Agriculture Adaptation Planning

A Proposed Guide for Climate Change Adaptation Planning in British Columbia Agriculture Sectors

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AGRICULTURE ADAPTATION PLANNING:
A PROPOSED GUIDE FOR ADAPTATION PLANNING IN BRITISH COLUMBIA AGRICULTURE SECTORS

by

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Executive Summary

The British Columbia Agriculture and Food Council Climate Action Plan outlines several goals geared toward addressing climate change in the agriculture industry, both through adaptation and mitigation. One of the goals is to assist in the development of commodity-based adaptation plans. This project attempts to aid in the development of these plans by providing a supportive framework for commodity adaptation planning through a proposed guide.

A conceptual framework is created through a brief academic review of adaptation planning. The conceptual framework is based on the fact that agriculture is a Social-Ecologic System, as defined in peer reviewed literature, and the components of the system contribute to its ability to adapt. The conceptual framework is further developed with fundamental principles of adaptation as defined in the literature.

The practical basis for the guide is derived from three decision-making frameworks which are detailed in this report. Practical components of each of these frameworks is applied to the guide. The guide illustrates the recommended process through a hypothetical planning process for on-farm water management. Brief descriptions and examples of tools are provided in sections throughout the guide.

The scope of this paper provides room for only a basic framework for agricultural climate adaptation in British Columbia. The proposed guide can be further detailed or expanded in the future. The guide provides producers and farm organizations with basic climate data and resources, as well as a framework and methods for utilizing the data for adaptation planning.

The project at large helps to meet the growing demand for industry specific climate adaptation planning. It demonstrates the process through which the concepts of good adaptation and a reliable planning processes can be catered to specific sectors. Agriculture is a sector particularly vulnerable to any shifts in climate or ecological systems. This project is an important step forward in thoughtfully addressing pending changes in climate and the associated impacts to agriculture.

Key Terms

Alternative: In this guide, an alternative is a choice, tool, mechanism, or agenda for adaptation to climate change. The literature uses many terms for this, and throughout the guide it may be referred to as an option, an adaptation measure, or simply a choice; all terms are interchangeable.

Climate Change Adaptation: The British Columbia Agriculture Council defines climate change adaptation as "the response (of individuals, groups and governments) to actual or anticipated changes in climate" (BC Agriculture Climate Change Action Plan, 2010).

Climate Change Projection: In keeping with the format of the Climate Action Initiative, this document uses the word projection over the commonly used word prediction. A projection is defined by the Climate Action Initiative as a representation of the climate at a future point in time, developed by using climate models based on current socio-economic trends (Climate Change Adaptation Risk and Opportunity Assessment Report, 2012).

Risk: Generally speaking, a risk is a threat to an outcome that we value. Since a value can range from measurable ends, such as gross domestic product, to immeasurable ends, such as well being, risk is not always easily defined or calculated (Fischhoff and Kadvany, 2011).

Stakeholder: Stakeholders are defined in the Strategic Planning framework (described in this report) as "interested, affected, and influential individuals, organizations, governments or agencies with a stake in, or influence on, the planning outcome" (EcoPlan International and UN HABITAT, 2005)

Introduction

Goal of the Project

Climate change projections and associated impacts to agriculture in British Columbia have been explored at a broad level throughout the Province. In March of 2012 the British Columbia-based Climate Action Initiative released "The BC Agriculture Climate Change Adaptation Risk + Opportunity Assessment Provincial Report" (referred to herein as the Risk and Opportunity Assessment). The Risk and Opportunity Assessment identifies impacts, risks, and opportunities and provides recommendations for moving forward with adaptation measures and strategies.

This project aims to assist in the next steps of agricultural adaptation in the Province. The concepts of climate change in relation to agriculture, as well as the qualities of good adaptation planning are reviewed. Through this review a conceptual framework for agricultural adaptation planning is created. A practical basis for an adaptation planning guide is provided through three decision-making frameworks. The conceptual framework and the practical applications are developed into a proposed guide for adaptation planning in the agricultural industry.

Purpose of the Guide

In keeping with the industry goals identified in the "British Columbia Agriculture and Food Council Climate Action Plan," detailed in the following section, the guide aims to assist in the development of commodity-based climate change adaptation planning. This is done in two broad sections, outlined below.

Section 1 identifies the context for climate change adaptation planning for agriculture in British Columbia by summarizing three key components:

- a brief history and current state of the industry;
- projected changes in regional climate patterns and;
- the programs in place to mitigate risk and adapt.

Section 2 provides sequenced guidelines influenced by three decision-making frameworks that can be used by producers or farm organizations in the development of adaptation plans, strategies, or actions. The guidelines are organized in six basic steps:

- defining the context and the manageable "whole";
- creating commodity-based vulnerability assessments;
- identifying broad goals, values, and objectives;
- creating alternatives;
- evaluating alternatives;
- implementing, monitoring, and iterating.

As noted in subsequent sections, the guide is flexible and is intended to assist in both developing new adaptation plans or incorporating adaptation strategies or actions into current initiatives. It may be used at a variety of scales from broad, for instance developing commodity-wide strategies, to specific, for instance, creating on- farm water management plans.

Supporting BC Agriculture and Food Council Climate Action Plan

The British Columbia Agriculture and Food Council has taken an active role in addressing the issues of climate change and the associated impacts to the agriculture industry. "The BC Agriculture and Food Council Climate Action Plan," referred to herein as the Climate Action Plan, outlined several goals geared both toward climate adaptation and mitigation in the industry. Goal 1.1 under the section titled, "Adaptation, Strengthening Resilience" is to: "Improve the state of knowledge regarding risks and opportunities associated with climate change," the details of this goal are further described in *figure 1*.

The Risk and Opportunity Assessment was carried out over the summer and fall of 2011 to fulfill the primary initiative of this goal. The full report was released in March of 2012. It identifies climate risks, opportunities, and uncertainties within the BC agriculture industry. A secondary initiative of Goal 1.1 is to "Facilitate the development of commodity-based climate change adaptation plans." The specifications of this goal are outlined in *figure 1*. As described previously, the guide proposed in this project will aid in achieving the objective: "implementation of a supportive framework for commodity adaptation planning."

figure 1: Climate Action Plan Goal 1.1

Goal 1.1
Improve the state of knowledge regarding risks and opportunities associated with climate change
Strategy 1.1.1- Assess the risks/opportunities, for agricultural production in BC, associated with climate change
Action b- Facilitate the development of commodity based climate change adaptation plans by:

1. ***Developing template commodity based climate change adaptation plans***
2. ***Identifying (technical and financial) mechanisms to facilitate/support commodity-based planning***
3. ***Facilitating a pilot project for commodity adaptation plans***

Priority: 1
Timeline: August 2011 to August 2013
Leaders: Climate Action Initiative, industry associations
Potential partners: Investment Agriculture Foundation, BC Agriculture Council, Ministry of Agriculture and Lands
Indicators of Success:

- ***Improved understanding of regional vulnerabilities/capacities/needs for agricultural adaptation in BC***
- ***Application of improved knowledge to inform agricultural adaptation priorities***
- ***Implementation of a supportive framework for commodity adaptation planning***
- ***Participation of commodity groups in adaptation planning***
- ***Increased availability of weather data that meets the needs of agricultural producers (for decision-making purposes)***

01 Review of Climate Change and Agriculture

Before creating tools for assisting in adaptation, it is important to first understand why adaptation is necessary. To explain why the industry needs to consider adaptation planning this section explores the current state of the agriculture industry and projected impacts of climate change.

The global agriculture industry faces an uncertain future, British Columbia is no exception. Globalization has already altered the institution of agriculture at large. Year-round availability of many types of food products and increased communications pertaining to food choices have shifted consumer demand (Caswell, 2005). The rocky global economy will likely bring more threats and perhaps opportunities in the coming years. Additionally, global population could reach more than 10 billion by the end of the century (UNFPA State of the World Population, 2011). Such major global changes will likely lead to more institutional changes in agriculture as governments review trade policies, food and growing regulations, and food assistance programs.

The structure and state of the industry has seen major shifts in recent years as well. British Columbia has experienced a steady increase in farm size, up 17.1% since 1981, accompanied by a 7.1% decrease in the number of farms since 1996 (2001 Census of Agriculture). From 2006 to 2011 the number of census farms in BC dropped 10.6% (2011 Census of Agriculture). Continued conglomeration of farms will likely decrease the diversity of land use cover and crop type and species. This general decrease in diversity could in turn reduce the resiliency of the industry as a whole and its ability bounce back from unanticipated shocks (Ostrom, 2009). There are presently growing movements to create smaller farms[1], but the political and economic climate today make that difficult. The age of the average farmer is on the rise; only 5.9% of farmers in 2006 were under the age of 35, while 45.3% were over the age of 55 (Statistics Canada, 2009). Though there seems to be some inclination in younger generations to take on farming[2], the costs and risks associated with making a living through the industry are daunting and make it difficult to break in.

In addition to growing institutional uncertainty and the increasing structural fragility of the industry, BC agriculture faces the same climate change projections as all other industries. Agriculture will be affected by climate change in many different ways depending on geographical, political, and institutional variables. Generally speaking productivity and geographic distribution of crop species is expected to change due to increasing temperatures, changes in water resources, and changes in the patterns of extreme events (Rosenzweig, 2007, Ostry, 2010). Changes in climate and specific impacts will vary from region to region.

British Columbia at large is projected to see a range of climactic changes: 2°-7°C increase in average temperature; glacial retreat; reduced snowfall; permafrost melt; changes in precipitation patterns and increased instances of storm surges; sea level rise of 0.1-1.0 meters; and changes in patterns of extreme events (BC MOA, Environmental Farm Plan Reference Guide, Chapter 12, 2010). These changes are projected to alter ecosystems and ecosystem services that the agriculture industry depends on.

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1 Urban farming in the Lower Mainland has seen a great deal of support through local and regional policies such as the Greenest City 2020 initiative in Vancouver. The number of farms in the Province under 10 acres increased from 5,335 in 2006 to 5,824 in 2011.

2 Interest is evident in the active BC Young Farmers Association and the BCAC Young Farmers Program.

Specific impacts to agriculture that are likely to occur as a result of these changes include: new pests and diseases; extreme events like wind and hail; sudden frosts or burning temperatures; and, perhaps most notably, changes in water resource availability (Ostry, 2010, BC MOA, Environmental Farm Plan Reference Guide, Chapter 12, 2010)[3]. While there are defensible projections for changes in temperature, precipitation, and extreme weather events, the exact changes are uncertain, and the associated impacts are even vaguer.

It is important to note that while agriculture will be impacted by climate change, research shows that the industry itself plays a role in contributing to human-driven climate change through greenhouse gas (GHG) emissions (IPCC Fourth Assessment Report, Working Group II, 2007). The British Columbia agriculture industry is a relatively small contributor to GHG emissions. The 2010 BC Greenhouse Gas Inventory Report estimated that agriculture was directly responsible for only 3.5% of emissions in the province (down 11.7% from 2007). The Climate Action Plan discusses goals centered around both mitigation through GHG emission reduction and adaptation. While mitigation and adaptation are interconnected and actions related to both will likely occur simultaneously, the scope of this project allows only for the discussion of research and measures associated with adaptation to climate change impacts.

Given the current state of the agriculture industry and the impending changes to the ecological system it functions in, producers and decision-makers in BC need to thoughtfully consider how to improve the state of the industry and determine how it will function within a new and unfamiliar ecological system. This implies that agricultural sectors need to go beyond considering means to cope with changes in climate and begin considering ways in which they can improve current function and adapt to a new environment. Producers will need to create strategies that can deal with both short and long term changes. They will need an adaptation planning process that will incorporate flexibility given the high degree of uncertainty associated with climate change, as well as the potential impacts from other institutional and structural variables such as those mentioned above.

3 Detailed regional climate change projections and impacts will be identified in section 1 of the guide and further in Appendix 1.

02 Methods

The approach for developing a defensible and useful guide for commodity adaptation was carried out in two basic steps: first through the creation of a simple conceptual framework and, second, through the application of predefined practical frameworks. Adaptation planning fundamentals and principles were reviewed to provide the basic conceptual framework. Three decision-making frameworks serve as the practical basis for the proposed guide. Each of the frameworks is described in brief and catered to the specific needs of the guide and related to the conceptual framework.

Conceptual Framework: Fundamentals of Climate Change Adaptation Planning

In the Climate Action Plan, adaptation is defined as the response of individuals, groups, or governments to actual or anticipated climate change. Adaptation is prevalent in international research and policy development, and has been increasingly integrated into Canadian and British Columbian policies and programs in recent years[1]. Process and practices range greatly across the board and having a well defined approach is necessary for success.

This section provides a review of recent literature and summarizes the basic concepts, principles, and applications of adaptation planning. Additionally, it relates the principles and applications to the agriculture industry in British Columbia and explains how they are incorporated into the proposed guide in the subsequent sections of this project.

A widespread theme among adaptation planning, especially in the agriculture industry, is that successful adaptation will have less to do with specific changes in climate and more to do with the social structures of the system attempting to adapt and the decision-making process that determines the outcome (Lemmen and Warren, 2004). Indeed, Adger et al (2007) argued that any limits to adaptation originate from societal values, ethics, knowledge, attitudes to risk, and culture (Adger et al, 2007 p. 338-339).

For this reason, many climate change adaptation researchers have given focus to the concept of Social-Ecologic Systems (SES). SESs are defined by Anderies et al. (2004) as social systems in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non-human biological units. Olstrom (2007) provides a framework for SES made up of six main elements, these are detailed in *figure 2* below.

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1 Evident in broad strategies such as the Ministry of Environment Climate Action Plan and the Living Water Smart initiative, and in more localized efforts such as the Adapting to Climate Change in Forest Management program and the Mountain Pine Beetle Action Plan.

figure 2: Elements of SESs (from Olstrom, 2009 p. 421)

Social, economic, and political settings (S)
S1 Economic development. S2 Demographic trends. S3 Political stability.
S4 Government resource policies. S5 Market incentives. S6 Media organization.

Resource systems (RS)
RS1 Sector (e.g., water, forests, pasture, fish)
RS2 Clarity of system boundaries
RS3 Size of resource system*
RS4 Human-constructed facilities
RS5 Productivity of system*
RS6 Equilibrium properties
RS7 Predictability of system dynamics*
RS8 Storage characteristics
RS9 Location

Governance systems (GS)
GS1 Government organizations
GS2 Nongovernment organizations
GS3 Network structure
GS4 Property-rights systems
GS5 Operational rules
GS6 Collective-choice rules*
GS7 Constitutional rules
GS8 Monitoring and sanctioning processes

Resource units (RU)
RU1 Resource unit mobility*
RU2 Growth or replacement rate
RU3 Interaction among resource units
RU4 Economic value
RU5 Number of units
RU6 Distinctive markings
RU7 Spatial and temporal distribution

Users (U)
U1 Number of users*
U2 Socioeconomic attributes of users
U3 History of use
U4 Location
U5 Leadership/entrepreneurship*
U6 Norms/social capital*
U7 Knowledge of SES/mental models*
U8 Importance of resource*
U9 Technology used

Interactions (I) → outcomes (O)
I1 Harvesting levels of diverse users
I2 Information sharing among users
I3 Deliberation processes
I4 Conflicts among users
I5 Investment activities
I6 Lobbying activities
I7 Self-organizing activities
I8 Networking activities

O1 Social performance measures (e.g., efficiency, equity, accountability, sustainability)
O2 Ecological performance measures (e.g., overharvested, resilience, bio-diversity, sustainability)
O3 Externalities to other SESs

Related ecosystems (ECO)
ECO1 Climate patterns. ECO2 Pollution patterns. ECO3 Flows into and out of focal SES.

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*Subset of variables found to be associated with self-organization.

The SES outline provides a foundation for adaptation. It helps to define the entire system and identifies the components of an adaptation planning process. Using SES as a foundation for the planning process will help to ensure the elements that will most influence successful adaptation, such as user variables, governance systems, and social characteristics are included when considering options for adaptation. The decision-making frameworks that serve as models for the proposed guide, described in detail in the following section, give attention to the many components of SESs.

With a basic foundation for adaptation defined, the Social-Ecologic System, the next step towards preparing a guide for the planning process is to define the overarching principles of climate change adaptation. The United Nations Development Programme released the report, "Adaptation Policy Framework for Climate Change" in 2004 (referred to herein as the UN Framework for Adaptation). The framework is centered around four broad principles:

- adaptation to short-term climate variability and extreme events serves as a starting point for reducing vulnerability to longer-term climate change;
- adaptation occurs at different levels in society, including the local level;
- adaptation policy and measures should be assessed in a development context; and
- the adaptation strategy and the stakeholder process by which it is implemented are equally important.

These four principles will be key in commodity-based adaptation planning, and will permeate through the guide proposed in this project. Perhaps the most crucial is the final principle which highlights the importance of the stakeholder process, this places a great deal of emphasis on an inclusive, thoughtful, and transparent process that the proposed guide is intended to facilitate.

An academic review of climate adaptation approaches (Füssel, 2007) outlines five principles for adaptation planning that were most evident in available literature. Though they are related to the UN Development Programme's framework, there is an added degree of detail. The principles (Füssel, 2007, p.273) are adapted below to the context of climate change adaptation planning in the agriculture industry and provide sound justification for allocating resources to adaptation planning as recommended in the proposed guide.

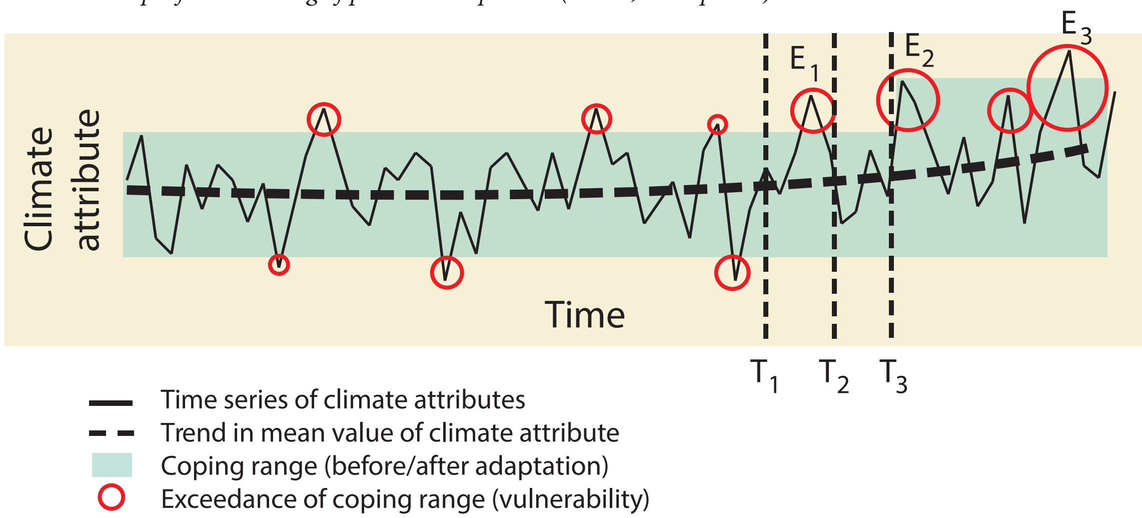
The importance of climate change over other projected changes: There is a significant need for a more detailed assessment of the localized impacts of climate change to the agriculture industry. Though socioeconomic factors will be important in determining the ability of the industry to adapt, the long-term sustainability of the industry is highly dependent on the quality of land, season length, vulnerability to extreme events, and especially accessibility, availability, and quality of water (Wall, Smit, and Wandel, 2007). However, globalization, international trade agreements, development policies, and market fluctuations have a noteworthy impact and should not be externalized when creating adaptation plans.

Better knowledge of specific risk allows for better action planning: Though more research is necessary and has been called on for regional climate change projections and associated impacts to British Columbia agriculture, there is substantial regional data and potential impacts have been hypothesized[2].

Less experience in managing risk equates to a greater need for action: Agriculture has historically handled a number of climate related risks, and is therefore arguably more prepared than other industries (Lemmen and Warren, 2004). However, there are factors that negate this experience and may prove to provide a false sense of ability to cope. Severity of projected changes and the ambiguity of timing creates unprecedented uncertainty. Many scientists and researchers are projecting changes that will fall outside of producers' historical ability to cope. This recent research is often termed as a loss of stationarity, it is illustrated in *figure 3*. Stationarity is pertinent in the context of agriculture because the industry relies on climate conditions that fluctuate within a known range.

2 The Pacific Climate Impacts Consortium provides climate change projections for regional areas of BC for 2020, 2050, and 2080. Research conducted for the Climate Action Initiative Risk and Opportunities Assessment identifies potential impacts to agriculture based on these projections and local and international research.

figure 3: Hypothetical example for the timing of planned adaptation (Füssel, 2007 p. 267)



Effective adaptation manages short-term impacts concurrently with long-term strategies: Many areas of British Columbia have been dealing with climate impacts since settlement. Drought in the northern and southern interiors, extreme frosts and heat around the province, and flooding and extreme storms in the Lower Mainland are just a few examples. Such risks are well documented and often have political or institutional programs or physical infrastructure in place to alleviate the impacts[3]. The proposed guide and methods provides a means to identify measures already in place and promotes planning that will effectively use such measures in the short term and incorporate them into a long term strategy through expansion or improvement.

Low-regret or no-regret alternatives do not require high levels of certainty in projected risk: There are numerous strategies that could be considered low or no cost, both in a monetary and non-monetary sense. The proposed guide encourages scenario planning to identify alternatives that achieve a desired outcome in multiple scenarios and prioritizing "low-hanging fruit" alternatives or adaptation options that build capacity and provide initial success and stakeholder support.

Beyond having a general understanding of the principles of adaptation planning, it is also necessary to acknowledge that there are features common among documented successful adaptation planning. In addition to the principles described above, Füssel provides a solid list of prerequisites for effective planned climate change adaptation. *Table 1* describes each of these prerequisites.

table 1: Prerequisites of effective adaptation planning (from Füssel, 2007)

Prerequisite	Definition
Awareness of the problem	Assessing and communicating vulnerability to climate change
Availability of effective adaptation measures	Triggering research that may lead to the development of new adaptation options

3 Examples range from the Okanagan Basin Water Board, an institution that helps to handle water risks in the region, to the dikes, a physical infrastructure surrounding areas of the lower mainland, that help to mitigate impacts from extreme weather events.

Information about these measures	Identifying and assessing effective adaptation measures
Availability of resources for implementing these measures	Evaluating co- benefits of adaptation (thus increasing perceived benefits) identifying ways for the most efficient use of resources, e.g. By mainstreaming adaptation in existing activity (thus reducing costs); and motivating the provision of additional resources, either domestically or internationally
Cultural acceptability of these measures	Educating people about risks and response options to increase the acceptability of unfamiliar measures

The prerequisites are incorporated into the proposed guide at multiple steps of the process. For example, the prerequisite of ensuring cultural acceptability of a measure, is incorporated in both the initial step of developing an alternative or adaptation option, and the later step of evaluating and monitoring a chosen option. This is because cultural acceptability would be an important criteria in both the development of ideas and determining their success. As described in the proposed guide, these prerequisites are explicit in certain steps, but most of them must permeate throughout the process. For instance, it is important to frequently communicate awareness of the problem throughout the course of planning as the situation may be changing or new players may be introduced at any time.

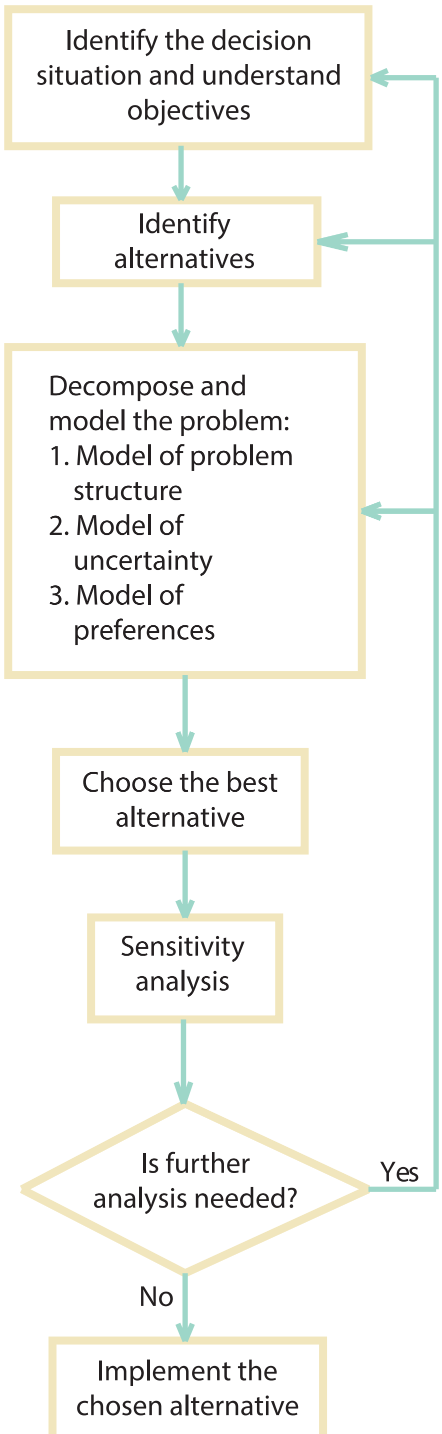
Though the concepts and principles of adaptation planning can be analytically explored at length, the fundamentals described in this section are sufficient for the purposes of this project. Climate change adaptation should be planned not simply in terms of ecologic changes, but in terms of the complex interactions of a Social-Ecologic System. There are basic principles that both qualify and justify adaptation and they are integrated throughout the guide together with the recognized elements of good adaptation. These fundamentals provide the conceptual framework for the proposed guide.

Practical Application: Decision-making Frameworks Influencing the Guide

In the previous section, a conceptual framework was created by identifying the basic concepts of climate change adaptation planning as they relate to the agriculture industry. In order to apply these concepts to the proposed guide, existing planning frameworks were catered to the unique elements of adaptation in the BC agriculture industry. Catering these frameworks provided the practical basis for developing specific steps in the proposed guide. The frameworks used were three decision-making frameworks which have been previously applied in adaptation planning and proved to be reliable. Modeling the proposed guide after these three frameworks helps to ensure that the proposed guide would be equally reliable. This section describes these frameworks and their basic application to the proposed guide.

The three frameworks are similar in structure and content. All three are related to the process of decision analysis. The basic flow of decision analysis is well represented in figure 4 (from Clemen, 2004 p. 6). The essential steps of the process are to describe the situation and the problem; create alternatives, which in the case of the proposed guide are adaptation measures; evaluate the alternatives and choose the best one, at which point iteration begins; and finally implement. The themes represented in this flowchart can be seen in each of the three frameworks described in this section as well as in the proposed guide.

figure 4: Decision analysis process flow chart (Clemen, 2004 p. 6)

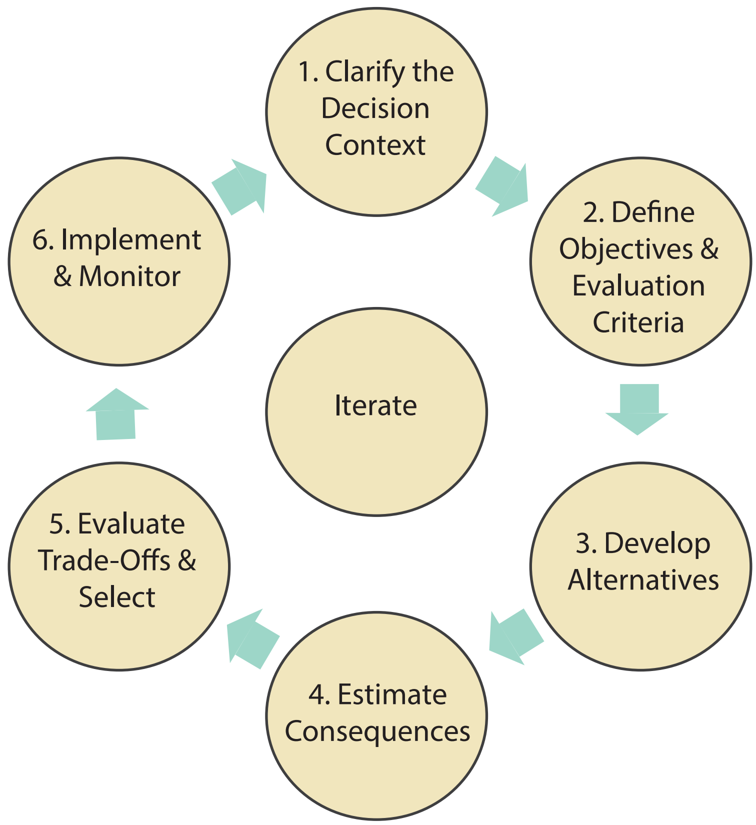


Further, all three frameworks incorporate Multiple Criteria Analysis which is a decision process that demonstrates preferences between alternatives using objectives (London Communities and local government, 2009). It is similar to Multiple Accounts Analysis and is often used as a policy analysis tool to incorporate non-monetary criteria into decision processes which otherwise focus on monetary-based approaches such as cost-benefit analysis (McDaniels, 1996).

Structured Decision-making framework

Structured Decision Making (SDM) was developed by the Climate Decision-Making Center in the Engineering and Public Policy department at Carnegie Mellon University and the Institute for Resources, Environment and Sustainability at the University of British Columbia. It is an iterative six step decision making process illustrated in *figure 5* below.

figure 5: Structured Decision Making (SDM) process (Source: www.structureddecisionmaking.org)



SDM is the primary decision-making process influencing the proposed guide. It provides the basic steps in a planning process and the tools needed to choose potential alternatives. The structure of the SDM process stems from the basic concepts of decision analysis, as defined by Ralph Keeney:

> "Decision analysis embodies a philosophy, some concepts, and an approach to formally and systematically examine a decision problem. It is in no way a substitute for creative, innovative thinking, but rather it promotes and utilizes such efforts to provide important insights into a problem" (Keeney, 1982, p. 828).

SDM is cited as a 'best practice' for decision-making and the intention of the process is to provide tools for integrating decision science and applied ecology with observations from cognitive psychology that have emerged from facilitation and negotiation processes (Gregory and McDaniels, et al., 2012).

There are a number of tools in the SDM process that are detailed at length and have been utilized and documented in successful decision-making or planning processes. A few of the tools that are highlighted in the proposed guide are described in *table 2*, derived from the SDM website.

table 2: SDM tools used in the guide (http://www.structureddecisionmaking.org/tools.htm)

Tool	Use	Description
Influence Diagrams	Graphically represents the causal relationships between decisions, external factors, uncertainties and outcomes.	Influence diagrams are created by defining what factors are at play in a given network, and how each of those factors affect the others. A simple model of boxes and arrows can represent this information in comprehensible way.
Value Models (Weighted Index)	A scale that weights and combines different impacts	Value models allow for the combination of technical scores and stakeholder values to be compared on a relative index. This is done by first creating a relative index and then determining the subjective importance of each criteria and applying weights.

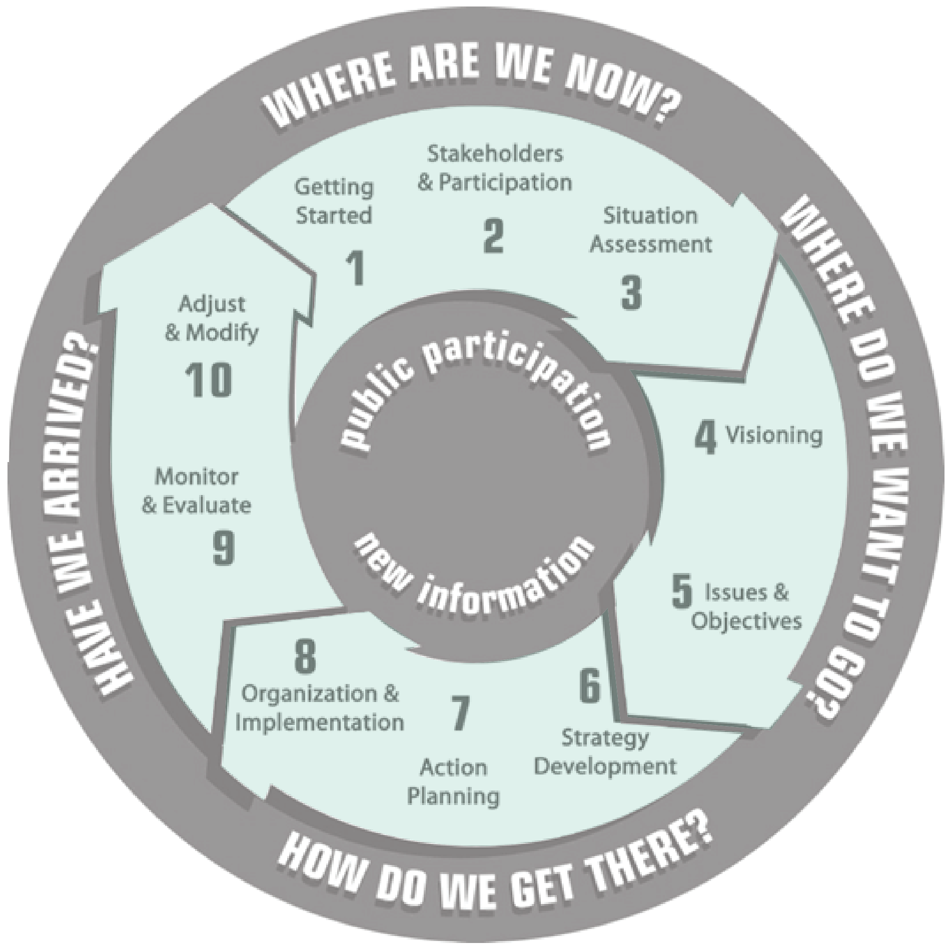
The successful use of SDM is documented in numerous scholarly articles. For example, in British Columbia SDM was successfully employed in a water-use planning process for a hydroelectric facility on the Alouette River (Gregory, McDaniels, Fields, 2001). This case provides an argument for the use of the SDM process over more commonly used dispute resolution techniques. Similarly, the SDM process was applied in an *ex post* analysis of fisheries decisions in the pacific northwest (McDaniels, 1996). The case provides an example of how multiple criteria analysis using subjective judgment can shift the decision by providing an analysis that would otherwise be overlooked.[4]

4 Further examples of the application of SDM and the tools mentioned in this section can be found at the website: www.structured-decisionmaking.org

Strategic Planning framework

The Strategic Planning framework was created by EcoPlan International Inc.(EPI) and further developed with the United Nations Human Settlements Programme (UN-HABITAT) for The Local Economic Development Series. It is a ten step iterative framework similar to the SDM framework. The ten steps are divided into four categories as illustrated in *figure 6*.

figure 6: Strategic Planning process (Source: The Local Economic Development Series, EPI and UN HABITAT)



Similar to the SDM framework, the Strategic Planning framework provides tools to complete each step of the process. The tools that are highlighted in the proposed guide are described in *table 3*, they are derived from The Local Economic Development Series and the guide, Planning for Climate Change: A Strategic, Values-Based Approach for Urban Planners released by EPI.

table 3: Strategic Planning tools used in the guide (EPI and UN Habitat)

Tool	Use	Description
Back casting and future casting	Identifying trends, helping to set a context and create possible alternatives	In collaboration with local and regional climate experts, extrapolate historical trends to model the future climate.

Vulnerability Index Mapping	Identifying vulnerable stakeholders, sectors, or geographic areas	With assistance from technical experts, overlay maps of vulnerability variables and identify hot spots for vulnerability. Incorporate local knowledge by having participants identify key components that may not be recognized in a technical analysis.
Visioning	Defines an end game and provides a point for developing objectives and alternatives	Ask the simple question: "What do you want the future to look like?"
Create objectives	Derived from a vision statement, ends and means objectives are created which provide both the basis for developing alternatives and measuring their appropriateness	This is a complex, but not necessarily complicated approach. To create ends objectives, break down the vision to specific components, things that will achieve the vision. Means objectives are then created by identifying what promotes or inhibits reaching those the ends objectives. One objective may simultaneously be both a means and an ends objective. Final clarity of such complications is not crucial, it is merely a step forward in the process and a way to trace alternatives back to the overall vision.

The Strategic Planning process is well documented and used. Several case studies demonstrate the use and success of the framework. EPI utilized the framework to create a successful water-use plan for the Coquitlam-Buntzen watersheds in British Columbia. Through the process an operating strategy was created which incorporated values from multiple stakeholders (Trousdale, Harris, and Harstone, 2002).

EPI and UN-HABITAT recently developed an urban planning guide for climate change action at the local level, Planning for Climate Change: A Strategic, Values-Based Approach for Urban Planners (Santucci, et al., 2012). The guide is geared towards urban communities in low and middle income countries. The EPI guide is based on the Strategic Planning Framework and serves as a model for the proposed guide. Though the EPI guide for urban planners is in the initial step of field testing and piloting for training, it received an honorable mention for Planning Publication in the 2011 Canadian Institute of Planners Award for Excellence in Planning.

Holistic Management framework

Though the SDM framework and the Strategic Planning Framework are the primary influences for the proposed guide, the Holistic Management Framework (Savory, 1999) provides a focus on integrated natural resource management. The steps in this framework are similar to those of the other frameworks, but place greater emphasis the ecological context:

1. Defining and verifying the goal from a holistic perspective;
2. Considering the ecosystem (water cycle, community dynamics, mineral cycle, energy flow);
3. Natural resource management tools;
4. Testing decisions (indicators and criteria);
5. Monitoring (feedback loops);
6. Guidelines for specific resource management (strategy development, rangeland management, cropping, population management);
7. Unique holistic planning procedures;
8. Trouble shooting, relevance, policy development.

The Holistic Management Framework is integrated into the guidelines in three primary ways. First, in defining a manageable whole. "A manageable "whole" must be defined by the needs of the people within it and the environment that must sustain their endeavors" (Savory, 1999 p. 47). This will be an important element of the adaptation plans. The uncertainty in climate change and the impacts to agriculture require that stakeholders have a clear goal, based on current circumstances and known variables and are willing to take ownership of that goal.

Second, the framework encourages describing a goal in terms of "four fundamental processes that are common to all environments, and through which the greater ecosystem—our ecosystem—functions." (Savory, 1999 p. 101), these are: water cycle, community dynamics, mineral cycle, and energy flow. These processes will drive the entire system and they ought to be at the center of a goal. The four fundamental components fit well with agricultural management considerations and systems thinking required for adaptation planning.

Third, Section 4 of the framework, testing decisions for implementation, provides seven test questions used for evaluating decisions. These questions are detailed in Section 5 of the guidelines for evaluating alternatives. This testing brings the process back to the original holistic goal. For example, one of the questions focused on sustainability asks, " If you take this action, will it lead toward or away from the future resource base described in your holistic goal?" (Savory, 1999 p. 268).

Additionally, the framework provides Some Practical Guidelines for Management. These are specific integrated tools and practices related to cropping and rangeland management. Though there is not room within the scope of this project to incorporate them into the proposed guide, they are noteworthy for their ability to build resilience into an adaptation plan. They should be considered for future research or further development of the guide.

A common thread among these three frameworks is their intentional ability to incorporate both societal values and technical information into a decision-making process. As described in the conceptual framework, climate adaptation planning is best carried out in the context of the Social-Ecologic System, the application of these three frameworks to the proposed guide will encourage just that. The SDM framework provided the six-step structure used in the proposed guide and the primary tools used for evaluation of potential alternatives. The Strategic Planning framework, and particularly its application in Planning for Climate Change: A Strategic, Values-Based

Approach for Urban Planners, provides process tools that work particularly well in a climate adaptation planning process as proposed in the guide. The Holistic Management framework provides a few concepts specific to ecosystem management that are not explicitly highlighted in the other two frameworks. Having an ecosystems-based approach is important to agricultural adaptation because the industry is so closely connected to land and water systems.

03 Proposed Planning Guide

The previous sections of this project reviewed the context of climate change and agriculture, developed a conceptual framework for the proposed guide, and described the three decision-making frameworks that influenced the practical basis for the proposed guide. The remainder of the project is the proposed commodity adaptation guide which is divided into two main sections: 1) History and Context, which provides the user with the basic information necessary to begin a process for commodity adaptation and 2) Guidelines for the Adaptation Planning Process.

Guide Section 1: History and Context

An initial step of the planning process is to identify the context and situation for adaptation planning. Though the scope of this project does not allow for a complete detailed review, some references will be necessary to start the process. Users of the guide can review these sections to develop a basis for the process and refer to appendices for an added level of detail.

Brief History and Current Statistics

British Columbia has a diverse agricultural history and a composition that has changed drastically over the past century. Farming has moved from a subsistence based activity to a prominent industry in the province. The industry exports over $1.2 million of agricultural products annually, employs roughly 200,000 people, and generates $11 billion in food retail sales and $1.5 billion dollars at the farm gate. It is the third largest industry in the province behind forestry and mining (BC Ministry of Agriculture, 2011).

The industry is comprised of mixed crop farms and field vegetables, grain and forage, livestock (mostly cattle, dairy, and poultry), tree fruit, soft fruit (mostly grapes and berries), and greenhouse growers. Only 4.7% of land in BC is suitable for agriculture (Walker, et al, 2008). Agricultural Land Reserve zones are used on the highest quality arable land to promote agriculture and control non-agriculture uses. There has been a documented rise in the hectares of irrigated agriculture area all over the Province since the 1996 Agriculture Census, with the exception of Vancouver Island, for which only a 2001 agriculture brief was available; it documented a small decrease in irrigated land area (2001 Agriculture Census).

The agriculture sector may face both opportunities and threats as climate projections come to fruition. Negative impacts or consequences of climate change such as new pests and diseases, water shortages, and extreme heat and frost events are common projections among climate change and industry experts and are being considered. However, the timing and severity of such impacts are unknown, making planning difficult. For example, water conservation efforts to address summer shortages are key, but may not suffice during periods of intense drought. Increased crop diversity prospects and opportunities for value added crops could be beneficial, if the industry is properly prepared for the change. Though changing crop types or species to cater to a new climate are actions often seen as opportunities, there are perceived and real risks associated with the change. For instance, low water use crops or crops suited for shorter growing seasons may not survive the market (Neilsen, et al, 2007). Further, there is a limit in the science to accurately predict these unknowns, and an even sharper limit to the time we have to identify these impacts and begin implementing adaptation strategies.

Vulnerabilities and Impacts: Regional Scans of Commodity Sectors

This section provides the user with the basic climate related vulnerabilities and impacts to regional agriculture sectors. Detailed climate data and agricultural statistics for sub-regions and associated sectors can be found in Appendix 1.

South Coastal Region

Forage crops in pasture land and cropland are vulnerable to climatic conditions in the region. Arctic outflow in the winter can damage grasses on rangeland and small fruit crops, specifically raspberries. Water deficits in the summer months require some irrigation, especially forage crops on Vancouver Island. Spring months bring the risk of low temperatures and excess moisture in the soil (Walker et al, 2008).

The winter precipitation increases in Metro Vancouver and the Fraser Valley could limit the length of the growing season and crop production levels as soils will remain water-logged into the planting season. While the hotter growing season and reduction in spring run-off may require more irrigation in the summer months and earlier harvesting times, this will have the greatest impact on field crops in the Fraser Valley and may eventually require replanting of more heat tolerant forage species. However, the drier summers may help to reduce pests and diseases associated with berry production (Walker, et al, 2008). Additionally, some areas in the region may need to deal with problems associated with sea-level rise, storm surges, and salt water inundation into agricultural areas (Zebarth, et al, 1997).

On Vancouver Island the potential for longer growing seasons due to the increased number growing degree days could lead to greater crop diversity on the Island. Notably, peppers, melons, and overwintering cabbage may become more viable. Some areas may also have a chance to implement planting strategies that incorporate double cropping. However, warmer winters, and a decrease in frost free days could lead to increased pests and diseases. Wetter springs could lead to a delayed planting season (negating the potential for longer seasons due to warmth). Snowpack water storage may decrease as winter precipitation and temperature rises, coupling this with drier irrigation seasons could lead to a decrease in crop options and quality and quantity of production, especially in the pasture lands in the Cowichan Valley and may require an increase in irrigation and water storage infrastructure (Walker, et al, 2008).

Southern Interior Region

Summer water deficits may require irrigation for tree fruits, vineyards, field crops, and pasture land. Arctic outflow in the winter can cause damage to tree fruits and vineyards. Production of forage crops can be limited by low winter temperatures (Walker, et al, 2008).

The southern portion of the region where the majority of tree fruits and soft fruits are produced may benefit from the warmer temperatures. Some studies show that the warmer summers could lead to a higher quality grape, though irrigation issues will have to be addressed as temperatures rise and spring runoff and summer precipitation decreases (Neilsen et al, 2001; Rayne et al, 2011). However, the warmer summers may damage tree fruits; timing of water availability greatly affects the quality of the fruit as well as the quantity of production (Neilsen et al, 2007). Warmer winters could provide a longer growing season, a greater option of crop varieties, and a reduced risk of cold. However, the late frosts in the early spring have potential to damage fragile fruits which may start to see earlier budbreaks, and the warmer, wetter winters may bring new pests and diseases with more life cycles. However, drier summers could ward off disease and damage the region has recently been exposed to, such as cherry splitting (Walker et al, 2008).

The northern portion of the region, where there is a great deal of pasture land and livestock production, will face similar issues to those that the lower mainland ranchers and grain producers will face. However, they may benefit more from the temperature increase and longer growing season because bigger harvests and a shift to more range grazing may be possible, but would likely require more heat tolerant species. However, any increase in production will require more irrigation, an issue that will be exacerbated by likely limitations to water supply and decreased summer precipitation (Walker, et al, 2008).

Northern Interior Region

Forage crops are the most prominent crops in the region and are vulnerable to a range of climatic variabilities. Water deficits in the summer may require expansion of irrigation. Low winter temperatures may reduce levels of production, shorten the growing season, and limit crop options (Walker, et al, 2008).

Similar to the northern portion of the southern interior region, longer growing seasons may benefit cattle and grain producers, the primary sector in the area. However, new, heat tolerant species may be required, and expanded irrigation will likely be necessary. This is a particularly pressing issue in the region, as there is limited irrigation infrastructure there now (Walker, et al, 2008).

Greenhouse Growers

Greenhouse production can be found around the province and producers don't face the same problems that other commodity sectors have. They will have the advantage of decreased heating costs as the winters get warmer and will need to consider energy efficiency and national energy polices as cooling costs rise in the summer (Walker, et al, 2008).

Agriculture and Adaptation Resources and Programs in British Columbia

In addition to having some basic knowledge about current climate and agricultural statistics and projected impacts, it is important for users of the guide to be aware of policies and programs available in the Province. Having this background information will make the initial steps of the planning process easier and will aid in creating adaptation alternatives and implementation plans. A more complete list and detailed descriptions of the following can be found in Appendix 2.

For further details about climate change and impacts refer to:
- Canadian Climate Impacts and Adaptation Network
- A New Climate for Conservation: Nature, Carbon, and Climate Change in British Columbia
- The Pacific Climate Impacts Consortium

For information about adaptation and potential strategies refer to:
- The Adaptation to Climate Change Team (Simon Fraser University)
- British Columbia's Climate Adaptation Strategy
- The Fraser Basin Council's Retooling for Climate Change

- The BC Environmental Farm Plan Program (reports and pilot projects)
- The BC Climate Action Toolkit

For potential mechanisms for funding or support refer to:
- British Columbia's Climate Adaptation Strategy
- A New Climate for Conservation: Nature, Carbon, and Climate Change in British Columbia (which encourages incentives for stewardship)
- The BC Environmental Farm Plan Program (funding environmental plans and projects)
- Ministry of Agriculture and Lands in the Business Risk Management Branch (BRMB)

For potential opportunities for collaboration refer to:
- Conservation Framework (of the BC Climate Adaptation Strategy)
- In addition to these projects and programs, adaptation guides have been created and are available to other sectors in British Columbia. Retooling for Climate Change provides links to some of these guides (listed below). However, none of these guides facilitate the creation of strategic adaptation plans, but rather discuss the application of sector-based solutions.
    - Municipalities: Adapting to Climate Change: A Risk-Based Guide for Local Governments in British Columbia: Volume 1: The Guide; Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation
    - Water: Rethinking our Water Ways: a Guide to Water and Watershed Planning for BC Communities in the Face of Climate Change and other Challenges
    - First Nations: Climate Change Planning Tools for First Nations
    - Homeowners: Slow it! Spread it! Sink it! An Okanagan Homeowner's Guide to Using Rain

Guide Section 2: Adaptation Planning Guidelines

This project has thus far provided a context for adaptation planning in the agriculture industry of British Columbia and a framework for the proposed guide. The first section of the guide provided preliminary tools for carrying out an adaptation planning process. The remainder of the report will be devoted to sequenced guidelines for an adaptation planning process. The stepped guidelines are the result of the conceptual framework and the application of the practical decision-making frameworks. The guidelines are intended for producers and planners to use at the farm or farm organization level in creating adaptation alternatives and strategies.

It is important to note that planning is an iterative process by nature. When an official planning process begins, the user may already be in one of the stages of the process, or may find that a stage along the way has already been addressed. The guidelines are flexible, and rather than providing a rigid process to be followed, are intended to provide guidance throughout the complex, elastic, and interactive steps of the process.

Each step of the guideline is described with a basic overview and general principles to consider when using the process for agricultural climate change adaptation.

Tools in the Guide

Boxes like these will be found throughout the guide, they contain brief descriptions of tools that can be used in each stage of the process. The scope of this guide does not allow for an exhaustive or fully descriptive use of the available tools, more tools and detailed descriptions can be found in the frameworks that influenced the guide (SDM, Strategic Planning and Holistic Management).

Example On-farm Water Management Plan

Throughout the guide, examples of tools used to accomplish each step can be found in boxes like these. These examples are based on the hypothetical development of an On-farm Water Management Plan for climate change adaptation. The hypothetical farm is in the Okanagan Valley. This region was chosen as an example because there is a great deal of literature available on climate change, water resources, and agriculture in the Okanagan and the agriculture sectors that are predominate within it (vineyards and tree fruit).

The invented farm operator will be referred to in these examples as 'Joseph'. Joseph produces from an orchard with mixed tree fruits (mostly apples and pears) totaling 20 acres, 5 of which he owns and 15 he leases. Joseph is 60 years old and has been farming for a total of 15 years, 10 at his current location in the southern Okanagan Valley. Joseph produces organically, as do many of his neighbors because the semi-arid, wind prone area makes pest control simpler and the market is right. Further background information about Joseph will be provided throughout the framework as the steps are described and demonstrated through the On-farm Water Management Plan example.

Step 1: Define Context and the Manageable "Whole"

DECIDE WHO will be involved in the process. At the farm organization level, there are members of each organization that can provide a good start for defining who will be involved[1]. Membership, however, does not provide an exhaustive list of stakeholders. There may be a long list of people to bring to the discussion. It is useful then to consider Olstrom's (2009) framework for Social Ecologic Systems: (1) A resource system, (2) Resource units, (3) Users, and (4) A governance system, (5) external social, economic, and political settings, and (6) related ecosystems (refer to *figure 2* for further details). The framework provides a starting point for considering who will play a role in the planning process. Stakeholders who may be identified through the SES framework can be found in *table 4*. This is a preliminary list of potential stakeholders and their involvement, the list is not exhaustive and should be catered to individual needs.

table 4: Preliminary list of potential stakeholder involvement

Stakeholder	Potential involvement
Representatives from local government	• Assist in relating the adaptation strategy to Official Community Plans within the planning area • Assist in questions related to the Agricultural Land Reserve
Representatives from regional government	• Assist in relating the adaptation strategy to Regional Development Plans in the planning area
Representatives from other commodity sectors	• Share information and experience; another commodity sector may be at an advanced stage of the process and would be able to assist • Share solutions; commodity sectors often share climate projections and impacts, for example a solution for dealing with new pests and diseases in the fruit and berry sector may provide lessons in the field crop sector
Representatives from other industries	• Help set the larger context; though the objectives of the adaptation plan should be defined within the agriculture sector, it is important to know how other industries and sectors plan to adapt to climate change, otherwise contradictions may impede things like policy development or funding procurement
Technical experts	• Assist in technical evaluations and data collection Assist in designing action plans and pilot projects
Interested researchers or NGOs	• Provide funding and resources • Help to develop networks

It is important in this part of the process to keep in mind the 'whole' must be manageable, as made clear in the Holistic Management framework. There is an extensive number of people who could contribute to the planning process in some way. Careful consideration of who will be involved in which levels of the process, and in what ways will result in a more efficient process. To be sure that there is solid leadership throughout and decision-making is not delayed, the Strategic Planning framework recommends that a core planning team be created. This team will be responsible for carrying out the process and reaching the goals established by all stakeholders.

1 A complete list of BCAC Farm Organizations can be found in Appendix 3.

DECIDE WHAT will be done. This is a crucial point to return to Füssel's first prerequisite for adaptation planning: Awareness of the problem (refer to *table 1*). Though this is an initial stage of the process and not necessarily the appropriate time for technical data collection, it is important to have an idea of the problem being planned for in order to have some notion of the means and mediums appropriate for adaptation.

Planning for adaptation to climate change may be easily carried out as an individual task at the farm or farm organization level. However, in referring back to the UN Framework for Adaptation we are reminded that adaptation occurs at different levels in society, including the local level. There are many projects and programs in place that can incorporate adaptation planning, some examples are described in table to the right. The general advantage of incorporating adaptation planning into an existing program would be the savings in time and resources, as well as the benefit of streamlining a process. On the other hand, if climate change impacts are imminent or severe, and solutions cannot be found within current institutions, a separate, but still related, plan may be necessary. This is a good point in the process to begin eliciting expert judgments. Multiple experts can provide information about the current situation, including technical experts and citizens with local or institutional knowledge.

Existing Mediums for Agricultural Adaptation

Industry or sector based strategic plans
Regional Growth Strategies
Environmental Farm Management Plans
Watershed management plans
Sector-based economic development plans or strategies
Regional food system strategies
Ecological or resource action plans
Emergency management plans

DECIDE HOW and WHEN the process will be carried out and completed. Above all, a timeline for climate change adaptation planning should consider when climate change impacts will occur. This will assist in determining not only the timeline for the process of creating the plan, but also the timeline for implementation. There is a great deal of uncertainty associated with when climate change projections will occur, and at this stage in the process there is no need to breakdown that uncertainty or waste time and resources in getting the best projections for each impact, but rather determine broad level outlooks. A good tool for this is the PCIC projections for 2020, 2050, and 2080, and the associated impacts noted in the CAI Climate Risk and Opportunity Assessment.

Beyond this broad level timeline, a reasonable timeline for the process should be determined by the core planning team based key project management factors. This will be highly context dependent, but basic project management factors to consider are:

- Budget: where is funding coming from and how will it be allocated?
- Resources: who is responsible for what components of the process, and how do timelines need to match up?
- Scope: what will be included and explicitly excluded in the process?
- External factors:
    - what are the timelines of related programs and planning processes?
    - how will the process and implementation coincide with planting and harvesting seasons?

Step 2: Create Commodity-based Vulnerability Assessment

This next step in the process moves on from identifying the problem and context to considering potential impacts. Again it is important to remember Füssel's first prerequisite, awareness of the problem and particularly communicating vulnerabilities that are identified.

The main objectives of creating commodity-based vulnerability assessments are:

- identify and document the current circumstances of the region and sector;
- describe and communicate climate change impacts (to a reasonable degree of certainty);
- illustrate and communicate trends and;
- determine who will be impacted and to what extent.

2.1 Identify and document the current vulnerabilities of the region and sector

The previous section of the guide identified broad level climate impacts. These usually, but not always, contribute to increased vulnerabilities. The resources and programs described in the previous section would generally contribute to reduced vulnerability. Further information for regional areas of the province as well as basic agricultural statistics can be found in Appendix 1. This information provides a starting point for defining the current circumstances of the region and sector. The Climate Action Initiative describes adaptive capacity as follows:

> 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 (Climate Action Initiative Risk and Opportunity Assessment).

There are many factors that will contribute to a sector's current capacity to adapt to climate change, some examples are described in *table 5*, further details are outlined in the Risk and Opportunity Assessment.

table 5: Broad factors contributing to adaptive capacity

Factor	Examples contributing to adaptive capacity (reducing vulnerability)	Examples damaging to adaptive capacity (increasing vulnerability)
Natural environment	• Accessibility to diverse water resources • Accessibility to affordable, arable land	• Water scarcity or inaccessibility • Proximity to harsh microclimates such as flood zones or regions prone to drought
External circumstances	• Tendency toward economic stability (sound multi-scale food policies) • Adaptation or related projects, policies, and programs	• Tendency toward sudden economic shifts • Local and regional development pressures
Internal circumstances	• Efficient and effective knowledge sharing networks • Access to technological advances • Steady farm income	• Retiring farmers • Lack of awareness of impacts • Lack of buy in for insurance or risk management programs

2.2 Identify and illustrate trends and projections

It is important to show the current state of the sector and identify its existing capacity to adapt. However, it is equally important to be aware of the direction in which the sector seems to be heading and illustrate those trends clearly to the stakeholders. This can be achieved through back casting and future casting. Back casting and future casting are tools identified in the Strategic Planning framework. With the help of technical and local experts, historical trends can be extrapolated to identify future trends. This is common practice for climate modeling, but can also be applied to other elements of the agriculture industry such as economic supply and demand trends within a sector, or production success in replanting schemes.

2.3 Identify who will be impacted and how

Not all stakeholders who will be impacted by climate change will be affected in the same way or to the same degree. To aid in determining what groups are most vulnerable to climate change, demographics associated with vulnerability can be mapped with climate change impacts. Additionally, influence diagrams, like the one created for the Joseph example in *figure 7* can be created to show what components of a system are dependent upon what other components and if there are any weak links.

2.4 Describe and communicate impacts

Current climate projections and associated impacts are described in this guide, as well as in related resources such as The Risk and Opportunity Assessment. A more regionally or sector specific study may need to be conducted to identify other primary and secondary impacts. Tools in the box to left can help to ensure stakeholders and decison-makers are well informed about potential impacts.

An impact assessment matrix, like the one created for the Joseph example in *table 6*, may help in determining how projected changes in climate impact various components of a given sector and how the sector can further impact the climate or ecology it depends on. The example shows three main components of the agricultural system, and all are impacted by the main components of the changing climate. Such an impact assessment could go into more detail in describing both systems. For example, it could include seasonally specific changes in precipitation, or specific factors contributing to the growing season. Even this most basic example depicts the overall impact climate change will have on all elements of the production timeline.

Tools for Communicating Vulnerability

Charts and graphic communication
Rather than verbally describing the economic, social, cultural, or statistical trends in the sector, visual aids can be created for a more broad spectrum understanding.

Network Diagrams
Network diagrams can illustrate in a plain way complex interactions between different components of the system. In essence, they illustrate the networks of the sector.

Mapping
Mapping vulnerability demographics with ecological risks aids in determining the overall vulnerability of the sector and points to potential focus areas. For example, overlapping uninsured farms with current and future flood plains paints a clear picture of high risk areas.

In addition to identifying who will be impacted, an influence diagram, like the one created for the Joseph example in *figure 7*, can help to determine key components of the network. In this instance the elements in red (climate patterns, market economy, funding, and population projections) are key. This can provide some direction in developing objectives and subsequently, alternatives for adaptation.

table 6: Example impact assessment matrix

Climate component \ Farming component	Planting	Growing	Harvesting
Temperature rise	• Later planting season • Different species required	• New growing season • New pests & diseases	• New harvesting times • Changes in quantities
Precipitation changes	• Different species required • New infrastructure required	• New infrastructure required • New pests & diseases	• New harvesting times • Changes in quantities
Increased frequency and severity of extreme events	• New planting season • New infrastructure required	• New infrastructure required	• Partial or full harvest losses

figure 7: Example network diagram to identify impacts on water availability, inputs in red are potential triggers

Step 3: Identify Broad Goals, Values, and Objectives

This step of the process is crucial. This is the foundation for creating successful adaptation options and reaching a desired future. As noted in the Strategic Planning framework, this is the first step in identifying where you want to go, and ultimately sets the stage for the process of getting there. The process begins by defining a vision and using that vision to create a game plan.

3.1 Elicit the goals and values of the stakeholders

Obvious goals may be things like a steady net income or protection from extreme events, but other, more subjective values of stakeholders may require some elicitation. Multiple tools are recommended within SDM and Strategic Planning to elicit values and subsequently create objectives. All are geared toward defining "what matters" in choosing among the alternatives.

This is an appropriate time in the process to create a local stakeholder committee to develop a broad vision and identify objectives associated with the vision (if the planning process is larger than the farm level and goes beyond the scope of an individual farmer). Through a participatory process, experts can elicit values through open discussion of the current circumstance and trends identified in the previous steps.

Tools for Eliciting Goals and Values

Visioning
Stakeholders can participate in an open visioning session to define a shared goal for the future of the sector.

Test Objectives
Objectives should be:

- important to the sector's future;
- the design criteria for alternatives
- a tool for evaluating trade-offs
- used as criteria to evaluate alternatives

3.2 Create objectives

Identify means and ends objectives, as discussed in the previous section of this report, ends objectives are created by breaking down the vision statement into more specific goals, and means objectives are how we reach those goals and ultimately the vision. It is important to incorporate long-term concerns and outside influences as identified in previous sections with influence diagrams and impact assessment matrices. Objectives can be used to create evaluation criteria for future steps in the process; when creating evaluation criteria, it is important to utilize both hard and soft criteria.

Table 7, created for the Joseph example, illustrates multiple objectives and associated evaluation criteria. It is based on values stemming from the embedded sustainability model wherein the economy is dependent on society is dependent on the ecosystem (Daly, 2005), and the fact that water is an interdependent resource.

table 7: Example objectives for hypothetical On-farm Water Management Strategy

Objectives	Example evaluation criteria
Sustain ecosystem (ensure the region has a reliable system from which farmers can obtain needed water resources)	• Maintain sufficient flow for a healthy river • Minimize impact of floods or droughts on the ecosystem in the long and short term • Minimize water lost to untimely peak flows

Sustain social well-being (ensure farmers, their communities, and the greater region thrive)	• Minimize impact of farm losses or setbacks • Consider outside stakeholders (maximize local food for the region and positive impact on provincial economy)
Sustain economic strength (ensure farmers can produce necessary revenue, and provincial costs are minimized)	• Minimize economic losses to the farmer and the province (farm insurance statistics) • Minimize cost of implementation • Minimize subsidies that have a negative impact on the industry, maximize efficiency of government assistance to farmers

Step 4: Create Alternatives

Step four begins the process of reaching the goals identified in the previous section. The process of creating alternatives should be participatory and include the core planning team as well as stakeholders identified in step 1. Generally, alternatives should be creative and offer a range of possibilities. Encourage discussion of all potential categories of alternatives like those listed below.

Mechanical: may include alternatives such as funding, participating in, or support infrastructure and farming practice pilot projects.
Institutional: may include alternatives that work to create, recommend, or support adaptation policy, by-laws or other political mechanisms.
Organizational: may include alternatives that work to restructure networks within the sector, or create knowledge sharing opportunities.
Extreme: though it may not ultimately be the most ideal alternative, extreme options, like migration to new climatic regions, are good to put on the table, as the SDM framework notes, as a 'bookend' alternative.

Some tools for creating alternatives are listed in the box to the left. Brainstorming is important to the process and can result in creative outcomes, but primary focus should be given to creating an objectives flow chart. This allows for all alternatives created to eventually be related back to the overall vision for the process.

Alternatives should describe their level of flexibility overtime, for example, testing new planting strategies can be done at multiple scales based on the anticipated success, and the effects of the alternative may only last one season, meaning it is flexible in the long term. Conversely, most infrastructure is relatively permanent and provides little flexibility over time, this does not mean it shouldn't be considered, but rather it should be carefully analyzed and incorporated appropriately. Alternatives should include some details about timing, for example, infrastructure changes may be a short term alternative and political lobbying a long term one.

This is a good point to refer back again to Füssel's prerequisites. Cultural acceptability of an alternative is crucial, the participatory process should aid in achieving this, but refer back to the vision statement to be sure. This is also an opportunity in the process to educate people about risks and adaptation options, this will increase the acceptability of unfamiliar measures. Finally this step will ultimately determine the availability of effective adaptation measures. This may result in the conclusion that further research is necessary for the development of more appropriate alternatives.

Referring again to the UN Framework for Adaptation, we can focus on the principle that "short-term climate variability and extreme events serves as a starting point for reducing vulnerability to longer-term climate change." Using this principle we can create alternatives by considering solutions to current problems, and then consider how to extrapolate those solutions to a future state.

Tools for Creating Alternatives

Brainstorming
Brainstorming allows stakeholders to get all ideas on the table. It can aid in opening communication lines and promoting innovation. Utilize the 'parking lot' method for ideas that don't meet the listed objectives or are outside the scope of the project.

Objectives flow chart
List individual objectives and match them up with actions or strategies that can accomplish them. Encourage stakeholders to consider the relationship of each proposed alternative to the others, and how broad alternatives can be broken down and reorganized.

From an ends objective, identify the means → From the means objective, create an action → Refine the action → Role into a strategy →

Another principle of the UN Framework for Adaptation is that "adaptation policy and measures should be assessed in a development context." The evaluation processes highlighted in this guide are focused on stakeholder values. The example provided is from the view point of a farmer creating a single management plan, so in this instance he may ask, what are the development outlooks in this region and how will that impact water resources?

Using these principles and an objectives flow chart, the alternatives in *figure 8* were created for the Joseph example using information from the previous steps.

figure 8: Example objectives-based alternatives

Example On-farm Water Management Plan

- Develop annual planting strategies for multiple timelines to implement when weather becomes more certain
- Develop a long-term plan for replanting old trees with varieties that can better handle water stresses and a wide range of growing seasons
- Consider other crops to mix with tree fruit
- Invest in water efficient infrastructure
- Develop owner-leaseholder agreements with landlords of leased land to implement capital improvements
- Lobby for farm programs to improve regional water-use efficiency
- Lobby for aquifer research
- Move to different markets that will purchase lower quality fruit

Step 5: Evaluate Alternatives

There are multiple tools for evaluating alternatives based on the agreed upon objectives. The purpose of the methods described in this section is to bring clarity to proposed alternatives. The tools are useful for gaining new insight and incorporating values that are not immediately evident. They are not all encompassing and do not by any means replace open and meaningful discussion.

There is rarely a perfect alternative that meets every desired objective without consequences. Evaluating the trade-offs that will have to be made for each alternative allows for objective comparison and can incorporate subjective values. A good first step for evaluating and eliminating alternatives is to create a consequence table. Refer to the On-farm water management example in figure 10 for further detail on how consequence tables can be created and evaluated. The method incorporates the SDM tools mentioned in previous sections of the project and described in brief in the box to the right.

According to Füssel's prerequisites, it is crucial to understand and have complete information about these measures. This will likely require more elicitation of expert opinion. SDM recommends taking steps to ensure that expert opinion, whatever the source, provides an unbiased evaluation of the alternative by: clearly identifying the conceptual framework; simplifying complex evaluations; quantifying judgements where possible; and detailing assumptions and uncertainties.

A good final tool in evaluating the alternatives is the *seven tests* provided in the Holistic Management framework (Savory, 1999 p. 268). The questions can be asked of each alternative and help to ensure that the option is economically, environmentally, and socially sound. However, there are certainly cases in which other evaluation criteria trumps the importance of the seven questions. If an alternative is incorporated into the adaptation plan despite receiving a negative answer, it should be justified in the plan. The questions are adapted for this guide in *figure 9*.

Tools for Evaluating Alternatives

Value Models (Trade-off evaluation)
Consequence tables and weighted scoring allow for an objective measurement based on values.

Risk Assessment Matrix
Matrices can illustrate increasing risk against increasing value; they show the 'decision sweet spot' for optimal economic development and ecosystem sustainability.

Scenario Planning
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, p. 951)

figure 9: The Seven Tests (adapted from Savory, 1999 p. 268)

1. Cause and Effect. Does this alternative address the root cause of the problem (refer to vulnerability analysis)?
2. Weak Link
   - Social. Could this alternative, due to prevailing attitudes or beliefs, create a weak link in the chain of actions leading toward your objectives or overall vision?
   - Biological. Does this action address the weakest, or most vulnerable point in the ecological network?
   - Financial. Does this action strengthen the weakest, or most vulnerable link in the chain of production?
3. Marginal Reaction. Which alternative provides the greatest return, based on objectives, for resources used?
4. Gross Profit Analysis. Which alternatives contribute the most to covering the overheads of the business?
5. Energy/Money Source and Use. Is the energy or money to be used in this alternative derived from the most appropriate source in terms of the objectives? Will the implementation process result in the overall goals?
6. Sustainability. Will this alternative lead toward or away from the resource base necessary to meet objectives?
7. Society and Culture. How do you feel about this alternative now? Will it lead to the quality of life you desire? Will it adversely affect the lives of others?

figure 10: Example evaluation process

Evaluating Alternatives

Expanded research will be necessary to determine the evaluation criteria measures for each alternative in Joseph's case. Since he has no technical experts available, Joseph has chosen to first consider the consequences at a meta-level and determine which alternatives should be further researched and prioritized within a packaged strategy. For a preliminary rating of the alternatives Joseph created a simple 0-1 index evaluation system, based on the uncertainties and assumptions of the alternatives that are mentioned above. *Table 8* measures his proposed alternatives against his three key objectives:

table 8: Preliminary consequence table based on hypothetical alternatives and objectives

		Objectives		
		Minimize implementation cost	Minimize impacts of drought on ecosystem	Maximize long-term capacity of farms
Alternatives	Annual planting strategies	1.00	.5	.75
	Replanting new varieties	.25	.75	1.00
	Invest in other crops (non-tree fruit)	0	.25	0
	Invest in farm infrastructure	0	.5	.5
	Owner leaseholder agreements	.5	.5	0
	Lobby for regional water efficiency	.5	1.00	.75
	Lobby for aquifer research	.5	1.00	1.00
	Move to different markets	.75	.5	.5

Now Joseph can begin to eliminate options and measures by: 1) eliminating irrelevant objectives and; 2) eliminating dominated alternatives. Each alternative has a different measure for each objective, so all objectives are relevant. However, the alternative to invest in other crops is measured to be as bad or worse on every objective, it therefore can be eliminated. All other alternatives should be considered.

This consequence table provides Joseph with a good basis to move forward in research and considering trade-offs, but may be revisited after new information is collected. For example, the implementation cost of creating annual planting strategies for multiple scenarios is relatively low, but implementation of those strategies could be high dependent upon costs of labor and lost product. It is crucial to be iterative in this evaluation and continually return to previous steps as new information is collected.

Swing weighting can now be used to evaluate the remaining alternatives. This is accomplished by: 1) setting up swing weights, 2) applying relative priorities and trade-offs and, 3) applying value functions.

1. To set up swing weights to compare objectives with different measures, the measures must be modified to a relative index. This does not need to be done for Joseph since his consequence table was already based on a relative index which he created for preliminary research. It will however be useful in the future when more specific criteria are available.

2. Apply relative priorities and trade-offs to determine what objective was most important to him by answering the question: *which would you trade from worst to best first*?

   Joseph feels that implementation cost is important to sustain his current operations and would change that to best first. He feels that even the worst impact on the ecosystem is not as bad as the worst impact on long term farming capacity and would change that from worst to best last. The results are depicted in *table 9*.

table 9: Trade-offs table based on hypothetical alternatives and objectives

Criteria / Range	Implementation cost	Impact on ecosystem	Long-term farming capacity
Best	1.00	1.00	1.00
Worst	0	.25	0

3. Apply value functions where applicable

   Now that the objectives are prioritized, weights can be given to each objective to determine how much more important a given objective is by answering the question: How important is the second priority to the first? the third to the second?

   Joseph has decided to give the following weights based on the question above:

   - Implementation cost: 3
   - Long-term farming capacity: 2
   - Impact on ecosystem: 1

   Now the weights can be applied to the original indices and added together to determine scores for each alternative. This is represented in *table 10*.

figure 10 (continued): Example evaluation process

Example On-farm Water Management Plan

table 10: Preliminary consequence table based on hypothetical alternatives and objectives

		Objectives			
		Minimize implementation cost	Minimize impacts of drought on ecosystem	Maximize long-term capacity of farms	**Score**
Alternatives	Annual planting strategies	1.00(3)=3	.5(1)=.5	.75(2)=1.5	**5**
	Replanting new varieties	.25(3)=.75	.75(1)=.75	1.00(2)=2	**3.5**
	Invest in other crops (non-tree fruit)	0(3)=0	.5(1)=.5	.5(2)=1	**1.5**
	Invest in farm infrastructure	.5(3)=1.5	.5(1)=.5	0(2)=0	**2**
	Owner leaseholder agreements	.5(3)=1.5	1.00(1)=1	.75(2)=1.5	**4**
	Lobby for regional water efficiency	.5(3)=1.5	1.00(1)=1	1.00(2)=2	**4.5**
	Lobby for aquifer research	.75(3)=2.25	.5(1)=.5	.5(2)=1	**3.75**
	Move to different markets	.75	.5	.5	

Step 6: Implement, Monitor, Iterate

This is the final step in the process, it brings each of the previous steps together to create a packaged adaptation strategy. This is the point in the process where ideas begin to become solutions and the utility of any given alternative is ultimately measured.

6.1 Create implementation plan

Creating an implementation strategy will differ greatly from farmer to farmer and community to community. However, there are elements of good implementation and monitoring that can be incorporated into any strategy. For most farmers the alternatives are not mutually exclusive or exhaustive. Creative packaging and iteration are crucial.

Some basic guidelines for implementation are to:

- Consider packaging options and get started with 'low-hanging fruit' alternatives immediately
- Incorporate flexibility
- Clearly identify the uncertainties in each strategy and incorporate a plan to monitor and evaluate progress regularly
- Build relationships with other stakeholders and decision makers to support implementation

Flexibility is key in implementation of any long term plan, but it is particularly important in climate change adaptation, and even more so in the agriculture industry. The high degree of uncertainty associated with climate change and the industry requires that not only should flexible alternatives be created, but that the timelines and mechanisms for implementing them provide room for adjustment. An example is provided through the Joseph process in *figure 11*.

Tools for Implementation

Action Plans
Action Plans promote follow-through by identifying specific tasks, key players, timelines, resources allocation, and risks. They provide a foundational tool for implementing specific alternatives.

Strategic Plans
The strategic plan is essentially the documentation of the entire planning process. It serves as a reminder of why and how alternatives were developed and is the primary tool for realizing the broad goals and objectives.

figure 11: Example implementation strategy

Example On-farm Water Management

Joseph chose to package three alternatives into a long-term strategy that can be rolled out over time:

1. Develop strategic planting plans (this is a simple 'low-hanging fruit' alternative that scored high in his evaluation). The plans can be developed immediately and implemented overtime as necessary.

2. Lobby for regional water efficiency programs and aquifer research (these strategies scored high in his evaluation and will be implemented over time). The strategy requires relationship development and becoming involved in local agriculture projects and programs.

3. Replant new varieties (this alternative did not have a very high score, but can be modified to help meet the long-term capacity objective). Joseph will replant some of the older trees in his orchard with new varieties and monitor the success and continually research projected climate changes to determine if replanting should continue or expand. This strategy meets objectives and also serves as a learning tool for Joseph.

6.2 Monitor and evaluate

Monitoring and evaluation are important, and often overlooked or oversimplified. Since many agriculture adaptation options are novel, monitoring is not only important for the success of the plan, but potentially for the success of the industry at large. For this reason, information sharing should be included in monitoring and evaluation.

Some basic guidelines for monitoring (demonstrated through the Joseph example in *figure 12*):

- Create sound analytical tools and evaluation criteria
- Develop a strategies that can evaluate both long and short term consequences
- Identify thresholds at which a strategy should be modified or concluded

figure 11: Example monitoring strategy

Example On-farm Water Management

Joseph chose to incorporate the following monitoring and evaluation measures into his strategy:

1. Identify thresholds for the planting strategy (i.e. identify the point at which does modified planting strategies become ineffective in terms of cost).
2. Monitor the success of lobbying and campaigning for new polices or programs and subsequent impact of the alternative
3. Include technical monitoring of plant varieties (i.e. water use, production rates, etc.).
4. Create a group to collectively research climate projections and discuss the success of adaptation strategies.

6.3 Adjust and modify

Iteration is key. This should not be considered a final step of the process, but one that occurs throughout. Adjustments may be made at any given point, but creating opportunities for adjustment throughout the stages of monitoring and evaluation is especially important.

Specific changes in climate and the impacts they will have on the agriculture industry are known only with high degrees of uncertainty. There is no way to create a plan that will address the impacts perfectly. It is important to be prepared to be wrong, and willing to learn from those mistakes.

Final Notes

The scope of this guide was limited and can be expanded in the future. Some opportunities for expanding the guide to provide more options, references, and information for planners and stakeholders alike are to:

- provide further detail in each of the steps and the background sections;
- provide more examples that demonstrate how to utilize the tools and;
- incorporate case studies that illustrate both process and potential action.

The guide could have easily been framed more closely to the 10 step process in Strategic Planning framework, the six step process is simpler and more appropriate for the scope of this project. If expanded on in the future it may be useful to further break the steps down.

Project Conclusions

The need for industry specific climate adaptation is growing. In British Columbia, this needs has been explicitly expressed in the agriculture industry. The structure of the industry is underpinned with uncertainty and climate change projections heighten the risk associated with that uncertainty. Given the industry's close connection to land and water resources, climate adaptation will be important for its future.

This project provides a conceptual framework for agricultural adaptation planning based on best practices identified in current literature. This framework is applied to a proposed guide to assist in the development of commodity adaptation plans. The practical basis for the guide is derived from three decision-making frameworks which were reviewed and mined for practices appropriate to the agriculture industry in British Columbia.

The previous section discusses briefly the way in which the guide could be expanded on before being put forth for use. Additionally, the conceptual framework could be further explored and compared to adaptation frameworks developed for other industries or sectors. Though the paper is limited in scope, it provides a step forward in industry specific climate change adaptation planning and can serve as a basic tool for agricultural adaptation in British Columbia.

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Appendices

Appendix 1 -Detailed Regional Statistics and Projections

(Expanded from the History and Context Section)

The regions outlined in this section are scoped by British Columbia Agriculture Land Reserve (ALC, 2002) designations and the research conducted in the Climate Action Initiative Adaptation Risk and Opportunities Assessment, as well as by available data. The scans provided herein are for broad areas of the Province.

Climate change projections provided in this section were collected from the Pacific Climate Impacts Consortium (PCIC) out of the University of Victoria in British Columbia. The data used in the PCIC projections comes from the International Panel on Climate Change (IPCC), global climate model for North America, and 14 global climate models from the IPCC's Fourth Assessment Report. Ensemble medians are used in all climate change projections in this section. Percent changes and differences are from a 1961-1990 baseline.

Unless otherwise noted, agriculture overviews and statistics were collected from the British Columbia Ministry of Agriculture within the Agriculture Brief Series, wherein data has been compiled from the 1996, 2001, and 2006 Agriculture Censuses.

"Field Crop" is a designation for an agricultural product grown in the field other than a fruit or vegetable, commonly for feed. According to Statistics Canada this includes hay, alfalfa and alfalfa mixtures; wheat (spring, durum, winter); oats; barley; mixed grains; corn (grain and silage); rye (fall and spring); canola; soybeans; flaxseed; dry field peas; chick peas; lentils; beans (dry white and other beans); forage seed; potatoes; mustard seed; sunflowers; canary seed; tobacco; ginseng; buckwheat; sugar beets; caraway seed; triticale; and other field crops such as solin, safflower, coriander and other spices, etc..

"Unmanaged Pasture", according to Statistics Canada, is land used for pasture that has not been cultivated and seeded, or drained, irrigated, or fertilized, including rangeland and grazeable bush. While "Managed Pasture" is land that has been improved from its natural state using one or more of those modifications. Neither includes land used for field crops.

Southern Vancouver Island

Agriculture overview

Majority of agriculture on Vancouver Island is located around Comox Valley and Cowichan Valley on the southern half of the island. The 2001 agriculture census noted that Comox-Strathcona Regional District produces a wide variety of 21 different types of vegetables. Southeastern portion of the Cowichan Valley Regional District agriculture lands are mostly managed and unmanaged pastures, with a majority of the lands dedicated to poultry and cattle raising. In 2001 roughly 11% of the total farmland in the region was irrigated.

Climate change projections

For the 2020 period Comox Valley and Cowichan Valley regions are both projected to have an annual median temperature increase of 0.9°C. The summer will be drier with a 9% decrease in precipitation, while winter precipitation will increase 3% in Comox and 1% in Cowichan. This equates to a 31% decrease in spring snowfall in both regions and a winter snowfall decrease of 15% for Comox and 24% for Cowichan . As well, 14 more frost free days are projected for Comox and 9 for Cowichan.

For the 2050 period Comox Valley and Cowichan Valley regions are projected to have an annual median temperature increase of 1.5°C and 1.6°C respectively. The summers will continue to become drier with a 15% decrease in precipitation in Comox and a 19% decrease in Cowichan, while winter precipitation will increase 5% and 6% for Comox and Cowichan respectively. This equates to a decrease in spring snowfall of 50% for Comox and 53% for Cowichan and a winter snowfall decrease of 29% for Comox and 39% for Cowichan. As well, 23 more frost free days are projected for Comox and 15 more for Cowichan.

For the 2080 period Comox Valley and Cowichan Valley regions are projected to have an annual median temperature increase of 2.4°C and 2.5°C respectively. The summers will remain dry, with a 14% decrease in precipitation in Comox and a 21% decrease in Cowichan, while winters will become much wetter with a precipitation increase of 10-11% in the area. This equates to a drastic decrease in spring snowfall of 72 and 73% for Comox and Cowichan respectively, and a winter snowfall decrease of 38% for Comox and 54% for Cowichan. As well, 34 more frost free days are projected for Comox and 21 more for Cowichan.

Metro Vancouver

Agriculture overview

The Metro Vancouver area consists of 21 municipalities as well as Electoral Area A. Over half of the total farmland is used for crop productions and more than half of the crops are field crops. The area generated 27% of British Columbia's gross farm receipts. The City of Burnaby accounts for a significant portion of the lower mainland's vegetable productions. The City of Surrey developed an agricultural plan in 1999 to protect and enhance local agriculture. Nearly half of all British Columbia potatoes come from the Corporation of Delta (1660 hectares in 2006). The City of Richmond produces almost exclusively cranberries and blueberries, accounting for 97% of all agriculture land in the City, and 40% of the province's cranberry lands. The Township of Langley also has a high proportion of land dedicated to raspberries and blueberries (the majority of their tree nut production) as well as large proportion of mushrooms, contributing 34% to the province total. In 2006 nearly 21% of the total farmland in the region was irrigated.

Climate change projections

For the 2020 period the Greater Vancouver area is projected to see an annual median temperature increase of 1°C. The summer will be drier with a 7% a decrease in precipitation, while winter precipitation will increase 2%. This equates to a 32% decrease in snowfall in the spring and 23% decrease in the winter, and 11 more frost free days.

For the 2050 period the Greater Vancouver area is projected to see an annual median temperature increase of 1.8°C. The summer will become much drier with a 16% a decrease in precipitation, while winter precipitation will increase 6%. This equates to a 57% decrease in snowfall in the spring and 13% decrease in the winter, and 18 more frost free days.

For the 2080 period the Greater Vancouver area is projected to see an annual median temperature increase of 2.7°C. The summer will continue to become drier with a 18% a decrease in precipitation, while winter precipitation will increase 9%. This equates to a drastic 74% decrease in snowfall in the spring and 54% decrease in the winter, and 26 more frost free days.

Fraser Valley

Agriculture overview

The Fraser Valley Regional District (FVRD) includes the cities of Abbotsford and Chilliwack. The majority of agriculture takes place in the southeastern portion of the FVRD near Chilliwack, Abbotsford, and Mission. Mixed farms, accounting for the majority of the agriculture that takes place, as well as managed and unmanaged pasture land. The FVRD is a major contributor to total gross farm receipts in the region, accounting for almost 35% of all regions in British Columbia. Raspberries are a major commodity for the City of Abbotsford, accounting for 80% of British Columbia's total production and 45% of Canada's. Chilliwack generates the second highest farm receipts of all municipalities in the province; the majority of the agriculture land is designated as field crops. In 2006 roughly 19% of the total farmland in the region was irrigated.

Climate change projections

For the 2020 period the Fraser Valley is projected to see an annual median temperature increase of 1°C. The summer will be drier with 9% a decrease in precipitation, while winter precipitation will increase 3%. This equates to a 32% decrease in snowfall in the spring and 13% decrease in the winter, and 14 more growing degree days.

For the 2050 period the Fraser Valley is projected to see an annual median temperature increase of 1.8°C. The summer will continue to become drier with 14% a decrease in precipitation, while winter precipitation will increase 6%. This equates to a 56% decrease in snowfall in the spring and 25% decrease in the winter, and 25 more growing degree days.

For the 2080 period the Fraser Valley is projected to see an annual median temperature increase of 2.8°C. The summer will be drier with 16% a decrease in precipitation, while winter precipitation will increase 9%. This equates to a drastic 76% decrease in snowfall in the spring and 36% decrease in the winter, and 38 more growing degree days.

Okanagan Region

Agriculture overview

Half of all cropland (excluding pasture land) is dedicated to the production of fruit, nut, and berry crops. In the City of Penticton, 40% of fruit, nut, and berry land is designated for apple production. The City of Kelowna, in the Central Okanagan Regional District, has over 2,000 hectares of farmland dedicated to fruit, nut, and berry productions, apple production accounts for 67% of that land. The District of Lake Country, also in the Central Okanagan, focuses agricultural land on apples and soft fruits as well and is especially known for production of ice wine. The North Okanagan Regional District has a much greater quantity of pasture land and field crops than the rest of the region, putting a great emphasis on the cattle industry. However, The City of Vernon in the North Okanagan Regional District has the highest percentage of fruit, nut, berry land dedicated to apple production at 89%. In 2006 roughly 15% of the total farmland in the region was irrigated.

Climate change projections

For the 2020 period Okanagan-Similkameen (Similkameen) and North Okanagan (North) regions are projected to have an annual median temperature increase of 1.1 and 1.0°C respectively. The summer will be drier with a 9% decrease in precipitation in Similkameen and a 4% decrease in the North, while winter precipitation will increase 2% in Similkameen and 4% in the North. This equates to a decrease in spring snowfall of 33% in Similkameen and 32% in the North, and a decrease in winter snowfall of 6% for Similkameen and 7% for the North. As well, 15 more frost free days are projected for Similkameen and 14 for the North.

For the 2050 period both Similkameen and the North are projected to have an annual median temperature increase of 1.9°C. The summer will be drier with a 14% decrease in precipitation in Similkameen and a 10% decrease in the North, while winter precipitation will increase 6% in Similkameen and 7% in the North. This equates to a decrease in spring snowfall of 57% in both Similkameen and the North, and a decrease in winter snowfall of 14% for Similkameen and 15% for the North. As well, 26 more frost free days are projected for Similkameen and 24 for the North.

For the 2080 period Similkameen and the North regions are projected to have an annual median temperature increase of 3.0 and 2.8°C respectively. The summer will be drier with a 16% decrease in precipitation in Similkameen and a 13% decrease in the North, while winter precipitation will increase 10% in Similkameen and 12% in the North. This equates to a decrease in spring snowfall of 78% in Similkameen and 76% in the North, and a decrease in winter snowfall of 22% for Similkameen and 23% for the North. As well, 39 more frost free days are projected for Similkameen and 37 for the North.

Kootenay Region

Agriculture overview

In the Regional District of Kootenay Boundary, farmland use is concentrated in unmanaged pasture lands, highest distributions in cattle and horses, followed by poultry. Almost all of the cropland in the area is dedicated to field crops. The Regional District of Central Kootenay also has a high quantity of unmanaged pasture land, but the greatest proportion of total agriculture land is cropland, the majority of which is designated for field crop production as well. The Regional District of East Kootenay has the highest amount of unmanaged pasture land in the region at over 64,000 hectares and produces nearly 10,000 hectares of field crops. In 2006 19,566 hectares of the total 486,079 farmed hectares were irrigated. In 2006 less than 6% of the total farmland in the region is irrigated.

Climate change projections

For the 2020 period the East Kootenay region is projected to see an annual median temperature increase of 1.0°C. The summer will be drier with a 3% a decrease in precipitation, while winter precipitation will increase 4%. This equates to a 29% decrease in snowfall in the spring and 1% decrease in the winter, and 13 more frost free days.

For the 2050 period the East Kootenay region is projected to see an annual median temperature increase of 2.0°C. The summer will continue to become drier with a 8% a decrease in precipitation, while winter precipitation will continue to increase 11%. This equates to a 52% decrease in snowfall in the spring and 6% decrease in the winter, and 25 more frost free days.

For the 2080 period the East Kootenay region is projected to see an annual median temperature increase of 2.9°C. The summer will continue to become drier with a 12% a decrease in precipitation, while winter precipitation will increase 16%. This equates to a drastic 70% decrease in snowfall in the spring and 8% decrease in the winter, and 36 more frost free days.

Cariboo/Thompson Nicola Region

Agriculture overview

The Cariboo Regional District accounted for 16% of all cattle and 21% of all beef production in the Province in 2006. It contains over 300,000 hectares of unmanaged pasture land and over 32,000 hectares of managed pasture land. It also has over 54,000 hectares of cropland, 99% of which is for field crops. The Thompson Nicola Regional District accounted for 21% of all irrigated land in British Columbia. It has nearly 400,000 hectares of pasture land (95% unmanaged), and 97% of the nearly 34,000 hectares is dedicated to field crops. In 2006 19,566 hectares of the total 486,079 farmed hectares were irrigated (approximately 4%).

Climate change projections

For the 2020 period both the Cariboo and Thompson-Nicola (TN) regions are projected to have an annual median temperature increase of 1.0°C. The summer will be drier with a 4% decrease in precipitation, while winter precipitation will increase 4% in both regions. This equates to a decrease in spring snowfall of 29% in Cariboo and 30% in TN, and a decrease in winter snowfall of 2% for Cariboo and 4% for TN. As well, 12 more frost free days are projected for regions.

For the 2050 period both the Cariboo and Thompson-Nicola (TN) regions are projected to have an annual median temperature increase of 1.8°C. The summer will be drier with a 7% decrease in precipitation in Cariboo and a 9% decrease in TN, while winter precipitation will increase 8% in Cariboo and 7% in TN. This equates to a decrease in spring snowfall of 55% in Cariboo and 34% in the TN, and a decrease in winter snowfall of 9% for Cariboo and 10% for TN. As well, 23 more frost free days are projected for both regions.

For the 2080 period the Cariboo and Thompson-Nicola (TN) regions are projected to have an annual median temperature increase of 2.6 and 2.7°C respectively. The summer will be drier with a 6% decrease in precipitation in Cariboo and a 9% decrease in TN, while winter precipitation will increase 11% in Cariboo and 12% in the TN. This equates to a decrease in spring snowfall of 75% in Cariboo and 73% in the TN, and a decrease in winter snowfall of 11% for Cariboo and 13% for TN. As well, 35 more frost free days are projected for Cariboo and 34 for TN.

Peace River Region

Agriculture overview

Grain and cattle are the primary agricultural industries. The 2001 Agriculture Census shows that 35.91% of the total 57.16 % of livestock farms are classified as cattle and 10.15% of the total 42.84% of crop farms are classified as grain or oilseed, while another 27.79% of total crop farms are classified as 'other field crop'. In 2001 only 421 hectares of the 868,599 farmed hectares were irrigated.

Climate change projections

For the 2020 period the Peace River region is projected to see an annual median temperature increase of 1.0°C. The summer will be wetter with a 2% a increase in precipitation, as will the winter with a precipitation increase of 7%. This equates to a 30% decrease in snowfall in the spring and 5% increase in the winter, and 9 more frost free days.

For the 2050 period the Peace River region is projected to see an annual median temperature increase of 1.8°C. The summer will be wetter with a 3% a increase in precipitation, as will the winter with a precipitation increase of 10%. This equates to a 56% decrease in snowfall in the spring and 7% increase in the winter, and 16 more frost free days.

For the 2080 period the Peace River region is projected to see an annual median temperature increase of 2.8°C. The summer will be wetter with a 1% a increase in precipitation, as will the winter with a precipitation increase of 17%. This equates to a 71% decrease in snowfall in the spring and 8% increase in the winter, and 26 more frost free days.

Fraser Fort George

Agriculture overview

The majority of agriculture lands in the Fraser Fort George Regional District are also dedicated to pasture and field crop production. The relatively small irrigated area of Prince George is dedicated to the cattle industry, roughly half in managed and unmanaged pasture and half in field crop production. In 2006 only 796 hectares of the 107,980 farmed hectares were irrigated.

Climate change projections

For the 2020 period the Fort George region is projected to see an annual median temperature increase of 1.0°C. The summer precipitation will remain the same, while winter precipitation will increase 7%. This equates to a

27% decrease in snowfall in the spring and 2% increase in the winter, and 11 more frost free days.

For the 2050 period the Fort George region is projected to see an annual median temperature increase of 1.7°C. The summer will be slightly drier with a 1% a increase in precipitation, while winter precipitation will continue to increase 10%. This equates to a 57% decrease in snowfall in the spring and 1% decrease in the winter, and 20 more frost free days.

For the 2080 period the Fort George region is projected to see an annual median temperature increase of 2.6°C. The summer will be slightly drier with a 2% a decrease in precipitation, while winter precipitation will continue to increase 15%. This equates to a 71% decrease in snowfall in the spring and 4% decrease in the winter, and 31 more frost free days.

Appendix 2 - Relevant Agriculture and Adaptation Resources and Programs

Canadian Climate Impacts and Adaptation Network (Natural Resources Canada) produced a series of reports on agricultural adaptation issues prior to its closure in 2007. Various research initiatives discuss climate change impacts (including commodity specific impacts), adaptation options and strategies, risk perception, and socio-economic impacts of adaptation.

The Canadian Agricultural Adaptation Program (CAAP), under Agri-Environment branch of Agriculture and Agri-Food Canada, provides funding to facilitate projects that are geared towards seizing opportunities and finding solutions for impacts associated with climate change. The program supports pilot projects to test new technologies and ideas.

In 2008 the Adaptation to Climate Change Team (ACT) of Simon Fraser University published a Summary of Recommendations for Climate Change Adaptation and Biodiversity. The recommendations call for:

- A shift to ecosystem based management
- Maintain and restore ecosystem resiliency
- Valuing ecological goods and services in decisions
- Strengthening legislative capacity of ecosystem management
- Nesting ecological services to maximize values

The report provides an economic argument for the transition to an ecosystem based management approach. The argument highlights the natural capital in the province and highlights the value of ecosystem goods and services. Noting how neglecting to protect biodiversity could reduce the productivity of ecosystem goods and services and reduce resiliency.

ACT will also be releasing a Crops and Food Supply report in September 2012. The report will include a focus on innovative crop insurance approaches as well as international implications for Canadian food imports and exports, impacts to iconic foods, and new opportunities that may arise.

British Columbia's Climate Adaptation Strategy (CAS) published by the British Columbia Ministry of Environment in February of 2010 is an extension of the Climate Action Plan focused on adaptation. The strategy provides and endowment for research geared towards climate adaptation and has several focus areas through which adaptation can be brought to planning and policy making.

Nested in the CAS, is the Conservation Framework which is being developed by the Ministry of Environment to move beyond the current Species At Risk Act; a federal Legislation which applies to species under federal control. The Conservation Framework goes beyond that to be proactive, rather than reactive- identify areas that need protections (ecosystems) before species become 'at risk'. The risk analysis approach is based on the following four steps:

- Determine priorities for ecosystem action based on each of the three goals
- Assign species management primarily to one of the goals
- Determine management activities
- Align resources and activities to implement management activities

A New Climate for Conservation: Nature, Carbon, and Climate Change in British Columbia is a report that was commissioned by the Working Group on Biodiversity, Forests and Climate, an alliance of environmental NGOs. It discusses climate change in British Columbia, the once and future ecology and biodiversity of the Province, and potential impacts of climate change on biodiversity, and adaptation. The report ends with a series of detailed recommendations. Two notable recommendations for the purposes of this research are: 1) Provide Incentives for Stewardship in Every Sector (e.g. Conservation covenants) ; and 2) Take the Lead on Carbon/Biodiversity Valuation.

The Fraser Basin Council's Retooling for Climate Change provides information on adaptation in a variety of sectors, most usefully for this guide, water and food security. The program helps to identify local impacts and adaptation strategies.

In addition to these projects and programs, adaptation guides have been created and are available to other sectors in British Columbia. Retooling for Climate Change provides links to some of these guides (listed below). However, none of these guides facilitate the creation of strategic adaptation plans, but rather discuss the application of sector-based solutions.

- Municipalities: Adapting to Climate Change: A Risk-Based Guide for Local Governments in British Columbia: Volume 1: The Guide; Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation
- Water: Rethinking our Water Ways: a Guide to Water and Watershed Planning for BC Communities in the Face of Climate Change and other Challenges
- First Nations: Climate Change Planning Tools for First Nations
- Homeowners: Slow it! Spread it! Sink it! An Okanagan Homeowner's Guide to Using Rain

Canada and British Columbia Farm Programs

BC Agriculture and Food Council Climate Action Initiative research is intended to provide information about the changing climate and suggestions for adaptation. Beyond the Council, there are a number of programs in place that assist farmers in adapting to short and long term changes.

The Provincial Agriculture Land Commission is an independent Crown agency. Their mission is to preserve agriculture land and enable farm business as well as promote collaboration among the agriculture industry and local government. The ALC is responsible for designated ALR land and, along with local government, must approve any additions, exclusions, subdivisions, or changes to nonfarm use.

The BC Environmental Farm Plan Program is a partnership between Agriculture and Agri-food Canada (AAFC), the BC Ministry of Agriculture (AGRI) and the BC Agriculture Research and Development Corporation (ARDCorp). The program provides a number of technical studies done around the region to help farmers in making decisions about environmentally sound management practices. The program has also published a series of recommended management guides for farmers to use when handling common issues such as riparian restoration, and grazing and irrigation management. The program provides farmers with assistance in creating five-year environmental farm plans, and offers funding for implementation of Beneficial Management Projects (BMPS) specifically identified in the plans. The BC Agriculture and Development Corporation (ARDCorp), responsible for EFP studies, announced that the Ministry of Agriculture greatly improved funding for the 2012 year.

The BC Climate Action Toolkit is an online resource for BC municipalities run by the Province, the Union of BC Municipalities, and Smart Planning for Communities (a program of the Fraser Basin Council). The website, which mostly focuses on tools to promote local GHG emission reductions, also hosts a section on adaptation challenges and opportunities.

The Water Bucket, a consortium lead by BC water and waste, focuses specifically on water resource issues in British Columbia and contains a section focusing on the agriculture industry. The section provides a report on agriculture water demand in the Okanagan, and FarmWest which provides efficient and conservative Water Management practices.

The British Columbia Ministry of Agriculture and Lands provides resources for farmers in British Columbia pertaining to current issues and discussions. On their website they have released the British Columbia Agriculture Plan, which is a twenty-three point strategy for sustaining the province's agriculture industry. The Plan has five key themes: 1) Producing local food in a changing world; 2) Meeting environmental and climate challenges (this theme focuses primarily on mitigation strategies); 3) Building innovative and profitable family farm businesses; 4) Building First Nations agriculture capacity, and; 5) Bridging the urban/agriculture divide.

Within the Ministry of Agriculture and Lands in the Business Risk Management Branch (BRMB), which assists farmers in utilizing insurance and recovery programs available at provincial and federal levels:

Production Insurance is regular crop insurance available through BRMB to growers of a wide variety of crops. The insurance compensates farm losses due to uncontrollable weather. Premiums are paid for by the farmer at the beginning of each growing season, and losses can be filed throughout the year, any time damage is suspected or occurs.

The AgriStability Program, previously under Agriculture and Agri-Food Canada is now under the BRMB as well. Similar to production insurance it offers risk management to farmers by allowing them to buy into the program with fees calculated based on coverage and a small administrative cost share fee, provided they meet eligibility criteria, and recovering losses of more than 15% of the farmers historical average. The program was born out of Canada's Growing Forward Agreement.

AgriInvest is a program under Agriculture an Agri-Food Canada (AAFC), jointly supported by the federal and provincial governments. The program allows farmers to invest money in a savings account which is matched by the program to be used for minor lost-income recovery or risk mitigation investments.

AAFC also administers the Advance Payments Program, which provides accessible credit to farmers through cash advances of up to 50% of the average market value of their product, and the interest of up to $100,000 of the advance is paid by the federal government. The loans can be used throughout the growing season to improve production or marketing of the farm goods. The loans are also available for emergency hardships caused by weather or natural disasters.

AgriRecovery is the final program offered by AAFC, the program works to assist the agriculture industry of British Columbia should a natural disaster on a regional scale occur and assistance is needed beyond the AgriStability or AgriInvest programs. The program works on a case by case basis to determine if the additional assistance is needed, and how it will be administered. Costs are shared by federal and provincial agencies.

Appendix 3 - British Columbia Agriculture Council Farm Organizations

BC Blueberry Council
BC Broiler Hatching Egg Producers' Association
BC Cattlemen's Association
BC Chicken Growers' Association
BC Cranberry Growers' Association
BC Dairy Association
BC Egg Producers' Association
BC Fruit Growers' Association
BC Grain Producers' Association
BC Grapegrowers' Association
BC Greenhouse Growers' Association
BC Landscape & Nursery Association
BC Pork Producers' Association
BC Potato & Vegetable Growers' Association
BC Poultry Association
BC Turkey Grower's Association
BC Wine Grape Council
Certified Organic Associations of British Columbia
F.A.R.M. (Food and Agriculture Responsibility Members') Community Council
Fraser Valley Cole Crop Growers' Association
Fraser Valley Peas, Bush Beans and Corn Growers' Association
Fraser Valley Strawberry Growers' Association
Horse Council British Columbia
Okanagan Kootenay Cherry Growers' Association
Raspberry Industry Development Council
United Flower Growers' CO-OP