Review of Alberta Climate Change Adaptation Projects within the Prairies Regional Adaptation Collaborative (PRAC) and Recommendations for Future Action on Climate Change Adaptation in Alberta

Prepared by:
J. H. Archibald Consulting
December 19, 2011

A project in partnership with:

Manitoba

Alberta

SRC

University of Regina

PARC

Saskatchewan Watershed Authority

With funding support provided by:

Natural Resources Canada / Ressources naturelles Canada

Canada

Review of Alberta Climate Change Adaptation Projects within the Prairies Regional Adaptation Collaborative (PRAC)

Table of Contents

Introduction

This report includes a summary of the projects undertaken within the Prairies Regional Adaptation Collaborative (PRAC), a compilation of interviews conducted with Alberta Government staff to determine how the work was used, and recommendations for enhancing future work in climate change adaptation in Alberta.

Purpose

This project is a review of the climate change adaptation projects initiated through the PRAC. It is intended to provide future direction for adaptation based policies and programming in the Alberta.

Background

Alberta is participating in a partnership with the Natural Resources Canada and Saskatchewan and Manitoba in the Prairies Regional Adaptation Collaborative. Sub-projects under the PRAC agreement include water resource management, drought and excess moisture and forest and land management. The Alberta Departments of Environment and Water, Sustainable Resource Development and Agriculture and Rural Development are participating in these sub-projects. The review of the Alberta-based projects produced under the PRAC will provide a summary of work done and lessons learned and will provide recommendations on subsequent actions that could be taken to ensure that government policies are better designed to adapt to the impacts of climate change.

Projects Reviewed

The projects reviewed in this work include:
Alberta Environment

1. Hydroclimatic Variability: South Saskatchewan River Basin – University of Regina
2. Hydro-Climate Modelling – South Saskatchewan Regional Planning - Golder Associates

Sustainable Resource Development

1. Impacts of Climate Change on the Western Canadian Southern Boreal Forest Fringe - Saskatchewan Research Council, Environment Division
2. Vulnerability of Prairie Grasslands to Climate Change - Saskatchewan Research Council
3. Climate Change Adaptation Framework – Manual - Sustainable Resource Development

Agriculture and Rural Development

1. Drought and Excessive Moisture – No reports were produced in the Alberta portion of this project to the time of this review however there is a project in progress regarding soil moisture modelling.

Project Summaries

Alberta Environment Projects

Hydroclimatic Variability: South Saskatchewan River Basin - University of Regina

Objectives
This project examines the amplification of climate extremes and departures from average conditions: excessive moisture and drought.

The analysis attempts to provide insight into the questions:

- How will water levels fluctuate around the trending mean?
- What will be the severity and frequency of wet and dry years?

Methods
Outputs from a Global Climate Model (GCM) can be used to generate a time series of a future water balance. However each run of each climate model produces a different time series; the only similarities among them are statistical properties, the mean and the variance. One approach to projecting future variability is to derive probabilities of critical water levels from a large number of climate model simulations. An alternative to this purely probabilistic approach is to understand the drivers of internal climate variability and how these drives or teleconnections will be affected by a warmer atmosphere and oceans. This approach involves the analysis of instrumental and long proxy hydrometric records to establish the nature and causes of trends and variability. A model that simulates the interannual variability in recorded streamflows from the climate drives (predictors) of hydroclimatic variability can then be used to simulate the variability of future streamflows by driving the model with climate indices derived from GCMs.

Results

The results of the studies are captured in 4 reports with conclusions below:

New reconstructions of streamflow variability in the South Saskatchewan River Basin from a network of tree ring Chronologies

- This study has clearly documented long-term low-frequency variability in regional hydroclimate that must be considered in any interpretation of recent trends in gauged streamflow and projections of future water supplies in the basin.
- A significant decreasing trend in the annual flow of the South Saskatchewan River is documented in recent analyses of gauge records. Much of this declining flow can be attributed to water storage, diversion and consumption but it is also consistent with projections of future flows derived by coupling hydrologic models and climate change scenarios.

- Future raw water supplies will be determined by global warming impacts on the hydrology of the headwater basins and imposed on the interannual to multidecadal variability revealed in our tree-ring reconstructions.

Northern Rocky Mountain streamflow records: global warming trends, human impacts or natural variability?

- According to this analysis of instrumental streamflow records, future water availability in southern Alberta does not look encouraging, even without considering the expected increasing water demands of a growing economy and population.
- The Pacific Decadal Oscillation (PDO) is shown to have a major impact on present-day surface water supplies. The PDO's regional importance is further underlined by tree-ring inferred streamflow reconstructions for the South Saskatchewan River Basin which show a PDO-like signal for the past six centuries, including prolonged 20-35 year low-flow regimes. Because of its influence on Alberta streamflow, the status of the PDO in a warmer world under anthropogenic climate change is of serious interest.
- Regardless of the exact relationship between the PDO and El Nino-Southern Oscillation (ENSO), the change to a more El Niño dominated world is expected to have major impacts (probably decreases) on southern Alberta river flow, given its strong connection to the PDO.

Projected Southern Alberta River Discharges: 2010-2050

- The 20th century hydroclimatology of southern Alberta is heavily influenced by recurring large-scale climate patterns: the Pacific Decadal Oscillation (PDO), the El Nino-Southern Oscillation (ENSO), and the Arctic Oscillation/North Atlantic Oscillation (AO/NAO).
- Regardless of the precise relationship between the PDO and ENSO, the change to a more El Niño-dominated and a more positive PDO-dominated world is expected to cause decreased southern Alberta river flow in the 21st century.
- This work is new in terms of the attempt to simulate the near-future status of the teleconnections that are strongly linked to observed water levels in southern Alberta and are apparent in long moisture-sensitive tree-ring records. Those climate models that best simulate this behaviour of the climate system were selected.
- A statistical climate-streamflow model driven by future annual values of the climate indices, shows that water levels consistently decline. The interannual variability in water level increases in to the future relative to the variability evident in the streamflow simulations for the latter half of the 20th century, although the models produce some large departures from average flows earlier in the 20th century simulation.
- Large and sustained negative departures from the declining mean water levels are particularly concerning and likely represent the major challenge presented by global warming impacts on the water supplies in southern Alberta.

Hydro-Climate Modelling – South Saskatchewan Regional Planning - Golder Associates

Objectives

This project applies a provincially accepted methodology and model (HSPF) to simulate the hydrologic effects of forecasted future climate change scenarios and to assess the impacts of those scenarios on the surface water supplies in the SSRP Area of Alberta.

Methods

1. The HSPF hydrologic model was set up for the five major basins in the SSRP, namely, Milk River Basin, Bow River Basin, Oldman River Basin, Red Deer River Basin and South Saskatchewan River Basin.

2. The calibration and validation of the model was undertaken using recorded natural flows where available and naturalized flow series developed by AENV where regulation of flows occurs.

3. The calibrated model was used to simulate down-scaled temperature and precipitation changes predicted by five Global Circulation Models and associated scenarios and for two time periods: 2011-2040 (2020s) and 2041-2070 (2050s). Each GCM-scenario reflects a possible temperature-precipitation condition that spans the range of expected conditions as follows:
   - CCSRNIES-A1F1 Warmer and Drier than median conditions defined by HADCM3-B2B.
   - CGCM2-B23 Cooler and Drier than median conditions defined by HADCM3-B2B.
   - HADCM3-B2B Conditions predicted by HADCM3-B2B are defined as Median conditions.
   - HADCM3-A2A Warmer and Wetter than median conditions defined by HADCM3-B2B.
   - NCARPCM-A1B Cooler and Wetter than median conditions defined by HADCM3-B2B.

4. The model simulations with the GCM-scenarios reflect changes in the 30-year mean temperature and precipitation. The hydrologic simulations do not reflect changes in future climate variability.

5. Changes in future climate variability were estimated from simulated flow series generated from a recent study for AENV to assess changes in annual flows in the Oldman and Waterton rivers due to predicted changes in climate and climate variability.

6. The coefficient of variation (CV) of an annual mean flow series, which is the ratio of the standard deviation and the mean of the series, can be used as an indicator of flow variability.

7. Changes in variability in annual mean flows were incorporated in the flow series simulated using HSPF and the five GCM-scenario predictions.

Results

1. The HSPF hydrologic model was calibrated to reproduce most observed annual and monthly flows to within the required statistical criteria. Calibration was deemed to be acceptable when observed and simulated mean monthly and annual flow rates were within 20% and 10%, respectively. Discrepancies were larger than the target values in some instances because of uncertainties in the transfer of recorded precipitation data to sub-basins without local precipitation stations and for low winter flows in some systems.

2. Changes to the nearest 5% (comparing simulated baseline and future annual flows) in mean annual flows in the Milk River, Bow River, Oldman River, South Saskatchewan River and Red Deer River basins using the climate predictions from the five GCM-scenario 2020s range as follows:
   - CCSRNIES-A1F1 Warm-Dry -15% to -30%
   - CGCM2-B23 Cool-Dry -10% to -30%
   - HADCM3-B2B Median conditions -5% to -15%
   - HADCM3-A2A Warm-Wet -5% to 5%
   - NCARPCM-A1B Cool-Wet -5% to +10%

3. The larger decreases in mean annual flows tend to occur for basins such as the Milk River Basin with low water yield in most part of the basin and the larger increases tend to occur in sub-basins at higher elevations, such as Bow River at Banff.

4. The effects (increases or decreases in flows) also tend to vary by basin and by month, with increases in mean monthly flows occurring during April and May, and decreases in mean monthly flows occurring during August, September and October. The effects on flows reflect the predicted changes in temperature and precipitation: increased temperatures result in earlier spring melt and less runoff available – further reduced by increased evapotranspiration – during the summer months. **The implications of the predicted future flow series on water allocations for irrigation and municipal water demands in the basins of the SSRP Area, and on necessary mitigation measures would be a next step to the present study.**

5. Changes to the nearest 5% (comparing simulated annual flows between 1952 and 1999 with flows between 2004 and 2051) in mean annual flows in the Oldman River near Lethbridge and Waterton River at Waterton Park as predicted by eight (8) GCMs that incorporate climate variability range as follows for two (2) selected scenarios:
   - Oldman River – 8 GCMs for Scenario A1B 0% to -30%, with an average of -10%
   - Waterton River – 8 GCMs for Scenario A1B 0% to -15%, with an average of -10%
   - Oldman River – 8 GCMs for Scenario A2 -5% to -30%, with an average of -15%
   - Waterton River – 8 GCMs for Scenario A2 -0% to -15%, with an average of -10%

6. The results from the HSPF simulations (this study) and from the simulations incorporating climate variability (independent study by another consultant for AENV), two independent approaches with different input data and assumptions, seem to be in agreement for the range (generally between +5% and -30%) of potential effects on mean annual flows. Since the relative changes mean annual flows using the two different approaches are similar, it is therefore possible to transfer the change in climate variability to flow series generated using the HSPF model.

7. Percent changes (to the nearest 5%) in the variability of annual flows (as measured by the coefficient of variation CV of simulated annual flows between 1952 and 1999 with the CV of flows between 2004 and 2051) in the Oldman River near Lethbridge and Waterton River at Waterton Park as predicted by eight (8) GCMs that incorporate climate variability range as follows for two (2) selected scenarios:
   - Oldman River – 8 GCMs for Scenario A1B +15% to +70%, average = +30%

- Waterton River – 8 GCMs for Scenario A1B -20% to +80%, average = +25%
- Oldman River – 8 GCMs for Scenario A2 -30% to +125%, average = +25%
- Waterton River – 8 GCMs for Scenario A2 -30% to +130%, average = +20%

The results indicate that there are significant differences in predicted changes in flow variability between flow series generated from the selected GCMs. This may reflect the uncertainties in the approach used to estimate changes in flow variability, the GCM predictions themselves, or a combination of both. **Notwithstanding the foregoing, the results provide an initial quantification of the potential changes in flow variability that cannot be determined by just simulating the 30-year average changes in precipitation and temperature.**

8. Based on the above results, an average change in CV of about 25% was assumed to occur in the future (2011-2040) HSPF simulated series to account for changes in climate variability. The CV of the observed annual flow series of the Oldman River at WSC station 05AD007 and of the Waterton River at WSC station 05AD003 have been estimated as 0.33 and 0.22, respectively.

9. The effects of the change in climate variability (change in CV of about 25%) on indicators of the low and high flows (10-year dry and wet annual flows, and 100-year dry and wet annual flows) in the Milk River, Bow River and Oldman River basins were estimated in terms of future HSPF simulated series with changes in variability incorporated compared to the unmodified future HSPF simulated series. A summary of the predicted effects is as follows:
   - Further decreases in low flows of the order of -10% to -25% for the 10-year dry low flow.
   - Further decreases in low flows of the order of -25% to -95% for the 100-year dry low flow.
   - The larger decreases occur in basins such as the Milk River Basin, while the decreases tend to be smaller for the upper portions of the Bow River and Oldman River basins.
   - Changes in the 10-year wet annual flows range from -5% to +10%, depending on basin and GCM scenario.
   - Changes in the 100-year wet annual flows range from -5% to +15%, depending on basin and GCM scenario.

10. It appears that by incorporating changes in climate variability the effects of climate change on flows tend to be magnified. The preliminary findings indicated that the impact of climate change on SSRP annual stream flow ranges from +5% to -30%. Climate variability would further decrease the stream flow by 25% or more in dry years, to a much lesser extent in wet years. **This suggests that low annual flows are affected to a larger degree by changes in climate variability that high annual flows, which has implications for water management in the moisture-limited environment of the low yield basin areas of the SSRP Area.**

Sustainable Resource Development Projects

Impacts of Climate Change on the Western Canadian Southern Boreal Forest Fringe – Saskatchewan Research Council

Objectives

The purpose of this report is to provide a review of the vulnerabilities, risks, and adaptation options for a number of proposed climate change impacts on the southern edge of Canada's western boreal forest. Vulnerabilities and risks were established by Alberta Sustainable Resource Development (SRD) using the Climate Change Adaptation Framework developed by Deloitte and Touche. This review is structured to be consistent with the Deloitte & Touche framework, and is organized by the following main concepts: Vulnerability Assessments, Risk Assessments, and Adaptation Options.

The goal of this report is to provide information on the current knowledge surrounding sustainable use of forests and their ecosystem services under future climate change to aid in decision making.

Methods

Climate scenarios using five different GCMs and three different emission scenarios were constructed for the 2020s, 2050s, and 2080s according to standard IPCC guidelines. For these five scenarios, yearly and monthly data was downloaded from the Canadian Climate Change Scenarios Network (CCCSN) website for the area encompassing the southern boreal fringe and forested regions (55.28° to 52.13° by -116.19° to -97.82°).

The SRD's Climate Change Adaptation Framework was used to identify key vulnerabilities for the forests of Alberta. A vulnerability assessment considers the sensitivity of ecosystem services and socio-economic sectors to changes in climate variables such as temperature and precipitation, and the existing adaptive capacity of an organization to respond to this sensitivity, in order to arrive at an assessment of vulnerability. The overall goal of this work is to provide information that can be used to support sustainable forest management and the maintenance of ecosystem services under future climatic changes by identifying the greatest sources of risk.

Results

Climate is the driving force behind ecosystem functioning and climate change models predict that increases in temperature and decreases in moisture will likely occur over much of the southern boreal forest. These changes in climate are predicted to be strong enough to cause impacts to many ecosystem services in the forest, including water supply, pest regulation, habitat, timber supply and carbon sequestration. The vulnerability of these services to climate

change was identified, quantified and ranked by SRD across the boreal forest. Areas predicted to be highly vulnerable to climate change impacts were:

- Drought
- Loss of forest and timber supply
- Increase pest damage and forest fires
- Decreased regeneration and revenue to the forest industry

Areas identified as having medium vulnerability to climate change were:

- Shifts in forest ecosystems,
- Habitat loss and fragmentation,
- Loss of species and with-in species genetic resources,
- Reduced carbon storage.

Extreme drought events are predicted to increase in frequency and intensity in the southern boreal forest. Consequently, decreases are expected in tree growth, regeneration, carbon sequestration and survival, while fire, susceptibility to pest attack and mortality are expected to increase. Effects of drought are mostly likely to be seen in transition zones, as these regions are already at the margin of their current existence. This makes the island forest of the boreal plain and southern edge of the boreal forest highly vulnerable to the effects of drought predicted under climate change and this is in concurrence with SRD's assessment.

Under a changing climatic regime, trees will have three options: adapt, migrate, or become extirpated. The boreal forest as a whole is genetically diverse and therefore a loss of species at the trailing edge of this zone may not have a large impact on the overall genetic diversity of the forest. However, genetic resources are unknown for trees located in remnant and isolated forests, like the island forests scattered across the southern boreal fringe. If the trees in this region have been isolated enough to have established unique genetic characteristics, there is a potential loss of genes if these forest die out. Overall, the risk of loss to genetic diversity within tree species is actually quite low according scientific literature and this should be placed at a lower concern unless new information is revealed. This area of research needs more work before concrete assertions can be claimed.

A few points can be assumed, however: habitats and landscapes in the southern boreal forest fringe will be among the first areas to suffer the effects of climate change. This region is likely to become slowly degraded and fragmented over time if climate change occurs as predicted. This may initially lead to changes in dominance of tree species (e.g. conifer to aspen) or changes in species mix. If climatic stressors become overwhelming, trees will suffer higher mortality, reduced regeneration, and disturbances such as fire may permanently remove them from the landscape. Fire is likely to increase with increase temperature and decreasing moisture predicted by climate change models.

Risk and vulnerability to this impact is very high because people have a limited ability to prevent fire over the landscape and as fire frequency increases, prevention measures may have to focus on particular areas of interest like wild land – urban interfaces and parks.

Like fire, Insect outbreaks and diseases are predicted to increase as temperatures rise and are also large agents of change in forest ecosystems, affecting more area each year than fire. Distributions of these pests are also expanding northward as temperatures increase and there is concern that new and exotic pests may become established across Canada as warming trends continue. The effects on diseases are largely unknown and more information is needed to make proper predictions. Insects are closely linked with temperature and warmer temperatures will increase insect outbreaks in extent and severity. This leads to the summation that the southern boreal forest is highly vulnerable to insect outbreaks in the future.

Due to these multitude change predicted to affect the forest edge, productivity is likely to change under rising GHGs but the direction of this change is still up for debate as many reports are currently ambiguous regarding the effects of CO2 fertilization and increased WUE in the field. Any positive benefits of climate change such as longer growing season, increased temperatures, CO2 fertilization, increase WUE, and potential for increase productivity will be counteracted by moisture stress, low nutrient availability, fire, insects and disease. Consequently, productivity and in turn timber supply, will likely be variable across the landscape and forest managers will have to determine which factors will be most pronounced at their sites of interest and take responsive measures.

Information on risk analysis was difficult to obtain for the study region and adaptation options were varied and often untested. Conclusions summarized from the material are quite general in nature; however, a few key points could be extracted.

1. It is important for forest managers to begin thinking about climate change risks to their operations and start implementing plans to counteract potential impacts and risks into their Forest Management Plans. Proactive adaptation is better and usually cheaper that reactive adaptation, so the sooner these plans are implemented the better able forest industry will be able to cope with climate change.

2. Sustainable Forest Management (SFM) is a good place to start when attempting to deal with risk. This scientific based approach helps forestry practitioners adapt practices to climate change while maintain proper forest functioning. SFM helps reduces future risk by enhancing forest resiliency to climate change.

3. Financial risk is currently unknown for forestry operations but predicted to be very large. The best option to take is to implement adaptation plans that are win-win options. These types of options contribute to both climate change mitigation and adaptation and wider development objectives, such as business opportunities from energy efficiency increases or sustainable management and would constitute a justifiable change even in the absence of climate change. What is known regarding financial risk is that adaptation measures will be more costly in the future as ecosystems continue to degrade; therefore it is prudent to start adaptation actions now to avoid future financial costs.

4. Management that aims simply to retain existing vegetation, or to restore historical vegetation distributions and ecosystems, will fail as the climate moves father away from its current condition. Actions will need to be taken to protect the Canadian forest by maintaining a

diversity of age classes, responding aggressively to insect and pathogen disturbances, and actively regenerating the forest with existing or alien tree species that are better adapted to new climate parameters.

5. Increased fire suppression and augmented forest regeneration efforts could slow or possibly halt the shift to grassland. But the business case of additional industry expenditures is currently weak, given that rising energy and labour costs are threatening the forestry sector's ability to generate income, e.g. in Alberta (Alberta Forest Products Association 2008). There may come a time when it becomes too expensive for the government to continue suppressing fires or implementing adaptation practices in these unique regions.

6. The negative impacts of climate change can be reduced through proactive adaptation. Many adaptation options have been provided within this report for consideration. However, these adaptation options are relatively general, and therefore organizations will have to find specific actions plans for their landscapes. Therefore, adaptation is possible via forest management and genetic and silvicultural options are currently available and should be used in an adaptive way that corresponds with individual forest sites. It is important to know the local forest conditions, its current and future stressors and limitations. In terms of the southern boreal forest, the future stressors are multivariable and can often be overwhelming. It is important to start planning for change now, using the information provided here to evaluate management objections, risks and opportunities. Be aware that uncertainty must be accepted and plan to be able to monitor adaptation measures and be willing to quickly change them if necessary. Flexibility, monitoring and accepting uncertainty will be key in beginning to apply adaptation measures in forest landscapes.

7. Humans have impacted forests even prior to recorded history, and it is likely that future forests will have to sustain impacts at least as great as those of the past. If the human population continues to grow, forests will exist only within the context of societal needs. However, the most basic of those needs is a functioning global ecosystem, which depends largely on the forests. Therefore, it is in our best interests to maintain diversity and promote system redundancy and resilience

Vulnerability of Prairie Grasslands to Climate Change - Saskatchewan Research Council

Objectives

The purpose of this report is to assess the vulnerability to climate change of native grasslands and other natural ecosystems in the Prairie Ecozone of Alberta, Saskatchewan, and Manitoba.

Methods

A detailed review of the scientific literature was conducted to address these questions, focusing on grasslands and their climatic relationships. In addition, ecoclimatic models were developed specifically for the Prairie Ecozone. Models for predicting the impact of climate on grassland production in the Canadian prairies were developed by Thorpe et al. (2004, 2008) and Thorpe (2007b). A model for predicting zonation of grassland types from climatic variables was developed by Vandall et al. (2006). The current project made use of these existing models, but with substantial refinements. For consistency between the production and zonation analyses,

both sets of models were recalibrated using a consistent set of climatic variables. Climatic mapping made use of the finer-resolution data surfaces that have become available in recent years, while the most recent outputs from Global Climate Models were used to project future changes.

Results

Climate change is expected to cause major impacts in the Prairie Ecozone over the coming century. Temperatures are predicted to increase substantially, although the size of this change depends on which climate change scenario is used. Only small changes are predicted for annual precipitation and seasonal distribution of precipitation.

Vegetation zones are expected to shift northward, with forest replaced by aspen parkland and grassland, and with current Canadian grassland types replaced by those found in the U.S. Great Plains. Northward movement of species will probably lag behind the change in climate, so it is difficult to predict future vegetation exactly. However, the zonation results imply the following trends:

- decrease in tree cover in the southern boreal forest and aspen parkland, and reduced woody encroachment on grassland.
- decrease in species dependent on woody cover, and increase in species dependent on open grassland.
- change in grassland structure: decrease in midgrasses, increase in shortgrasses.
- decrease in cool-season (C3) species and increase in warm-season (C4) species.
- gradual introduction of plant and animal species currently found only in the U.S.
- new community types resulting from differences in migration rates among species.

Grassland production is expected to decrease, but the size of this loss ranges from slight in the cooler scenarios to moderate in the warmer scenarios. Decrease in average production implies decrease in sustainable stocking rates. The fertilizing effect of rising CO2 concentrations could help to moderate production losses.

The change in average production could be less important than increased occurrence of low-production years (i.e. droughts). Besides the immediate reduction in growth, prolonged drought shifts grassland composition toward shorter or earlier-growing species.

For the livestock industry as a whole, the increased area of rangeland in formerly forested areas could help to compensate for reduced production in the drier areas.

Changes in grassland zonation and production will have broader implications for overall biodiversity. Species respond to climate change by moving (i.e. shifting ranges) or by adapting in place (by changing phenology or evolution). Species with long-distance dispersal and generalist habitat requirements will be more likely to keep pace with climate change, while slow-dispersing or habitat specialist species are more likely to lag behind.

Invasive species are likely to be winners under climate change, because of rapid dispersal, use of disturbed habitats, and capacity for rapid evolution. However, invasion also depends on resource availability, and increasing droughts may help to reduce invasion success.

Climate change is expected to reduce the number and area of wetlands, leading to losses in duck production and other wetland biodiversity. As with other climate change impacts, this effect will interact with changes in land use, which could be more immediately important.

Climate change will affect species at risk, but the impacts will vary depending on the biology and habitat requirements of the individual species. Some of those listed in Canada are northern fringe populations of species that are common in the U.S., so climate change could increase the climatic suitability for these species.

The overall impacts of climate change will vary among different types of grassland. Northern fescue prairie and other types of moister regions could be most severely impacted, because of low total area, high habitat fragmentation, and high potential for exotic invasion. The more widespread mixed prairie has relatively more capacity to adjust to climate change. One of the unknowns is the future development of former forest land; in many situations retreating forests are likely to be replaced by exotic grassland.

Climate Change Adaptation Framework – Manual - Sustainable Resource Development

Objectives

The Climate Change Adaptation Framework Manual (the Adaptation Manual") is intended to help organizations address climate change risks in a comprehensive and consistent manner. It integrates the key elements for robust climate change adaptation: integration with strategic planning, standardized processes, continuity and stakeholder involvement. The users of this manual can be any individual or group responsible for managing or understanding climate change adaptation risks; and may include elected or senior officials, division leaders, or technical staff.

Methods

The Adaptation Manual accompanies the Climate Change Adaptation Framework, an evidence-based decision support tool that provides a consistent yet flexible approach to understanding where an organization may be vulnerable to climate change impacts, analyzes the risks to achieving objectives and identifies options to adapt and build organizational capacity to respond. The Adaptation Framework can be modified for any enterprise risks as it is based on broadly recognized standards for risk management.
Climate change may threaten an organization's ability to achieve its strategic objectives. Development of climate change adaptation plans should therefore be integrated with strategic planning and Enterprise Risk Management (ERM) processes. The Adaptation Manual provides guidance in this integration.

Results

The complexity of the impacts and the responses required to address climate change adaptation, requires input from a diverse group of members across an organization. The Adaptation Manual recommends developing an "Adaptation Management Team" (AMT) to coordinate understanding, assessment and response to climate change impacts. The AMT can operate on two-levels, facilitated by an identified Adaptation Coordinator. A senior-level team, or Strategic Planning Team, will provide the broad organizational vantage point and guidance for completing the activities in the Adaptation Framework. The Technical Team is the working-level team that conducts assessments and identifies adaptation options, among other activities. The Adaptation Coordinator acts as liaison between the Strategic Planning Team and the Technical Team, facilitating the specific application of the Adaptation Framework, in addition to other activities as required.

The Climate Change Adaptation Framework is a robust, risk-based approach that can be adopted to enable the identification of adaptation responses that perform well across a range of plausible futures. The tool follows a straightforward process including:

- identifying the scope of the assessment and communicating expectations to all team members involved;
- conducting activities to identify organizational vulnerabilities;
- prioritizing risks; and,
- identifying a suite of potential adaptation options.

The development of an adaptation strategy is closely connected to this process, but it is out of the scope of the Adaptation Framework and the Adaptation Manual. The concluding section to the Manual, „next steps", provides a high-level overview of how the framework links to the strategic planning process.

Alberta Agriculture and Rural Development Project

ARD 2011-2012 PRAC Project Objectives and Scope

Purpose
Alberta Agriculture and Rural Development (AARD) need to enhance its capacity to simulate (model) and report drought and excessive moisture conditions across the province and provide decision makers, with measures to improve current drought and excessive moisture risk management policies, regulations and strategies as well as develop new programs. To this end, AARD is working on a new generation of year round (both growing and winter seasons) soil moisture and drought monitoring models that will make best use of data from current provincial weather station networks.
The Versatile Soil Moisture Budget (VSMB) Model forms the basis for the AARD's drought and excessive moisture risk assessment tool and AARD recognize the need for improvements in VSMB components, their calibration and validation, using field and laboratory measurements. The following are the two projects that are currently underway in cooperation with the University of Calgary.

1. Performance Evaluation of the (VSMB) Model for growing seasons

- Monitoring and analyzing the surface energy balance and soil moisture data in a wheat/barley field during July-October 2011, and analyzing the energy balance and soil moisture data collected in a barley field during the growing seasons of 2009 and 2010. The data will be used to validate the crop coefficients and drying curves used in the existing VSMB and, if necessary, to adjust the values of these functions. Moreover, soil profile samples of the soils representing typical agricultural soil in Alberta are collected and are being analyzed for soil water retention characteristics and saturated hydraulic conductivity. The results will be used to determine the VSMB model parameters, namely field capacity, wilting point, and soil diffusivity for different soil types.

2. Development and Implementation of an improved Snow and Frozen Soil Algorithms for VSMB Model.

- Algorithms to represent winter processes involving snow and frozen soil are being developed, and will be incorporated in VSMB. The model will be tested using the field data collected during 2006-2011 as part of M.Sc. thesis by a graduate student

Summary of Interviews

The second stage of the project involved interviews with individuals and groups from the Alberta Government Departments of Sustainable Resource Development, Environment and Water and Agriculture and Rural Development. The interview guide is included in Appendix 1. The findings from the interviews are presented as a combined summary below.

Current Context for Adaptation

The three departments have different but related mandates in the management of land and water resources in Alberta.

- Alberta Sustainable Resource Development (SRD) encourages balanced and responsible use of Alberta's natural resources through the application of leading practices in management, science, and stewardship.
- Alberta Environment and Water (AEW) Alberta Environment assures the effective stewardship of Alberta's environmental systems to sustain a high quality of life.
- Agriculture and Rural Development (AARD leads in knowledge and innovation; provides the frameworks and services necessary for Alberta’s agriculture and food sector to excel; and assures the public of the quality and safety of their food. AARD also leads the collaboration that enables resilient rural communities.

The three departments are currently working on climate adaptation in program areas as follows:

Sustainable Resource Development

- SRD has a climate change adaptation team that leads adaptation in the department

- Currently projects are Climate Change Adaptation Manual and Best Practices, forest adaptation through Canadian Council of Forest Ministers, biodiversity, fire management, and tree improvement.

Alberta Environment and Water

- AEW has a broad commitment to advance a provincial strategy on adaptation (reflected in 2002 and 2008 climate change plans); approach is bottom up assessment and analysis (vulnerability – economic, environmental, social; risk, etc.)
- There is also an element of investment through Climate Change and Emissions Management Fund (under provincial greenhouse gas emission regulations for large industry).
- Current work includes grass roots action in water management and regional planning, and the International Joint Commission on Water with the State of Montana

Alberta Agriculture and Rural Development

- AARD has many activities that address climate change adaptation; however, these activities are often not directly called climate change adaptation but are seen largely as responses to climate variability and extremes.
- Drought management, environmental stewardship, modelling and networking are all activities that include climate change components

The actual projects undertaken under PRAC funding are summarized earlier in this report in the Project Summaries Section. The general consensus from the three departments was that while additional work was planned in the original PRAC proposal, the financial and human resources to undertake this work was not available. The impact of this was largest in Alberta Environment where significant portions of the Water Management project plan were not undertaken thus limiting the impact of the project within the department.

Implementation

Implementation of climate change adaptation within the participating Government of Alberta departments (GOA) is at different stages of development.

Sustainable Resource Development

SRD is planning to implement results of climate change manual analysis into departmental business plans to get firm commitment to move issues forward. This will enable discussions in operational divisions as business planning proceeds. The Forest Fringe and the Grasslands project validated the science base and impacts in Alberta and will be used in ongoing policy development.

The next steps for implementation include more regional analysis around a variety of land management issues and moving to more specific adaptation questions. It was observed that the mandate for climate change adaptation is not as high as it could be. There is a need to continue building credibility and bringing attention to the issue.

Climate change adaptation is currently perceived as a government prerogative.. The private sector, civil society and the NGO community have not yet been fully engaged in adaptation management processes in the province. While the next step is to engage these diverse sectors, fire management provides an exceptional case where there is currently an effort, through the FireSmart programs, to develop partnerships with municipalities to reduce risk of fire for communities.

Barriers to implementation of climate change adaptation actions within SRD include:

- Difficult to get air time with senior management to discuss adaptation as other issues are seen as higher priority
- Leadership is lacking although the departmental action team is still functioning at the working level
- Departments across government are not moving forward at the same rate
- Budgets are a severely limiting factor
- Climate change not seen as a priority issue
- Capacity is lacking as people are not assigned specifically to the issue
- Political level does not understand the adaptation issue.

Alberta Environment and Water

AEW has a grass roots focus in some directed studies (e.g. water in the south) although it is recognized that additional work is required on the broader strategy. Information and awareness is encouraged through policy development on the role of adaptation. There is engagement and coordination with other Ministries as AEW is the systems manager for climate change and adaptation management. Developing mechanisms to incorporate adaptation in government policy processes and business are broadly competing with higher immediate priorities

Adaptation touches on several program areas within the Department but it is not clear how responsibilities, relationships and accountabilities are defined. There is a need to identify potential areas of leadership on the issue and the resources to support adaptation actions should be supported as a priority item. Comprehensive provincial awareness around the adaptation issues is needed. Further, more focused and detailed risk assessment work may be a process to facilitate this

In terms of other agencies that could be collaborating on adaptation, it is recognized that collaboration across GOA is necessary as many of the issues need integrated management. While AEW is responsible for leading adaptation across government and leads the Alberta Climate Change Adaptation Team (ACCAT), support for this team has been diminishing across departments in recent years. Municipalities will need to be involved in many of the water management issues.

The development of a Provincial Adaptation Strategy, which was identified as an action item in Alberta's 2008 Climate Change Strategy, is seen as part of the action needed to bring climate change adaptation to a higher level of priority within the Department and across government. While the development of a Provincial Strategy is being planned, it is currently in early stages. A framework for strategy development has been developed and risk assessment processes have been initiated across departments to provide guidance on priorities.

Even though support is being provided on an issue-specific basis (e.g. water), there is generally an overall lack of political and policy leadership—long-term thinking at a broad scale. This is because there are other short term priorities outcompeting resources and focus of long term issues

Alberta Agriculture and Rural Development

AARD is having some success with implementing climate change adaptation as they have dedicated staff dealing with climate change adaptation issues within their environmental stewardship programs. The current focus is on adapting to variability and extremes, even though activities in that regard are not always referenced as climate change adaptation.

The department recognizes that there could be more collaboration with the Agriculture Service Board, the Alberta Association of Municipal Districts and Counties and the Agriculture Financial Services Corporation as climate change adaptation activities are implemented. The Agricultural Research and Extension Council of Alberta could be a valuable partner in future.

Barriers to climate change adaptation include lack of understanding and leadership at senior department levels and little political support. Conflicting and competing policies may actually inhibit adaptation, or better still may avoid serious consideration of climate change issues.

Priority Areas and Actions

The priority areas and actions for climate change adaptation efforts are discussed below by Department.

Sustainable Resource Development

The areas where the most additional work is required to deal with challenges associated with both existing and changing climate include:

- Mountain Pine Beetle and Fire Management
- Developing a better understanding of changing disturbance regimes
- Integrated modelling.
- Need ability to influence operational planning and policy through the use of modelling tools
- Strategic level land use planning
- Rangeland management needs to develop broad policy and operational policy to deal with climate extremes and variation (e.g. drought and forage changes)

- More work needed on risk management
- TTAC needs to continue getting adaptation into business plans and mainstreaming
- Leadership needs to develop

In terms of priorities for future work, the following points were raised

- Continue developing the science base to support ongoing operational policy.
- A better understanding of the social and economic implications of climate change impacts and adaptation.
- Need tools to facilitate the exploration of impacts and adaptation, as well as to understand possible and potential trade-offs e.g. cost-benefit analysis.
- Need for increased integrated modelling capacity.
- Need the science to engage the social aspect of climate change adaptation with the public and producers

Alberta Environment and Water

Within Alberta Environment, additional work is needed to deal with variability and extremes with an emphasis on water management for both existing and changing future climate. The current water management system is designed to cope with the range of conditions that were experienced in the past but may fail in the future under a wider range of variability.

The following points were identified:

- AEW is still at the stage of assessing the basic scientific questions and creating the data sets necessary to develop the scenarios to inform the policy conversations
- Need to go beyond current discussions and get into integrated issues and real action
- Need broader discussion beyond department and government
- Need to work with other departments in integrated analysis e.g. future of agriculture and impact on environment, changes in forests and impacts on water
- Emergency management – flooding and drought is important
- More comprehensive risk management processes are required.
- Little effort being put toward public education on climate change impacts. This makes public engagement in the issue very difficult

In terms of priorities for further work, the intent is that this would be guided by a provincial strategy, with priorities informed through departmental or sector-specific risk assessments. Operationally, it is important to focus on completing baseline assessments of potential future climatic conditions, and translate the outputs into information that is suitable to be run through our current management models and tools.

There is a need to go further with all work but need confirmation of direction (leadership), resources and internal capacity. Also need to look at environmental and water management

policy and do a detailed analysis of what needs to change to adapt for the future. Ongoing screening and development of adaptation options both structural and policy is required as part of any adaptation strategy.

The highest priority would be an integrated review of the risks associated with the extremes and variability of water supply and identification of potential adaptation actions that could be initiated. There should be emphasis on both drought and flood as already identified in risk assessment processes completed within the department.

Alberta Agriculture and Rural Development

In terms of additional work required to deal with existing and changing climate within AARD, dealing with climate extremes (both drought and excess moisture) are seen as important. This includes improving monitoring, enhancing data quality and modelling capacity and delivery (outreach) of data and model outputs to policy makers, producers, emergency services and Agricultural Financial Service Corporation (AFSC) producers risk management programs. Irrigation technology, soil and crop research, water management and supply and, efficient land and water use, integrated management are all important areas.

Priorities for the Department include:

- Developing information systems to support adaptation – this includes development of modelling capacity in a range of areas from soil water, crop and weather interactions, insects and disease, and changing productivity to address impact assessment and adaptation issues.
- Building capacity to improve current drought and excessive moisture policies on adaptation, mitigation preparedness and response to risks.
- Enhanced capacity to deal with a more variable and extreme future climate

AARD would like to obtain additional funding for advancing modeling capacity to address adaptation issues related to drought and excessive moisture risk management as well as assessing crop agronomic managements to develop preventive measures to risks. It should be noted however that dollars and resources for cost shared projects would be difficult given current budget projections.

Barriers and Opportunities for Advancing Adaptation in Priority Areas

Barriers and opportunities to advancing adaptation exist in all 3 departments and some common themes emerge.

Sustainable Resource Development

Barriers to climate change adaptation work in the past have largely centered on funding. SRD took advantage of funding available from Alberta Environment to do an initial risk assessment project which became the basis for the Climate Change Adaptation Manual. This was later enhanced with funding from the PRAC project.

In future, funding for climate change adaptation work is anticipated to be a continuing problem as departmental funding allocations are not projected to increase in the near term.

Opportunities for the future are identified as:

- Need to take advantage of circumstances as they arise. Recognize that climate change adaptation is not a high priority for the department but continue to work at getting the issue raised as obvious climate change impacts arise.
- There is an opportunity to have Climate Change adaptation become part of the business planning process. Using the Enterprise Risk approach based on ecosystem services for all business areas would allow a more integrated business planning cycle for all of SRD's business not just climate change.

Alberta Environment and Water

Barriers facing adaptation work in the past and currently are related to lack of leadership from senior levels in the department, lack of a climate change adaptation strategy, and lack of commitment and resources. Even though processes to complete a provincial adaptation strategy are currently on-going, the above-mentioned problems still exist and require further action. There is a need to have more staff committed to the adaptation issue to build momentum and facilitate action.

There are opportunities to collaborate with outside agencies on adaptation but no action has been taken. The regional planning process provides a good platform to examine climate risks and to address future adaptation actions, but there needs to be a recommitment to incorporate climate change impacts into the mandate to be addressed in regional plans.

As in other departments, funding for adaptation work is the largest limiting factor at this point; however, there are emerging opportunities through investments by the Climate Change and Emissions Management Fund

Alberta Agriculture and Rural Development

In AARD, barriers and challenges have been related to the lack of full acceptance of climate change as a risk. Department management endorses priorities on climate extremes and variability but does not appear to fully accept long term change as a high priority risk. This has still not been fully overcome but progress is being made. Tight budgets have prevented expansion of a program in the climate change adaptation area.

There are opportunities to study the adaptation issues to related drought and excessive moisture risk management and dry land farming agronomic practices as well as improving AFSC weather and soil moisture based insurance and risk management business.

Programs are becoming more future-oriented and there is shift to preparedness thinking which may help in future.

Institutional Arrangements

This area discusses roles of government departments and opportunities for collaboration with different levels of government and other agencies

Sustainable Resource Development

SRD has several key roles in adaptation:

- Continuing need to be involved in policy and regulation development dealing with climate change.
- Facilitation role to assist industry in making necessary changes.
- Stewardship role which is shared with users of the land and also needs to share adaptation leadership.
- Role as a provider and interpreter of climate change information

During the PRAC there was collaboration with Saskatchewan Research Council in developing the forest fringe and rangeland vulnerability assessments. There has been little other collaboration as adaptation options have not been discussed outside government to any extent. Going forward, there is abundant opportunity for collaboration but the department recognizes that it needs a plan of action based on adaption priorities. This provides another reason for the urgent completion of the provincial adaptation strategy.

Interprovincial collaboration on adaption is important as there are many different approaches that can be shared. From a forest management perspective, there is opportunity for increased collaboration with B.C. especially since the province has made significant progress on forest management adaptation issues. Many of the forest management issues in Saskatchewan and Manitoba are different than Alberta due to different scales of the industry

Collaboration with other levels of government such as municipal governments is recognized as important in the Fire Management activities but little else has been done. The province is looking to the federal government to provide funding for adaptation activities which is not available in current provincial budgets. Federal support for development of adaptation networks is seen as a useful approach. The leverage or cost-match concept is difficult at this time of tight provincial budgets and a soft financial picture for the forest industry.

Alberta Environment and Water

Alberta Environment and Water staff feel that the department needs to accept its leadership role and act accordingly. This leadership role needs to start from senior levels within the department to ensure continuing action. From the GOA perspective, external (quasi- or non-governmental agencies or NGO's) could begin to take on an increasing lead in advancing work and

recommendations on climate change and adaptation. Such an approach could help in satisfying public demand and interest in adaptation-related information. There could be an opportunity for partnerships in ways that reduces the possibility of AEW becoming only reactive to external advice and processes.

At present there is little collaboration beyond government. This is recognized as a weakness but also presents a large opportunity for future work.

Interprovincial collaboration is useful where there are cross-jurisdictional issues such as water management. It is useful to share the costs of detailed assessments and studies. Policy environments are different across provinces, requiring independent formulation of adaptation options. There could also be collaboration on monitoring, planning and education / awareness activities. Trans-boundary management bodies like PPWB, IJC, MRBB could be a mechanism that facilitates or leads cross-jurisdictional work

Collaboration with municipal governments is seen as important in future water management adaptation issues; however, the department is not ready to move on this at present.

Higher levels of government can provide funding and overarching impact information. There is also a continuing role in developing regional climate modelling.

Alberta Agriculture and Rural Development

Alberta Agriculture and Rural Development has a continuing facilitation and extension role directed toward agricultural producers. AARD is at the centre of the adaptation issue and needs capacity to provide information to assist in adaptation. Facilitation and coordination of research is also important as is product and market development to reflect the changes in productivity and crop types that will occur as a result of changing climate.

During the PRAC there was collaboration with other provincial governments as AARD shared its Drought Management Framework. There was also collaboration with municipalities and Agriculture Produce groups.

Continued collaboration in future is necessary to continue education efforts on climate change adaptation efforts. Need collaboration at all levels of government and with agriculture producers and producer groups. An integrated approach across agencies and departments will be necessary as this is a cross cutting issue affecting many sectors.

There are opportunities for collaboration with other provinces in information sharing and, to some extent, there are also issues of shared interests which could benefit from collaborative research. Differences in policy approaches and mandates are a barrier to some collaboration

Dollars and resources are the biggest limiting factors at present therefore assistance from the federal level would be helpful. Leadership is also important. It is difficult to build support within provincial organizations when federal government does not have a consistent message on

the importance of adaptation. There is a need to introduce programs at high levels in organizations and build support from the top rather than trying to come in to the middle of organizations

Issues Influencing Adaptation

The three departments had similar views on effective ways to move forward with climate change adaptation when dealing with short term political horizons.

It was general view across the departments that it was important to get climate change adaptation into departmental business plans to ensure longer term continuity of programs. This would be assisted by a Provincial Climate Adaptation Strategy to provide over-arching guidance and a sense of priorities. It is felt that an increased level of political support would be necessary to facilitate this.

The overall perception is the that commitments have been made, but other priorities have limited progress thus far, although grass root actions are underway

Recommendations

Based on the review of the projects completed under the PRAC and the interviews with staff in the departments Sustainable Resource Development, Environment and Water, and Agriculture and Rural Development, it is clear that some progress is being made in the climate change adaptation program area but there are significant barriers that need to be overcome before adaptation becomes a mainstreamed issue across these departments.

The major issues that are slowing progress on adaptation are:

- Leadership on climate change adaptation from senior levels in all departments is weak.
- There is little cooperation across departments on this issue making integrated analysis and adaptation planning very difficult.
- Departmental budgets and human resource assignments have not reflected the need to address the climate change adaptation issue.

To address the leadership and cooperation issues it is recommended that AEW take the lead in completing the Provincial Climate Change Adaptation Strategy based on the following principles:

- The strategy should to be a cross-ministry initiative that builds from ongoing risk assessment processes
- The strategy should provide a framework for integrated action based on identified priorities.

- The strategy should identify external partners and involve those partners in consultation processes that serve to educate and gain commitment to the climate change adaptation issue.
- The strategy should be supported by the political level to ensure its success. The strategy should identify the leadership and priority needed to advance the adaptation issue.

To ensure that the Provincial Climate Change Adaptation Strategy is implemented across the province, it is recommended that a Climate Change Adaptation Governance Network be established

- Due to the cross cutting nature of climate change adaptation issues, a multi-stakeholder cross sector group (or alternately a cross-ministry team) should be established to lead action on climate change adaptation (this team would replace the existing Alberta Climate Change Adaptation Team which has declined in effectiveness due to lack of a renewed mandate).
- This group would be guided by the Provincial Climate Change Adaptation Strategy and would be charged with coordinating efforts on climate change research, monitoring, impact and vulnerability assessment, and providing adaptation options to policy makers. Participating government departments would need to provide appropriate staff to support this initiative.

To ensure that adequate funding is made available for climate change adaptation the Provincial Climate Change Adaptation Strategy should identify long term budget and resource estimates to support adaptation programs.

- Based on the priorities identified in the Provincial Climate Change Adaptation Strategy, it will be necessary to provide appropriate funding and human resources to advance the issue towards targets identified in the strategy. Funding sources from the federal government should be accessed where available to assist in the effort. Leverage opportunities with affected economic sectors should be explored and partnerships developed to jointly advance adaptation actions. Opportunities for continued funding from the CCEMC should also be explored through forward planning.

Recommendations for participation in further collaborative efforts initiated by the Federal Government are as follows:

- Ensure that projects that are defined under a collaborative agreement are integrated across sectors to facilitate a full exploration of issues and adaptation options that lead toward robust policy development. This would also help increase commitment and participation in collaborative projects.

- Expand the collaborative effort beyond government departments to include other levels of government and industry partners as well as the NGO sector. This would serve to broaden the constituency of participants in climate change adaptation issues and increase commitment to action.

- Obtain senior level support for the adaptation collaboration projects to ensure that the work actually results in appropriate changes to policy. This will also help ensure that budget and manpower commitments are implemented.

-

Appendix 1

Alberta PRAC Synthesis and Next Steps

Interview Guide

General Information

Name(s):

Position(s):

Agency:

Date interviewed:

Interviewed by:

Method: Telephone

Current Context for Adaptation

1. What is the mandate of your department (e.g., policies, programs, operations)?
2. What programs are you currently working on in climate change adaptation?
3. What projects did PRAC support or facilitate in your organization?
4. Do you have any other ongoing projects or initiatives that could have been facilitated by PRAC? Please explain.

Implementation

1. How do you see climate change adaptation being incorporated within your existing mandate (i.e., programs, policies and operations)?
2. What do you think the next steps are in terms of incorporating climate change adaptation within your existing mandate (i.e., programs, policies and operations)?
3. Are there other agencies (municipal, provincial or federal) you believe it would be beneficial to collaborate with in advancing climate change adaptation? Please describe the nature of the potential collaborations.
4. From your perspective, what are the barriers to advancing adaptation in Alberta?

Priority Areas and Actions

1. Within your mandate (i.e., policies, programs, operations), where is there the most additional work required in order to meet the challenges associated with **existing climate** (i.e., long-term conditions, variability and/or extremes)? Please explain.

2. Within your mandate (i.e., policies, programs, operations), where is there the most additional work required in order to meet the challenges associated with a **changing climate** (i.e., long-term trends towards warmer/drier climates and increasing uncertainty and risk from climate variability and extremes)? Please explain.
3. Within your mandate, how would you prioritize additional work related to adaptation? Please explain.
4. Do you have any ongoing or planned projects or initiatives that could be facilitated by a second round of PRAC funding, or funding from a similar program, that fit within your priorities for adaptation? Please explain.
5. Of the above which areas are the most priority?

Barriers and Opportunities for Advancing Adaptation in Priority Areas

1. What barriers or challenges have you faced related to adaptation work in the past? How did you overcome these?
2. Do you see opportunities developing over the coming years to advance adaptation within your organization? Please describe
3. Do you see barriers or challenges in the coming years to advance adaptation within your organization? Please describe

Institutional Arrangements

1. What role do you see for your organization in adaptation now and in the future?
2. Was there collaboration with other organizations and agencies/other levels of government or with NGOs in the PRAC project?
3. Do you see opportunities for interagency collaboration on adaptation in future? Please explain
4. Do you see opportunities for interprovincial collaboration on adaptation? Please explain
5. How do you see your organization collaborating with other governance levels (municipal, or federal) on adaptation initiatives? Please explain
6. How can higher levels of government facilitate adaptation in lower levels and vice versa? Please explain

Issues Influencing Adaptation

1. Given short-term political time horizons and the long-term nature of climate change impacts, what are effective ways to define goals/objectives in terms of adaptation?
2. What is your perception of your department's, or the government's overall efforts towards adaptation?

Other comments

1. Are there additional topics related to adaptation that you would like to speak about today?
2. Do you have any final comments?