- Ability to coordinate across landowners, jurisdictions, sectors and land uses to identify and implement solutions
- Level of priority placed on agriculture relative to other land/water uses

Widespread flooding

The case of large scale flooding poses novel challenges for agriculture. Impacts on agricultural land in floodplain areas deserves particular consideration by society as a whole due to the fact that flood management policies quite commonly discuss the option of using agricultural land as temporary storage areas in the event of flooding.*

The occurrence of ***widespread inundation*** of land in the floodplain as a result of rising water levels, dike overtopping and/or a dike breach, poses a high risk situation for agriculture in southwestern BC

* For an overview of agricultural land drainage requirements, see the Government of British Columbia Fact Sheet, "Agricultural Drainage Criteria" at www.agf.gov.bc.ca/resmgmt/publist/500Series/535100-2.pdf

in particular.[*] ***Crop and infrastructure damage and loss, relocation or loss of livestock***, and ***interruptions to supply lines*** are some of the major impacts of this scenario. All of these entail significant ***financial costs*** and ***psychological impacts for producers and communities***. For perennial crops especially, ***recovery could take years***.

Sea level rise and increasing storminess pose major threats in parts of Delta and Richmond where agricultural land is concentrated. In addition to the issues associated with widespread inundation just discussed, the longer term implications of ***salinated soils*** in the case of sea dike overtopping or breach is a fundamental threat to agriculture in this region. The rate and depth of infiltration of salt water into the soils affects how much this situation can be managed, if at all.

Factors impacting manageability — On-farm

- Location and characteristics of land and soil
- Type of production system (varying impacts and solutions)
- Quality and condition of existing on-farm infrastructure (e.g., ditches, drainage, pumps)

Factors impacting manageability — Beyond the farm

- Availability of management and technology options
- Level of financial and political commitment to infrastructure improvements and maintenance
- Coverage through insurance programs
- Availability of collective, long-term planning and investment (to mitigate, prepare and respond)
- Adequacy of emergency management and planning for agriculture's specific needs (currently deemed inadequate)
- Level of priority placed on agriculture relative to other land uses

* This issue was identified as a significant concern by producers; however, there is little information at present about how flood risk might change under future climate scenarios. There exists the potential for rising flood risk, but this is very site specific, varying by region, local watershed features and the timeframe (M. Schnorbus, PCIC, pers. comm. 20/02/12).

Damage & disruption due to more frequent extreme weather events

Damage and disruption due to extreme weather events was consistently rated by producers as having high impact and low manageability. While technology and management practices exist in many cases, the investment that would be required is typically not deemed justifiable for relatively infrequent events. At the same time, many agricultural systems in BC are tightly linked to supply and distribution lines across regions and borders. This makes them vulnerable to disruptions arising from extreme weather event impacts.

Projections suggest *an increased frequency of extreme heat events*, which can negatively impact the ***quality of crops*** (e.g., sunburn on fruit and berries) and ***inhibit productivity***. Livestock, in particular poultry and dairy, will also experience reductions in productivity and even ***illness or mortality*** under conditions of more frequent or extended extreme heat.

An increase in storminess and the frequency and intensity of extreme rainfall events can have an array of impacts. More intense storms can cause ***damage to plants, crops, livestock and infrastructure***. In addition, ***regional infrastructure and supply lines can be interrupted***, causing problems, especially for industries reliant on power and imported feed supplies. There is the possibility that more frequent interruptions to supply (in part due to impacts in other regions) may ***raise awareness of local food security*** and, by extension, support for local producers.

The projected increase in rainfall intensity suggests a ***higher risk of flash floods, soil erosion*** — especially where such events occur during drier summertime conditions — and ***landslides***.

Factors impacting manageability — On-farm

- Amount of time required for production system to return to full capacity after the event
- Farm-level emergency planning and preparedness for extreme events
- Previous experience dealing with adversity, change and variability

- Access to back up supplies, power, support
- Degree of reliance on external inputs, power, municipal water supply
- Availability of mitigation techniques or technology (specific to type of extreme event)
- Size of operation (capacity to buffer impacts)
- Extent to which inputs and supplies can be substituted locally (e.g., blended feed vs hay)
- Proximity to regional infrastructure and distribution points

Factors impacting manageability — Beyond the farm

- Extent of coordination and cooperation among producers and the community for emergency response, including ability of all producers to access emergency supplies
- Level of government preparedness and planning to support agriculture during extreme events
- Nature of financial compensation/support available — tends to be available for one-time disasters (e.g., wildfire, landslide, major floods) more often than for incremental conditions (e.g., drought, successive extreme weather events)

Seasonally dry conditions & water supply effects

For all agricultural production systems, water is an essential input that has no substitutes. An inadequate water supply will at minimum reduce productivity and quality, and in the worst scenario render an agricultural system unviable. Much of the ALR land in the province is in areas where water licenses have been fully allocated, so there is no additional in-stream water supply available.[108] Nonetheless, the challenge in many areas of BC was not seen to be a lack of water supply, but rather an inability to access water when and where needed. This is a significant hurdle due to the extent of cooperation and coordination required to effectively manage the range of stakeholders and interests involved in water management.

Within the context of an overall increase in annual precipitation for most of the province, various shifts in the hydrological regime will combine to produce, on average, drier conditions in the summer and early fall. *Less precipitation falling as snow* contributes to *earlier peak river flows* and *lower runoff and soil moisture in the summer* when demand is typically at its height. *Summer precipitation is projected to decrease* for most of the province. At the same time, increasing temperatures will contribute to *higher evapotranspiration rates and crop water demand*, further exacerbating the ***water deficit*** at this time of year.

Hot and dry conditions ***may be positive for plant growth***,* if irrigation is an option. Such conditions can also make ***harvesting easier or less costly***. Inadequate moisture levels have an array of impacts on plant growth. Plant water stress contributes to ***lower crop productivity and/or quality***. Less water would be available for some common practices used to ***manage conditions like extreme heat, sun scalding, frost, and pests***. Restricted use of water for pest management could lead to ***increased use of pesticides.***

Crops grown to feed livestock also have these challenges with some variation. Decreasing forage growth and quality means ***added costs*** to buy additional feed, or a choice to ***reduce herd sizes***. Rising temperatures promote *eutrophication and algae growth* in standing water sources such as ponds and dugouts. Direct consumption of water by livestock could be compromised as ***quality and quantity of water decline***. On the positive side, hot and dry conditions are ***better for haying*** and enable a ***longer grazing season*** as long as grazing patterns can be adjusted.

For producers in the Fraser Valley delta area, there is an added complication. As sea level rises and peak flows in the Fraser occur earlier, the salt wedge at the mouth of the river pushes upstream earlier in the season. This means that, at intake points, *river water will become salinated earlier on*, ***cutting off the option to irrigate*** even earlier. As the situation in this and other areas becomes more acute, changing the intakes on the Fraser River may be required, and there may be a more convincing ***case for investing in***

* Depending on the type of plant, and within a certain temperature range

storage and irrigation infrastructure to address water supply challenges.

As demand continues to increase and supplies become more restricted, ***conflict between neighbours and across stakeholders*** could escalate. Hot and dry conditions increase ***forest fire risk***, which in turn can negatively impact the regional hydrology. Disasters such as wildfires and drought in turn have ***cascading effects on the regional economy*** and supporting industries like feed distributors or processors.

As described earlier, water management differs from other issues due to the ***degree of complexity*** involved in effectively addressing it. The hydrological system does not abide by defined geographic, regulatory, sectoral and political boundaries, and so management responses that cross these silos are also required. With *increasing pressures on the water supply*, of which climate change is just one, there will be less excess to work with and therefore an increasing need to effectively manage this resource across all of these boundaries.

There is a threshold beyond which hot and dry conditions pose a categorically high risk. While hot and dry conditions can be positive in a given year, *consecutive hot years with low moisture levels* can ***severely impact soil moisture***. Once conditions cross into the category of *drought*, by definition crops are negatively impacted and the challenges described above compound one another and become severe. *Successive years of drought*, such as the conditions experienced recently by producers in the Peace region, can ***push producers out of business***.

Factors impacting manageability — On-farm

- Location and characteristics of land and soil
- Ability to irrigate (existing infrastructure, water source)
- Type of water source(s), extent to which it is under control of the producer
- Availability of management techniques and infrastructure
- Cost of infrastructure and alternatives
- Willingness of individual producers to change practices
- Cost or availability of land to use for water storage—regional infrastructure will be required
- Reliability of weather forecasts and longer term projections as a basis for management and investment decisions
- Access to crop insurance
- Price of water, in the context of already slight margins
- Tenure of land (for leased land there may be lack of incentive for either landowner or producer to invest in infrastructure)

Factors impacting manageability — Beyond the farm

- Availability of drought-resistant variety trials
- Degree of coherence and coordination in water management (currently fragmented jurisdiction)
- Number/extent of competing water uses (and rising demand)
- Level of priority placed on water use for agriculture
- Capacity to implement long-term, comprehensive water management decisions
- Presence of international agreements (constraining autonomous choices about water allocation)
- Impact of Water Act modernization process on access for agriculture
- Extent of political and financial investment to ensure water access for agriculture

Shifting range of conditions affecting suitability of varieties, crops, livestock

Under the climate conditions projected for the 2020s in BC, some varieties, crops and livestock being grown or raised in the various regions of BC may become less suitable, while other options may become viable. A commonly held view is that climate change will be a boon for agricultural producers in Canada. However, producers generally saw at most a moderate opportunity due to uncertainty, and because any change brings with it costs and risk. From the perspective of current producers, transitions to new varieties, crops or livestock are more likely to be driven by increasingly extreme or unsuitable conditions rather than by opportunity.

While *shifts in average conditions* could in time drive changes, in the more immediate term it is likely to be the *increase in variability and extremes* that will ***increase uncertainty, costs, loss and damage*** to the point where producers have to make changes for the business to remain viable.

On average, a *warmer climate* would ***improve productivity and quality*** for many crops in this part of the world, if other climate variables were to remain the same. This creates the potential to switch to ***higher value products, diversify crops and livestock***, to try out ***longer maturing varieties*** and take advantage of ***multiple harvests***. However, we know that in addition to a *rise in average temperature and the number of growing degree days, projections also include increasing spring precipitation, increasing variability, more extremes, and pressures on water supply*, among other things. In effect, while more growing degree days would lead to a longer *potential* growing season, the ***actual growing season is limited*** by the timing of the first hard frost, extreme rainfall or hail, and other such events (which are projected to become more variable and/or more frequent).

Factors impacting manageability — On-farm

- Land and soil characteristics (suitability for new varieties, crops, breeds)
- Extent of costs and risk involved in making a change
- Level of risk tolerance, knowledge, willingness to experiment and be an early adopter
- Presence of sufficient financial resources for producer to invest in learning process; alter practices or technologies
- Type of production system (e.g., annual crops can be experimented with more economically than perennial crops or switching to something entirely new)

Factors impacting manageability — Beyond the farm

- Extent of support available for transition (financial incentives/support, information on how to transition, extension services, regulatory environment, etc)
- Degree to which alternatives (varieties, crops, breeds) are available and have been tested for this region
- Accessibility of information on options/alternatives
- Presence of innovators ("early adopters") to learn from (within region or production system)
- Reliability of seasonal forecasts and longer term projections as a basis for management and investment decisions
- Consumer preferences and demand, future market conditions (e.g., will there be demand for the products that are climate-suitable?)
- Capacity to effectively market new products

Changes to biological & ecological interactions

Agricultural systems are tightly linked to other biological and ecological processes that will also be impacted by a changing climate. The web of cascading and compounding impacts makes it difficult to anticipate, let alone plan and prepare for, the many possible interactions that could occur. The arrival of new pests and diseases, and further pressures on pollinators are of key concern as they could have substantial and long-term negative consequences for production.

Milder winter conditions will ***increase the reproduction and survival rates of many pests and diseases***, also enabling ***additional pest cycles*** to occur within a season. This increases pressure on current conventional, integrated and organic pest management systems and is likely to result in ***greater use of pesticides*** as the limits of other management options are surpassed. ***Predator species (beneficial insects) could also thrive*** in milder conditions, offsetting enhanced pest populations.

Milder conditions, and a changing climatic regime more generally, are also likely to increase the risk of ***new pests, diseases and invasive species appearing in BC***. The complexity of pest management is multiplied with the introduction of species or varieties that are not currently present in this region. The lag time between the threat emerging and a response being implemented creates ***potential for severe damage and losses*** to occur, and for the new species to establish. The presence of certain pests and diseases, or chemicals used to control them, could lead to ***restrictions on exports***, further harming the industry.

These same conditions could also ***improve survival and reproductive rates of various wildlife and bird populations*** that cause ***crop damage and losses***, and create other challenges for agricultural production.

Increasing spring rainfall, and especially extreme rainfall events, could ***slow down or prevent pollination of crops*** within the short window required to enable full crop development. The result would be ***lower productivity***, and potentially even ***complete losses***.

The *accelerating rate of change and increase in variability* in the climate system will greatly ***increase the pressure on current systems*** for managing pests, diseases, weeds, invasives, wildlife and pollination.

Factors impacting manageability — On-farm

- Location and type of operation (species or crop produced)
- Previous experience with a pest, disease, invasive
- Degree of unknown/unfamiliar conditions (e.g., how new invasive species would interact in particular region, timing, options for dealing with them, etc)
- Range of management options available (to conventional and organic production systems)
- Cost of mitigation and response measures
- Extent of access to support systems (information, education and extension)

Factors impacting manageability — Beyond the farm

- Degree of isolation of the region
- How regional/local conditions and practices combine with other pressures driving movement of pests, diseases and invasive species (globalized trade, land use change, etc)
- How regional/local conditions and practices combine with other pressures on pollinator populations (disease, land use change, etc)
- Extent of conflict or cooperation with other interests and stakeholders (e.g., wildlife management)
- Presence of effective pest control measures (e.g., natural predators and competitors, or chemical and management responses)
- Responsiveness of permitting and regulations (emergency chemical permits helpful)
- Availability of insurance programs
- Presence of associations and cooperatives with capacity for ongoing research and dissemination of information
- Flow of information, learning from other regions or producers
- Amount of resourcing aimed at research, monitoring and response to new invasive species, pests and diseases (or increases to existing populations)
- Availability of extension services
- Availability/distribution of research currently conducted by private companies

Changing economic factors: input costs, consumer demand & markets

Controlling input and management costs is a key mechanism available to BC producers to try to maximize their return on investment in a given season, and over the longer term. Some of these costs depend significantly on weather and climate conditions.

Producers are always looking for the right balance between costs and potential revenue. For example, economic viability of dairy, poultry and greenhouse production systems is tightly linked to managing costs of external inputs like energy (for heat and lighting), water, feed, and nutrients. As variability and extremes increase, adjusting the use of external inputs is an option available to these industries to offset the reduction in productivity and quality that would otherwise result. In this sense they are less sensitive to climate change and extremes, but will incur ***increasing input and management costs***. *Warmer winter temperatures* could ***decrease heating costs***, while *warmer summers* ***add to ventilation costs***.

Climate change impacts in other growing regions will affect market conditions for BC production as well. These impacts are likely to lead to ***increases in feed costs***, for industries reliant on feed imports and could affect availability of supply. *Negative impacts in key growing regions* elsewhere ***could also increase prices and demand for BC products***. However, combined with other pressures this could enhance the ***upward pressure on land values*** in agriculturally suitable areas, reinforcing this barrier to entry for new farmers.

Factors impacting manageability — On-farm

- Type of production system
  - extent of climate control possible (enclosed vs open-air)
  - age/quality of facility and technology
- Cost of inputs and exposure to changing input costs
- Degree of dependence on external inputs, and substitutability of inputs

Factors impacting manageability — Beyond the farm

- Presence of innovators ("early adopters") to learn from (within region or production system)
- Extent of strong (high value) markets for BC products
- Degree of consumer support for, and understanding of, BC agriculture
- Competitiveness of BC agricultural production (relative burden of taxation, price and cost structures and regulatory requirements for local vs external products)

Managing risks & opportunities associated with climate change

The themes emerging in the focus groups around the province pointed to some key ways that the nature of risks and opportunities for agriculture will shift with climate change. Some of the projections are variations on conditions already familiar to producers, while others represent fundamentally new challenges. Some of the novel aspects of projected conditions that impact agriculture include:

Variability

The projected increase in variability of conditions is a primary concern for producers, particularly because this introduces a new level of uncertainty into the decision-making process. In the context of increasing variability, producers face a greater range of potential conditions and extremes, which must be factored into their planning and decision-making. In a given year, a producer could face both extreme wet and extreme dry conditions. Decisions have to be made about how best to invest already stretched resources, given limited information and experience with such conditions.

Changes to average conditions & to extremes

Changes to average conditions will require adjustments and could eventually drive significant transitions in agricultural production systems. Increases in extreme conditions and the potential for abrupt shifts (e.g., the introduction and establishment of a new pest or disease) pose an acute risk to production systems and may not be manageable with current options and approaches. In particular, the unpredictability in timing and frequency of such events makes it difficult to plan for, or invest in, options to effectively manage the risk. Also, some issues like disruptions to pollination, inadequate water supply or salination of soils are effectively unmanageable for producers.

Complexity

Overall, climate change increases the complexity of management and decision-making for agricultural operations and the sector as a whole. The scale and pace of climate change is unlike anything producers have dealt with in the past. Increasing pressures on land and resource use, ecological services, globalized food systems and farmers' bottom lines magnify the impacts of any one source of pressure. As one producer put it, "climate change is the ultimate stressor that could push us over the edge."

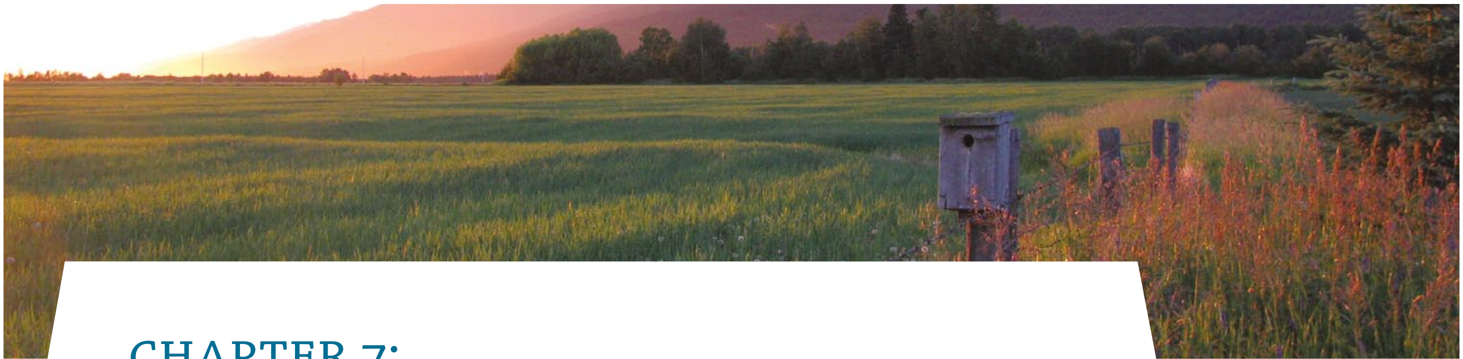
Cumulative impacts

A succession of smaller climate change impacts can build to have a large effect. Large, high impact events are a major concern but a series of smaller events can also create significant pressure, and typically there is less awareness and support in this kind of scenario.

The potential risks and opportunities due to climate change for BC's agriculture sector arise from these changing climatic conditions together with the evolving status and capacity of the sector to anticipate and respond to changes.

Increasing support for adaptation will help to better balance the challenges facing farmers with an enabling context for maintaining resilience of the agriculture sector. Decisions around issues like land use, water management, and transitions to new agricultural or economic models require the cooperation of actors outside of the industry. Prioritizing agricultural production in BC and equitably sharing the risks and costs taken on by producers and the industry are necessary steps for adaptation.

The next chapter draws together the results of this assessment into key actions for industry, government and other stakeholders, to contribute to building a more resilient agriculture sector in the face of climate change.



CHAPTER 7: Toward a More Resilient Agriculture Sector

During this project's year long engagement process, a consistent message from producers across the province was that much of the sector is already being strained in ways that are undermining its resilience. Factoring in the complexity and challenges associated with climate change, it is clear that immediate attention to agriculture's capacity to adapt is needed.

Although beyond the scope of this study, the broader impacts of climate change to food production globally, create additional incentive to prioritize sustaining and enhancing BC's agricultural production. Climate change places different pressures on decision-making systems from the farm to government to the marketplace. It also poses new challenges that demand particular attention from producers, industry associations, academia, the public, and all levels of government. Fundamentally different approaches are required.

Therefore, an environment that is supportive of adaptation to climate change will include not just new tools, resources and information, but also a shift in the underlying approach to development of policies and decision-making at all levels. The following ***Principles of Adaptation*** will better enable adaptation to climate change.

TABLE 7.1. PRINCIPLES OF ADAPTATION

Principle	Application
Integrated	Interrelated aspects of the whole system are taken into account. Processes and different actors are coordinated. Climate change information and adaptation considerations are a standard part of decision-making.
Flexible	Policy and regulations enable decision-making and action that is responsive and adequately flexible to deal with unexpected and changing conditions.
Collaborative	Collaborative approaches to knowledge generation, planning and decision-making contribute to building capacity to deal with uncertainty and complexity. Decision-making and actions are enabled across levels of governance and stakeholders. Local and regional scales play a primary role.
Transparent	With a flexible system, the need for transparency, communication and trust increase. Transparency also facilitates shared decision-making and responsibility.
Proactive & future oriented	Decision-making and actions are enacted in advance of pending challenges, rather than waiting for the worst-case scenario. The best knowledge available is applied, taking into account that uncertainty is an inherent part of climate change. Climate change requires a longer term view than most political and financial systems apply.
Resilient	Overall, policies and regulations enhance the capacity of the system to cope with change, variability and shocks; and to learn and adapt to new information and experience. Continual re-evaluation and adjustments are made.

Key actions

The preceding chapters are intended to provide BC producers, governments, and citizens with the background to set priorities for improving the resilience of BC's agriculture sector now and for the future. The remainder of this chapter will outline specific key actions for enhancing the ability of the agriculture sector to adapt to climate change. The key actions are organized into five sections:

- → ***Governance & policy****
- → ***Financial resources***
- → ***Human & social resources***
- → ***Knowledge resources***
- → ***Physical resources***

The engagement process with producers and specialists was the basis for development of many of these actions.

For each type of climate change impact a web of actions are required to effectively enable adaptation. For example, addressing the impacts associated with pest and disease management involves policy and regulation, research and development, monitoring and communication systems, extension services and on-farm management.

Therefore, action items are intended to involve the broad range of actors who have roles to play in adaptation of agriculture to climate change including: various levels of government, citizens, research institutions and agriculture sector organizations and producers.

Governance & policy

Governance refers to the systems and processes of decision-making that organize collective action. This is broader than just government and includes sector organizations and other stakeholder groups, as well as producers and other citizens. As the complexity of decision-making increases, due to the scale and pace of change, collaborative approaches that connect stakeholders in meaningful dialogue will become more important for effective decision-making and implementation.

Local and regional governments are key decision-makers for land use, water and resource allocation decisions that are of direct consequence for agriculture sector adaptation. For this reason, the relationship between the agriculture sector and local and regional governments is of particular importance for adaptation. However, in some cases, the capacity of individual producers and/or organizations is already stretched and this may limit effective participation in government processes. Strong industry organizations are important assets that contribute to the ability to organize, learn, exchange knowledge, share resources and act collectively.

Integrating climate change adaptation information and goals into decision-making at all levels is an important to ensure that decision-making reflects the changing reality and to avoid direction or policy that is maladaptive (and difficult to undo). Because climate change is an ongoing process, continual re-evaluation and adjustments to chosen paths will be required.

The recommendations made here relate specifically to building a basic foundation for governance and policy (in government and industry) that is well suited to improving the resilience of both agriculture and the food system in BC.

Key actions

- Integrate consideration of agricultural resilience and climate change adaptation into decision-making frameworks concerning agriculture by:
  - → Developing tools tailored for various levels of government, agencies such as the Agricultural Land Commission and for sector organizations and individual farm businesses
  - → Factoring into decision-making both climate change impacts in BC and impacts of global changes and medium to long term implications (See *Overarching Research Priorities*)

* This title does not mirror the "Policy and Regulatory Resources" title in Chapter 4 because this section takes a slightly broader perspective which, while inclusive of regulatory context, is not focused on it.

- Review impacts of the regulatory regime on BC's agricultural businesses to better understand its relationship to agricultural adaptation; evaluate for coordination, flexibility, consistency and transparency

- Identify and implement strategies to strengthen agricultural organizations and facilitate their participation in community, regional and provincial dialogue and decision-making (See *Human & Social Resources*)

- Continue to focus on greenhouse gas emission reductions in order to prevent the most extreme potential impacts of climate change

Financial resources

The base requirement for agricultural operations to adapt is financial viability. As climate change places greater demands on producers to manage variability and extremes, and to constantly adjust to changing conditions, they will require the financial resources to both buffer against adversity and to adapt to changes. Governments and industry organizations can assist the industry to adopt adaptive practices and technologies and to address economic barriers and challenges, while supporting producers through circumstances where losses are inevitable.

Key actions

- Focus investment and programming on business development, economic sustainability and financial resilience for BC farms. For example:
  - → Explore regional competitive advantages, diversification options and opportunities to increase and stabilize farm income
  - → Identify and promote transferable business models that are tested and profitable within BC or comparable jurisdictions
  - → Assist farm businesses with costs associated with planning and transitioning to more diversified and resilient business models
  - → Identify and address gaps in processing, value-added and marketing infrastructure
  - → Foster development of collective/cooperative systems for purchasing, processing, distribution, marketing, insurance and infrastructure, particularly for small operations/industries or more isolated regions
  - → Develop educational and planning resources to support profitability and increased economic resilience for small and new farms
  - → Promote buying local agricultural products to enhance regional production and markets

- Conduct multi-criteria cost-benefit analyses* of adaptive practices and technologies (incorporating climate change projections) at both the regional and farm levels

- Develop financial tools to support on-farm planning, innovation and infrastructure for adaptation to climate change. For example:
  - → Bolster incentives for adoption of adaptive farm practices included in existing programs such as the Environmental Farm Plan and Beneficial Management Practices Programs
  - → Identify alternate financial mechanisms to support investment in on-farm adaptive practices and technologies (e.g., ecological goods and services)
  - → Utilize business risk management supports for transitioning to more adaptive systems (for example: linking premiums or payouts to incentives for investing in adaptation)

- Identify mechanisms to manage and share new types of risk for farm businesses associated with climate change impacts including:
  - → Incremental (and compounding) impacts from more frequent small events
  - → Successive years of extreme weather event impacts

* For more information: http://unfccc.int/files/adaptation/methodologies_for/vulnerability_and_adaptation/application/pdf/multicriteria_analysis__mca_pdf.pdf

Human & social resources

While there are many experienced and knowledgeable producers in the province, as well as dozens of active industry organizations, the demographics of the sector and the growing demands on industry organizations are stretching the current resources. The difficulty of attracting new entrants into agricultural livelihoods in BC is an issue of concern for the entire province, not just for individual farmers struggling with succession planning. Addressing this issue requires a concerted effort to communicate the value of agriculture, promote educational opportunities in the area and improve the economics of the sector to attract new entrants.

Despite the industry's diversity and the number of industry organizations, there is significant common ground amongst agricultural producers. A collaborative approach that maximizes the available resources across the sector could help address collective challenges associated with climate change such as access to water and supports for adaptation

Key actions

- Identify strategies for increasing interest and participation in farming amongst young people in BC, for example:
    - → Supporting and promoting post-secondary training and education in agricultural fields
    - → Developing resources to fill gaps in industry training/education within BC
    - → Facilitating the transfer of knowledge from experienced producers to new or young farmers
- Bolster commitment and support for the Agricultural Land Commission, with a particular focus on its mandate to "encourage and enable farm businesses in BC"
- Bolster producer and industry organizational capacity by:
    - → Identifying mechanisms to support industry organizations with long-term and strategic planning and action, and provide incentives for innovation and experimentation at the farm level
    - → Minimizing overlap across industry organizations by developing cross-cutting services, resources and tools that are needed by all producers
    - → Increasing communication and collaboration across commodities, regions and communities to address key issues and challenges for the sector
    - → Increasing cooperative approaches to industry representation in government processes and consultations (to maximize resources)
    - → Facilitating participation of agricultural producers and organizations in planning and decision-making processes (e.g., per diems, consider timing of meetings, maximize time of participants, etc)

Knowledge resources: information, extension & research

Climate change adaptation requires ongoing learning at all levels in the system — from producers and agricultural organizations, to government and citizens. Collaborative approaches to knowledge generation, planning and decision-making are an important part of building the capacity to deal with uncertainty and complexity. For climate change science and research to be useful and applied, collaboration is needed between researchers, government and the private sector.

In addition to the need for primary research, the co-production of knowledge by researchers and academics working with agricultural producers, associations and specialists can improve the application of research in the field. Translation of existing and new information into forms that can be used by producers is an important step in the process of enhancing awareness and enabling action. Similarly, building on information, experience and technologies that already exist will expedite learning and make the best use of limited resources.

Key actions (knowledge & education)

- Increase availability of informational and extension resources for producers about climate change, potential impacts and adaptation, transition management, and building adaptive capacity

- Translate weather and climate science into applied tools for producers, industry and other decision makers (local and regional government)
- Improve public/community understanding of agriculture and climate change adaptation, specifically around agricultural water needs, how this will change over time, and current work to improve efficiency

Key actions (overarching research priorities)

- Develop thorough and detailed "impacts and options" evaluations for key commodities/regions in the province
- Review regional and global climate change impacts for agricultural production to evaluate implications for BC markets and competitors
- Improve data and modeling of current and future groundwater supplies

Key actions (weather & climate science research)

- Ensure ongoing availability and reliability of seasonal and shorter weather forecasts
- Increase the network of weather stations for standardized data collection
- Build on existing informational tools to expand the weather and climate information available for agricultural planning and management
- Expand the network of snowpack monitoring
- Develop climate projection reports specific to agriculture for all major agricultural regions of BC
- Increase investment in downscaled climate projections and information specific to agricultural applications. (Specific data gaps noted by focus group participants are identified in the box 'Knowledge Gaps'.)
- Improve data on future risk of extremes, floods, water demand and other climate conditions of consequence for agriculture

Knowledge gaps

→ Reliable forecasting
→ Extreme events (severity, frequency, duration, timing)
→ Consecutive years of drought
→ Metrics of variability
→ Hydrology
→ Flood risk
→ Humidity
→ Evapotranspiration, soil moisture, water demand & water deficit
→ Wind, hail
→ Risk of late/early frost
→ Season length
→ Suitability ranges (crops, livestock, weeds, pests & diseases)

- Conduct suitability modeling for new and existing production systems and varieties under projected climate and specific local conditions (soils, etc)
- Improve understanding of yields, nutrient value, productivity of new and existing crops under projected conditions

Key actions (farm practices, technology transfer & variety trials)

- Review and evaluate adaptive on-farm practices, technologies and approaches that could potentially be applied in BC
- Support piloting of new or transferable practices and technologies with adaptation potential (for example: reward innovation and experimentation, share risks taken by individual producers that benefit the entire industry)
- Strengthen proactive breeding and variety trial programs through incorporation of adaptation considerations. For example:

- → Test crops and varieties with enhanced resilience to projected conditions
- → Evaluate variety trials and breeding in other jurisdictions with conditions similar to projected conditions for BC regions
- → Evaluate potential for alternate varieties and breeds to be better suited to changing conditions in BC
- → Assess potential for new crops and varieties in different areas of BC (including evaluation of soils, water availability, etc) and, where promising, support trials or demonstration

Key actions (pests, diseases & invasive species)

- Increase comprehensiveness and coordination of early identification and monitoring for pests, diseases and weed threats
- Invest in development of quantitative modelling, improved management practices, and area-wide pest management

Physical resources

Physical resources (including land, water and infrastructure) determine the range of options and possibilities available to decision makers. Approaches to infrastructure can either constrain or enable adaptive activities. Significant changes to infrastructure tend to be costly, and are often limited by competing priorities and policies and planning with a short-term focus. Particularly due to the long lifespan of a lot of infrastructure, decisions made today have significant implications for adaptation options down the road.

Land and water management (and their decision-making frameworks) are pivotal elements of the province's capacity to support agricultural production through a changing climate. In all cases, investment in infrastructure requires analysis of costs, benefits and the range of stakeholder and community needs. For agriculture, key infrastructure priorities depend on the particular region and local production systems and so must be determined at the regional or local level.

Some of the high priority infrastructure issues identified by producers include:

- → Development or expansion of regional water storage
- → Development of on-farm water sources and storage
- → Improvement and expansion of irrigation capacity
- → Improvement of regional drainage, ditch and dike infrastructure and pumping capacity
- → Improvement of on-farm ditch and dike infrastructure, and pumping capacity
- → Increased implementation of alternative energy generation to improve self-sufficiency

Some regional and local governments in BC have already undertaken adaptation planning. However, these evaluations have not necessarily prioritized a review of agricultural adaptation in relation to infrastructure, land use and planning.

Key actions (physical resources)

- Undertake collaborative regional consultations and develop strategies to ensure that infrastructure development, land use and planning processes are supportive of agricultural adaptation. Key areas for infrastructure improvements include:
  - → regional and on-farm water supply, storage, and irrigation capacity
  - → regional and on-farm drainage, ditch and dike infrastructure and pumping capacity
- Conduct a review of regional infrastructure (such as dykes and transportation networks) for potential impacts of extreme events that would affect the agriculture and food system
- Integrate agricultural adaptation considerations into land use planning processes and decision-making through mechanisms such as:
  - → Local and regional government Official Community Plans
  - → Government infrastructure and asset management plans

- Agricultural Land Commission policies

- Identify and implement mechanisms to promote improvements (e.g., water source development, drainage etc) to leased land

- Integrate *agricultural adaptation impact assessments* into environmental impact assessments for new developments and industrial activities (e.g., impacts to hydrology, drainage, pollination capacity, etc)

- Bolster commitment to, and support for, the Agricultural Land Commission, with a particular focus on its mandate to preserve agricultural land

Emergency management & planning

The impacts of extreme events have implications for emergency management and planning. Certain regions and agricultural operations are particularly vulnerable to climate change-related extreme events, such as the over-topping of dikes (Delta/Richmond) or the spread of wildfires (Okanagan and Central Interior region). The extent of regional and on-farm emergency planning varies, but could be strengthened in most areas.

Key actions (emergency management & planning)

- Improve emergency management planning and preparation for extreme events at the producer, industry and government levels. For example:
  - Increase integration of agricultural needs into the provincial emergency management system
  - Integrate supports for farm level emergency management into planning and programming

Water management

The issue of water — too much or too little at a given time and place — is a concern for producers across BC. It requires particular attention because it an essential input for agriculture and because of the complexity of water management. Of greatest concern for producers is the establishment of agricultural water use and access as a priority, and the development of an integrated approach to its governance and regulation.

Critical water management issues identified for BC's agricultural producers include:

- Coordination across jurisdictions, land uses, end users
- Access to sufficient water supply for agriculture in the future
- Access to (critical) water supply in the dry season
- Improved drainage capacity of individual properties and regions

Key actions (water management)

- Strengthen coordination and integration of water management governance with particular attention to the role of agriculture. For example:
  - Include agricultural adaptation issues in water-related provincial and regional/local decision-making
  - Ensure continued access to adequate water supplies for agriculture (e.g., through development of an *Agricultural Water Reserve*)
  - Ensure integration of climate change projections and impacts into water management policy, planning and decision-making
  - Streamline and coordinate ditch and drainage regulations (including mechanisms to address agricultural needs and fisheries and habitat legislation)

- Invest proactively and strategically in water storage to ensure flexibility and the ability to deal with variability and extremes

- Invest proactively in water supply improvements (past examples of government support include the National Water Supply Expansion Program)

- Improve and expand on modeling of future crop water demand and regional demand relative to supply in regions across BC (building on work underway in the Okanagan)

- Further develop and expand decision support tools for effective on-farm water and irrigation management, and soil and nutrient management practices

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APPENDIX 1: Methods

TABLE A1.1. OVERVIEW OF INTERVIEWEES CONSULTED IN THIS STUDY

Region	Commodity	Producers	Specialists
Peace	Grain	2	1
Interior	Cattle	3	1
Okanagan	Apples	2	1
Okanagan	Cherries	2	
Okanagan	Grapes	1	1
Fraser Valley & Delta	Greenhouse	3	1
Fraser Valley & Delta	Field Vegetables	2	1
Fraser Valley	Poultry	2	1
Fraser Valley	Dairy	2	1
Fraser Valley & Delta	Berries	3	1
Vancouver Island	Mixed Farms	3	1
Vancouver Island	Dairy	1	
Fraser Valley & Delta	Nursery		1

Interviews

The first step in data collection began in March 2011 with a series of thirty-seven interviews with agricultural producers and other specialists around the province. Interviews were conducted in person where possible and otherwise by phone. The interview schedules used in each type of interview are based largely on those used in Belliveau et al. (2006), and are included at the end of this appendix.

Participants for producer interviews were identified through industry networks and associations (see Table A1.1 for an overview). Typically, the producers interviewed are involved as leaders in their respective commodities or regions and so have considerable knowledge of the collective industry issues beyond their individual farm. Specialists included provincial government commodity specialists and agrologists as well as key private sector advisors and agricultural association staff.

Climate change science synthesis & translation

A critical step in the process of conducting a participatory risk assessment with the industry was to synthesize and translate* existing climate science for the province and each region included in the study. "Regional scan" reports were developed to serve as discussion documents, providing an introduction to climate science; an overview of past trends and future projections for BC and the region of focus; and an initial list of potential impacts for the commodity of focus.

Key inputs into each regional scan included:

- → An introduction to climate science**
- → Downscaled regional climate data***
- → A compilation of results from climate trend and projection studies applicable to BC and the region of focus****
- → Specific results from a literature review of climate impacts for the specific commodity.

* Climate science is a specialized technical field. This information was "translated" in the sense of presenting this information in a form that was meaningful to this particular audience. This involved choosing which climate information was relevant and how to present it so that it could be readily understood and integrated with the knowledge of producers and other agricultural specialists.

** This was based in large part on material developed by Trevor Murdock of the Pacific Climate Impacts Consortium

*** Available from the Pacific Climate Impacts Consortium, www.plan2adapt.ca

**** This was drawn from a range of sources, most notably Rodenhuis et al. 2009

TABLE A1.2. FOCUS GROUPS REGIONS & COMMODITIES

Region	Commodity	Number
Peace	Grain	1
Interior	Cattle	2
Okanagan	Tree Fruit	1
Okanagan	Wine Grapes	1
Fraser Valley	Dairy	1
Fraser Valley	Poultry	1
Fraser Valley & Delta	Greenhouse	1
Fraser Valley & Delta	Berries	1
Fraser Delta	Field Vegetables	1
Vancouver Island	Mixed Farms	2

Focus groups

Twelve focus groups were held in nine locations around the province, each for a particular agricultural commodity and region (Table A1.2). In total, 78 producers and other industry specialists attended the sessions, an average of 7 per focus group. Participants were again selected or self-selected through communications with (and by) industry associations and networks.

Focus groups were scheduled based on recommended times (from industry specialists) for each production type, and within the limitations of the timeframe for the project.

Regional climate projections for the 2020s were summarized and presented as a scenario around which to focus the workshop. The focus group process aimed to connect the general climate science information with the specific context of on-farm and regional agricultural operations. Participants also assisted in identifying key issues and determining the relative importance of various changes and impacts from a producer perspective. The focus group sessions were between four and six hours long.

Focus Group Agenda

9:00–9:30	Introduction
9:30–10:20	Climate Background & Discussion
10:20–10:35	Break
10:35–11:45	Climate Scenario & Impacts Discussion
11:45–12:00	Rating Top Issues
12:00–12:30	Lunch
12:30–2:15	Degree of Impact, Manageability Exercise
2:15–2:25	Break
2:25–2:50	Priority Actions & Recommendations
2:50–3:00	Wrap Up

Analysis

All interviews were recorded, and detailed notes were taken. Notes were then coded and a thematic analysis was conducted to develop an overview of ability to adapt (adaptive capacity) and current issues for the industry and each region/commodity of focus.

Focus group notes were taken by a minimum of two people. These notes were compiled and analyzed to identify key risks and opportunities, characterize manageability and degree of impact for these issues, and generate priority actions and recommendations for 1) the agriculture industry at a provincial level, and 2) each region/commodity of focus.

Interview schedules — producers

- Please describe your operations, including location, type, and general characteristics.
  - a) How long have you been farming, at this location and altogether?
  - b) Characterize size of your farm (small/med/large)
  - c) What markets do you sell to? (local, provincial, national, export)

- In the past ten years or so, have you seen any particularly good years for your operations?
  - a) What factors made it a good year?
  - b) In what ways did this impact your operations?
  - c) How did you respond to the situation?
  - d) Did this change anything about your operations in the short term (e.g., next season) and in the long term?

- In the past ten years or so, have you seen any particularly challenging years for your operations?
  - a) What factors made it a challenging year?
  - b) In what ways did this impact your operations?
  - c) How did you respond to the situation?
  - d) Did this change anything about your operations in the short term (e.g., next season) and in the long term?

- What types of weather-related issues have created the biggest challenges or opportunities for your industry, or your own operations, in this region?
  - a) In what ways have operations been impacted?
  - b) How did you or other producers in your region respond to these situations?
  - c) Looking back, is there anything you would have done differently? Why?
  - d) In what ways have you or others in the industry accounted for those issues in their operations over the long-term? Has the industry made any changes to manage these risks?

- Are there other off-farm resources that you draw on during challenging times or to take advantage of opportunities that we've been discussing (especially for weather- and climate-related issues)? Some examples:
  - a) Information sources?
  - b) Technologies?
  - c) Government programs?
  - d) Extension/specialized support?
  - e) Financial programs/strategies?
  - f) Other networks/organizations
  - g) Social connections among producers?
  - h) Others?
  - i) Any that are not available, that you feel are needed?

- Are associations, government or other organizations important to how you access these types of off-farm resources? Which ones do you work with, and why?

- What are the most significant weather- or climate-related challenges and opportunities for your industry and your own operations that you anticipate over the next 10 years?
  - a) Do you feel these issues are manageable?
  - b) What are the key barriers to managing these issues effectively?
  - c) What other support would be helpful?

- Have you taken any actions so far, to prepare for some of these future challenges and opportunities?

- If you (or other producers you know of) aren't taking actions to manage some of these future challenges currently, what kinds of things would motivate or enable you to take early action?

- How would you characterize the long-term prospects of your industry, and its ability to adapt to changing conditions?

Interview schedules — specialists

- Tell me about yourself (job title, your area of specialization, regions you work in, history working with industry)
- Please describe operations in your region/commodity, including location, type, size, and general characteristics.
- Are the associations quite active? Are there other ways that producers share resources and information for managing risks?
- Do you know of any big shifts and changes in the industry in the recent past? In response to what influences? Was the response successful, why/not?
- What types of weather-related issues have created the biggest challenges or opportunities in your region/commodity in the past years?
  a) How do these issues impact operations?
  b) How has the region/industry responded to the situation?
  c) What types of off-farm resources do producers have access to, for managing or capitalizing on these issues? Some examples:
    - → Technologies?
    - → Government programs?
    - → Extension/information support?
    - → Financial programs/strategies?
    - → Other networks/organizations
    - → Social connections among producers?
  d) Has this changed anything about operations in your region/commodity in the long term?
  e) Do you know of specific examples of responses by individuals that are particularly successful?
  f) Are those responses likely to be taken up by other producers? Why/not?
- How does this region/commodity compare to others in BC that you know of, in terms of current challenges and opportunities, and long-term prospects? What major factors influence this? Does the sector have the capacity to manage/capitalize?
- Are producers talking about climate change impacts? Have you heard any requests for support in dealing with impacts of climate change, more frequent/intense extreme weather, etc?
- What are the major challenges and opportunities that you see for operations in your region/commodity over the next 10 years?
- How would you characterize the ability of the industry to adapt to changing conditions?
- What do you see as the main barriers to producers' or the sector/region's ability to manage those challenges and take advantage of opportunities in the coming years?
- What do you see as key ways that producers or the sector/region could be supported to manage risks and take advantage of opportunities in the coming years?
- What seems to make the difference between producers who respond to challenges or opportunities by innovating, versus those who end up leaving the industry?

APPENDIX 2:
Select Government Agencies: Roles Pertaining to Agriculture

Agency	Role
Federal Government	
Agriculture and Agri-Food Canada	Provides information, research and technology, policies and support programs to agriculture and agri-based products sector
Business Development Bank of Canada	Provides financing, consulting services, access to venture capital
Canada Agricultural Review Tribunal	Review of notices of violation issued by federal agencies regulating agriculture and food.
Canada Border Services Agency — Public Safety Canada	Programs, services and regulations on all import and export requirements
Canada Revenue Agency (CRA)	Taxation related to agriculture
Canadian Centre for Occupational Health and Safety	Workplace health and safety
Canadian Dairy Commission	Coordinates federal & provincial dairy policies and creates a control mechanism for milk production
Canadian Food Inspection Agency	Responsible for public health risks associated with the food supply and transmission of animal disease, labelling and packaging, meat inspection, animal health, risks of and inspection for invasives
Canadian Transportation Agency	Handles complaints from shippers about federally-regulated air, rail and marine transportation
Citizenship and Immigration Canada	Laws and policies that govern Canada's immigration and citizenship processes (i.e. temporary foreign workers)
Environment Canada	Environmental protection of water, air, soil, flora and fauna; migratory birds and species at risk protection; meteological information & forecasting
Export Development Canada	Insurance and financial services, bonding products and small business solutions to Canadian exporters and investors and their international buyers
Farm Credit Canada	Provide specialized and personalized business and financial services and products to farming operations and related businesses
Farm Products Council of Canada	Oversee the national supply management agencies for poultry and eggs
Fisheries and Oceans Canada	Management and authorizations regarding fisheries, habitat and aquaculture; aquatic species at risk
Health Canada	Govern the sale and advertisement of food, natural health products sold in Canada, consumer product safety, Hazard materials info, pesticide registration and residue limits; labour code; food and feed inspection; labelling requirements for food
Industry Canada	Provide regional & rural development, innovation, economic & marketing research, business tools
Public Health Agency of Canada	Develop food safety standards and policies to help minimize the risk of foodborne illnesses.
Statistics Canada	Provide statistical information and analysis about Canada's economic and social structure
Transport Canada	Rules and regulations governing the safe operation of commercial vehicles, drivers and operators; transport of dangerous goods
Western Economic Diversification Canada	Promote the development and diversification of the economy of Western Canada through grants and contributions programs

Agency	Role
Provincial Government Ministries	
Agriculture	Agriculture, aquaculture and food industry development; animal health and crop/plant protection; food safety; crop insurance; range policy; ALC; FIRB
Community, Sport and Cultural Development	Responsible for local government governance; Farm Assessment Review Panel, BC Assessment
Environment	Air, land & water quality standards; pollution prevention and waste management; species at risk; conservation enforcement; climate action; flood management; emergency response
Finance	Tax collection including property, income and consumer; fiscal planning and tax policy
Forests, Lands and Natural Resource Operations	Tenures and pricing; crown land allocation and authorizations; resource roads and bridges policy; forests and range authorizations; water use planning and authorizations; drought management; wildfire management
Health	Public health planning; health regulation and licensing; Health Authorities
Jobs, Tourism and Innovation (responsible for Multiculturalism)	Regional economic and rural development; land use planning; export market development; international and internal trade policy; industry training; B.C. brand designations
Labour, Citizens' Services and Open Government	Business and personal property registries services; employment standards; occupational health and safety; Workers Compensation
Transportation and Infrastructure	Transportation planning and policy; highway construction and maintenance; commercial vehicle safety and inspections
Local Government	
Local Government	Land use planning; permitting; by-law development and enforcement; infrastructure development and maintenance

APPENDIX 3: BC Agriculture Business Risk Management Programs

At present, a significant portion of the funding that is available to assist BC's agricultural producers through the provincial government and federal governments is earmarked as part of the Business Risk Management "portfolio."[111] This area incorporates a number of funding and financial support programs intended to assist agriculture by stabilizing farm incomes or providing compensation when losses occur.

Production insurance

Production insurance is intended to provide financial protection against crop losses due to uncontrollable weather. Compensation is paid out to ease financial hardship for producers who have experienced losses.

AgriStability

As the name suggests AgriStability is intended to help buffer farmers from shifts in farm income that occur because of changes in market conditions, production losses or increased production costs. Payments to producers are calculated based on a reference margin for three of the past five years of income (lowest and highest margins are dropped). Producers may qualify for payment when the a production year's margin (program margin) falls more than 15% below the reference margin.

Advance payments program

The Advance Payments Program is a financial loan guarantee program which is intended to improve producer access to credit by providing cash advances on the value of their agricultural products during a specified period. The federal government guarantees repayment of the cash advances issued to farmers by producer organization. The guarantees help the producer organizations to borrow money from financial institutions at a lower interest rate and to issue producers with cash advances on the anticipated value of their farm product under production or in storage.

AgriInvest (AI)

AgriInvest is intended to assist producers with managing small income declines and supports investments to mitigate risks or improve income. Producers are able to make annual deposits of up to 1.5 percent of their Allowable Net Sales and then receive a matching contribution (from federal and provincial governments).

AgriRecovery

When assistance is needed beyond existing programs, AgriRecovery provides producers affected by disasters with assistance to help to take quick action to mitigate impacts of the disaster and resume with business operations as quickly as possible. Disasters are assessed on a case-by-case basis (including extreme weather, disease, pests).

APPENDIX 4: Glossary

The following are principally based on definitions provided by the Pacific Climate Impacts Consortium, accessible at http://pacificclimate.org/glossary *and* http://www.plan2adapt.ca

Climate

Climate in a narrow sense is usually defined as the average weather. The classical method for averaging climate variables is 30 years, as defined by the World Meteorological Organization. This typically describes variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. [IPCC Fourth Assessment, Working Group I, Appendix I Glossary, p. 942]

Climate Change

Climate change refers to a change in the state of the climate. This is identified (e.g., by using statistical tests) by analyzing changes in averages or in climate variability that occur over an extended period, typically decades or longer. [IPCC Fourth Assessment, WG I, Appendix I Glossary, p. 943]

Climate Model

A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes [IPCC Fourth Assessment, WG II, Appendix I Glossary, p. 872]. The results of climate models can be presented in forms such as numbers, tables, graphs, or maps.

Two main types of models that are used in climate impact modelling, are Global Climate Models and Regional Climate Models. Global climate models generate results based on approximating the dynamics of the entire climate system. Regional climate models use ***downscaling*** techniques to represent climate variables at a local- to regional-level.

Climate Projection

A climate projection, as described in this report, is a representation of the climate at a future point in time, developed by using ***climate models***. The term "projection" is used instead of "prediction" because climate projections depend upon the emission/concentration scenario used, which is based on assumptions about future socioeconomic and technological developments. In this report, results are typically based on the mid-range of emissions scenarios, and/or the combined results of a number of emissions scenarios. [IPCC Fourth Assessment, WG I, Appendix I Glossary, p. 943]

Climate Variability

Climate variability refers to variations in the average state of the climate on time scales beyond that of individual weather events. ***ENSO*** and ***PDO*** are examples of climate variability on a time scale of years, or decades, respectively. [IPCC Fourth Assessment, WG I, Appendix I Glossary, p. 944]

Downscaling

Downscaling is a method that produces local- to regional-scale (10 to 100 km) information from larger-scale models or data analyses. [IPCC Fourth Assessment, WG I, Appendix I Glossary, p. 944]

El Niño-Southern Oscillation (ENSO)

ENSO is one of two large-scale atmospheric-ocean phenomena have a particular impact on climate and weather in British Columbia (the other is PDO). ENSO has two phases, ***El Niño*** (warm) and ***La Niña*** (cold), that shift based on ocean temperatures in the equatorial region of the Pacific Ocean. These phases occur in approximately three and seven year cycles, and effects are most pronounced in winter and spring. Compared to La Niña years, conditions in BC during El Niño typically include:

Warmer temperatures from December to June. The Peace region experiences some of the most significant shifts in temperature of the regions of BC, and

- Less precipitation in winter (from October through March), and more precipitation in summer and fall.
- A shift of the storm track such that it avoids southern BC

ENSO has been extensively studied, but it is unclear how this dynamic might be affected by climate change, or contribute to it. In addition, ENSO and PDO cycles overlap, and can either enhance or dampen the overall effect on weather in a given year. [Moore et al. 2007; Rodenhuis et al. 2009]

Extreme Weather Event

An extreme weather event is an event that is rare at a particular place and time of year. By definition, the characteristics of what is called extreme weather may vary from place to place. [IPCC Fourth Assessment, WG I, Appendix I Glossary, p. 945–946]

Growing Degree Days (GDD)

Growing Degree Days (GDDs) indicates the amount of heat energy available for plant growth, useful for determining the growth potential of crops in a given area. It is calculated by multiplying the number of days that the mean daily temperature exceeded 5°C by the number of degrees above that threshold. For example, if a given day saw an average temperature of 8°C (3°C above the 5°C threshold), that day contributed 3 GDDs to the total. If a month had 15 such days, and the rest of the days had mean temperatures below the 5°C threshold, that month would result in 45 GDDs. [www.plan2adapt.ca]

Pacific Decadal Oscillation (PDO)

The Pacific Decadal Oscillation is the second large scale atmospheric-ocean phenomenon that significantly impacts the climate and weather in BC. Like ENSO, there are distinct "warm" and "cool" phases of PDO, but these phases last for 20 or 30 years. Compared to the cool phase, conditions in BC during the PDO warm phase typically include:

- Warmer winter temperatures
- Less precipitation in the mountains and interior (also reducing snowpack)

During the negative phase, the jet stream shifts such that arctic outflow events are more frequent, leading to lower air temperatures in BC. The warm phase of PDO enhances El Niño effects, and the cool phase of PDO enhances La Niña effects. When the two phenomena are in opposite phases, effects can be dampened. [Rodenhuis et al. 2009; Moore et al. 2007]

Runoff

The water that travels over the land surface to the nearest surface stream; runoff of a drainage basin that has not passed beneath the surface since precipitation. [IPCC Fourth Assessment, WG II, Appendix I Glossary, p. 881]

Scenario

A plausible and often simplified description of how the future may develop, based on a coherent set of assumptions. Scenarios may be derived from ***projections***, and are often based on additional information from other sources, sometimes combined with a narrative storyline. [IPCC Fourth Assessment, WG I, Appendix I Glossary, p. 951]

Snowpack

Snowpack is the snow that accumulates on land over the course of a season. It is commonly measured in terms of "snow water equivalent" which is the amount of water that would remain if that amount of snow were melted.

Streamflow

Water flow within a river channel, for example expressed in cubic metres per second. [IPCC Fourth Assessment, WG II, Appendix I Glossary, p. 881]

Water Deficit

When precipitation and soil moisture fall below the amount needed for full plant growth.

Endnotes

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