



Adaptation To Climate Change And Potash Mining In Saskatchewan:

Case study from the Qu'Appelle River Watershed

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Sustainability



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Case study From The Qu'Appelle River Watershed

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Introduction

Climate change is expected to have significant implications for Canada's economy. Many of these implications are cross-cutting (e.g. changing water availability, excessive moisture, extreme weather events) and will affect a number of key economic sectors, including the potash mining industry, which employed 5,041 Canadians and contributed \$6.7 billion to Canadian exports in 2011 (NRCan 2012). To assess the readiness of the potash mining sector for climate change and support adaptation, decision makers need to know the nature of vulnerability, in terms of who and what are vulnerable, to what stresses, and in what way, and also what is the capacity of the system to adapt to changing conditions (Smit et al. 2000; Turner et al. 2003).

This research examines climate change vulnerability and adaptation in a case study of the potash industry in Saskatchewan's Qu'Appelle River Watershed and aims to shed light on ways to enhance the competitiveness and adaptive capacity of the industry under a changing climate. The report begins by providing background information on the case study and research methods. It then presents the results, focusing on existing adaptation actions, the drivers of these actions, how the progress of these actions towards meeting desired goals is tracked, lessons learned for future climate change adaptation, and the potential role of government in increasing the industry's adaptive capacity. Finally, the main conclusions from this work are presented.

Box 1. Explanation of key terms

Adaptation, or "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (IPCC 2012), in Saskatchewan's potash industry is about more than simply dealing with climate risks – it is about enhancing the economic competitiveness of the industry by increasing its adaptive capacity for climate stressors not just in the future but also today. Adaptive capacity refers to "[t]he combination of the strengths, attributes, and resources available to an... organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities" (IPCC 2012). Increasing the adaptive capacity of Saskatchewan's potash industry means reducing its vulnerability, or its "propensity or predisposition to be adversely affected" (IPCC 2012), allowing the industry to remain profitable while dealing with climate risks.

Case Study Description

Saskatchewan is a world leader in potash production, with export markets in the U.S., China, India, Brazil and other parts of Asia and Latin America. Saskatchewan produced an average of over 8.5 million tonnes of potash per year from 2000 to 2009 (Saskatchewan Ministry of Economy, pers. comm., 2013 – see Figure 1). The total value of sales during this same period averaged over \$2.7 billion per year. A significant amount of Saskatchewan’s potash production occurs in the Qu’Appelle River Watershed, where there are currently six mines operating and eight additional mines proposed (Saskatchewan Ministry of the Economy 2013). Potash is used mainly as fertilizer to enhance the agricultural production of various crops around the globe.

Water is an essential resource in the potash mining process. Potash mines in the Qu’Appelle River Watershed get their water from three sources: the Qu’Appelle River system itself (which includes the Buffalo Pound Lake reservoir), groundwater, or from Lake Diefenbaker via the Saskatoon South East Water Supply System (SSEWS). This case study research focuses on mines that do not source their water from the SSEWS, since the SSEWS is connected to the South Saskatchewan River Basin and is considered to be a different system in terms of water management. There are eight potash projects in the Qu’Appelle River Watershed that do not source their water from the SSEWS - four producing mines and four non-producing mines at various stages of development (Figure 2). Of these eight mines, six are covered in the interview sample (see Methods section).



Potash mine near Saskatoon. Photo taken by Jeremy Pittman.

Water is used in the extraction and milling of potash, with the magnitude of water use varying significantly by mine type. Conventional mines, where ore is physically extracted by machinery operating deep underground and transported to the surface, is less water-intensive than solution mining, where ore is extracted by injecting heated brine into potash deposits, allowing potash to dissolve into the brine, and then pumping the potash-rich brine back to the surface. Following extraction, water is used similarly in both types of mines in different aspects of milling, such as flotation, drying and sizing, and also during tailings disposal, as tailings-saturated brine is injected deep underground.

The reliance on water makes the industry sensitive to water availability, although no major stresses due to water shortage were reported during this research. Notably, operations are sensitive to excess moisture and flooding. Recent excess moisture events in Saskatchewan have been problematic for the potash industry, since they result in increased volumes of brine for disposal, increased operating costs, and higher potential for flooding from offsite surface water. In addition, due to the nature and location of their facilities and equipment the industry is sensitive to extreme weather events and extreme temperatures. This research examines these and other climate sensitivities and their related adaptation actions in six mine case studies (four producing and two not producing) in the Qu'Appelle River Watershed. The names of specific mines and mining companies are kept confidential, unless the companies have given consent for the disclosure of these names.



Note: The reductions in both annual production and sales value for the potash industry in 2009 are largely due to the impacts of a global economic recession.

Figure 1. Potash production and sales in Saskatchewan, 2000-2009
(Saskatchewan Ministry of Economy, pers. comm., 2013)

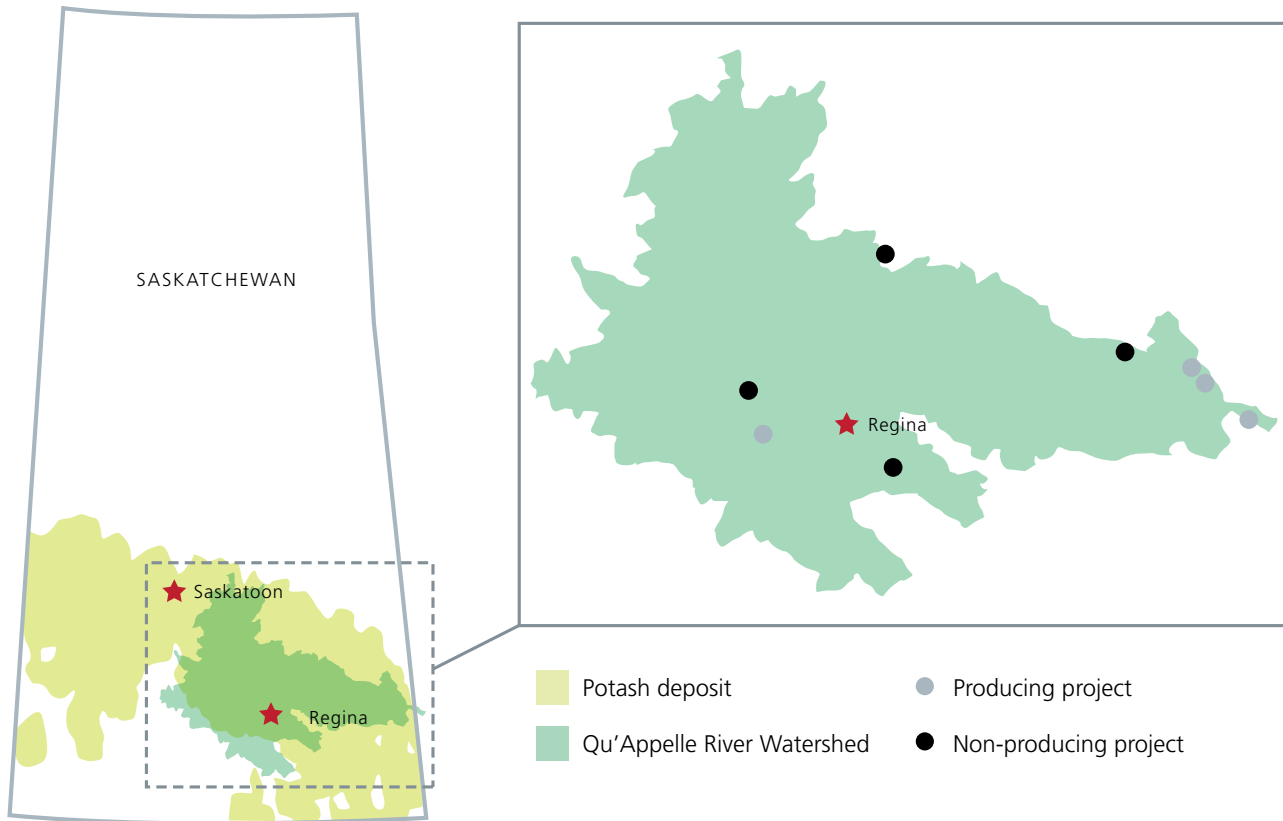


Figure 2. Map of Saskatchewan, the Qu'Appelle River Watershed, and the targeted mines

Methods

This research draws on key informant interviews with potash mine professionals and document analysis to identify how climate change adaptation can enhance the competitiveness of Saskatchewan's potash industry via a case study of the Qu'Appelle River Watershed. Key informants were selected based on their practical and applied knowledge and expertise in dealing with the impacts of climate on the potash industry. These individuals were typically operational or environmental personnel employed by mining companies or knowledgeable individuals in provincial ministries responsible for some aspect of mining operations. Researchers conducted six in-depth interviews – four with mining company representatives and two with provincial ministry representatives – following a semi-structured interview guide (see Appendix I).

The interview guide was organized around the themes of vulnerability (exposure-sensitivity and adaptive capacity) and adaptation to climate change. Interviews were complemented by a number of secondary sources, including Environmental Assessments (EAs), Sustainability Reports, and other government documents. There are eight potash projects in the Qu’Appelle River Watershed that do not or were not planning to source their water from the SSEWS. Of these eight, six were covered in the interviews (Table 1). Of the four producing potash projects, three are conventional mines and one is a solution mine.

Table 1. Coverage of interview sample

Status of Project	Project in the Case Study Region (N)	Projects Represented in the Interview Sample (N)
Producing	4	4
Not producing	4	2

How are companies currently adapting to climate change and variability?

Potash mining companies in the Qu’Appelle watershed are employing a number of strategies to adapt to climate variability and change. The main climate risks addressed by the adaptive strategies are excessive moisture and flooding, water scarcity, extreme weather events, and extreme temperatures (Table 2). Adaptive strategies can be grouped into four categories: (1) investing in infrastructure, (2) water reuse and recycling, (3) innovative and alternative water sourcing, and (4) proactive planning. A number of factors drive adaptation actions, including previous experience with climate stressors, regulations and standards, economics, and voluntary measures.

To complement the information below on observed adaptation, Wittrock (2013) and Wheaton (2013) provide detailed reports on experienced and expected climate risks associated with this case study. Wittrock (2013) places the recent excessive moisture events over the last few years into historical context. She shows how these events, where multiple back-to-back wet years are experienced over large areas, are rare and that the recent events are similar to those experienced in the 1950s. Wheaton (2013) assesses the most probable and worst case scenarios for future drought and excessive moisture and shows how both are expected to increase in magnitude and severity over the next century.

Table 2. Results summary

Climate risks	Why they're problematic?	How are they addressed?	What's driving action?
Excessive moisture and flooding	<p>Increases need for brine disposal, which increases operating costs</p> <p>The cumulative impacts of back to back periods of excessive moisture are more problematic than single-year events</p>	<p>Investing in infrastructure (e.g. water bypass/retention)</p> <p>Proactive planning</p>	<p>Experience with recent events</p> <p>Regulations and standards</p> <p>Economics</p> <p>Voluntary</p>
Drought-related water scarcity	<p>Reduced quantity of water available for operations</p> <p>Decreased water quality</p> <p>Can challenge existing water supply infrastructure</p>	<p>Water reuse and recycling</p> <p>Innovative and alternative water sourcing</p> <p>Proactive planning</p>	<p>Voluntary</p> <p>Economics</p>
Extreme weather events (e.g. strong winds, heavy precipitation, tornadoes)	<p>Infrastructure damage</p> <p>Health and safety concerns</p>	<p>Proactive planning</p>	<p>Regulations and standards</p> <p>Economics</p> <p>Voluntary</p>
Extreme temperatures (hot and cold)	<p>Can adversely affect the operation or condition of some equipment and infrastructure</p>	<p>Proactive planning</p>	<p>Regulations and standards</p> <p>Economics</p> <p>Voluntary</p>

Investing in infrastructure

One way that companies are addressing risks due to excessive moisture is by investing in additional deep-injection wells to dispose of brine. These wells allow for brine disposal without any offsite surface discharge by injecting the brine into a deep, pre-existing saline aquifer; a process that is approved by the Saskatchewan Ministry of Economy. Currently, most mines would have multiple deep-injection wells to keep pace with recent excessive moisture events. These events result in excess brine volumes from both heavy precipitation and prolonged wet periods. Brine injection can be slow in relation to extreme precipitation, but mines have a number of safe storage facilities in place to effectively manage their brine. Safe storage facilities include perimeter dykes, ditches, and berms around brine ponds, whose designs are all approved by the Saskatchewan Ministry of Environment. These facilities are operated, as per the requirements of the Saskatchewan Ministry of Environment, to maintain adequate freeboard space for wave run-up and other factors.

In addition, some potash companies construct flood water bypass or retention infrastructure. Retention ponds dampen high water flow around the mine site, which reduces the fresh water flooding potential downstream. Flood water bypass allows companies to direct excess surface water away from the mine site. Companies must seek proper approvals to prohibit offsite water from entering the plant site or to release surface water from an adjacent area (i.e. to eliminate the water from backing up onto the plant site). Companies collaborate closely with regulators, such as the Saskatchewan Water Security Agency, Saskatchewan Ministry of Environment and Saskatchewan Ministry of the Economy, to ensure that water bypass and releases follow existing environmental regulations.

Water reuse and recycling

Potash companies in the case study were very active in terms of water reuse and recycling. Many optimize their water use and, in almost all cases, the goal is to have no direct discharge of water other than the deep-well injection of saturated brine. This means that a significant amount of water is reused. Water can be reused and recycled in a number of ways and in different stages of the process. For example, excess water from the Tailing Management Area can be used in the milling process. However, the specific details of water reuse and recycling practices are proprietary. It should be noted that potash companies are proactively reducing their sensitivity to drought by optimizing their water use, even if this is not always the direct motivator of action.

Innovative and alternative water sourcing

Some companies are actively seeking innovative and alternative water sources to ensure secure and sustainable access to water. For example, Western Potash Corp. recently developed an agreement to purchase wastewater from the City of Regina. Western Potash Corp., once their mine is producing, will receive the

water directly from the City of Regina via pipeline. This water will then either be treated on site and used in the milling process equipment or used directly in cavern development as part of the solution mining process. Western Potash Corp. could also potentially use excess surface water from their site in their operations by capturing runoff and transferring it into their raw water reservoir. Again, this water could either be treated for use in the process equipment or used directly in cavern development.

During drought, some mines have explored alternative water sources, such as switching from surface water to groundwater. Alternative water sourcing strategies are typically combined with continued operational water use reduction. However, it should be noted that although alternative water sources have been explored they have never been needed in the case study mines. Operational water use reduction strategies have provided enough coping capacity to deal with the droughts that have been experienced to date.

Proactive planning

Proactive planning is a major component of climate adaptation in the potash industry and covers a range of topics from determining surface locations for mines to emergency readiness. All respondents indicated the importance of proactive planning for reducing vulnerabilities to climate and weather events. Within the industry, proactive planning takes many forms and is undertaken in relation to a number of potential stressors.

Proactively planning and selecting mine sites are essential for reducing vulnerability to excessive moisture events. The selection process must adequately factor in existing topography, natural drainage, and observed extreme precipitation events. Effectively locating mines based on these factors can reduce the mines' sensitivity to excessive moisture.

Climate risks are also addressed during the permitting process for the development of greenfields¹ or the expansion of brownfields². These risks are diverse, but typically include potential issues related to water availability, excess moisture and extreme weather. For instance, most EAs take into account two scenarios for extreme precipitation: the 1/100 year precipitation event for the mine site and the industry standard design storm of approximately 300 mm in 24 hours. These scenarios are used to assess and design the capacity of flood management infrastructure (for more information see Regulations and Standards section below).

Additionally, proactive planning is completed for many climate-related emergencies and safety threats. Surface emergency plans address many anticipated extreme weather events, such as flooding and tornadoes. Emergency plans help improve preparedness for many short-term events, and are embedded within broader safety management systems. Safety management systems typically incorporate a variety of programs

1 Greenfields are mines that are currently undeveloped but are being considered for development.

2 Brownfields are mines that are developed and producing.

to improve preparedness for climate-related emergencies. The programs provide education, training, investigation and reporting of all incidents on site. Occupational Health and Safety (OH&S) committees are in place and help guide preparedness processes.

Operational readiness for assets protection and materials replacement is also practiced within the industry. This involves applying building codes and construction techniques for building and other infrastructure that effectively considers severe weather conditions. To deal with extreme temperatures, mines can use underground pipelines, insulation and other engineering design work.

Some companies noted that climate change and its related risks are integrated into their long-term issues management planning. For example, K+S Potash Canada plans to develop a Climate Change Management Plan over the next several years to explicitly deal with future climate risks. Most other companies, however, address climate risks and hazards as part of other long-term management plans or strategies rather than having plans specifically for climate change.

What's driving adaptation?

The drivers of climate change adaptation actions are complex, and often actions result from multiple interacting drivers. For the potash industry in the Qu'Appelle River Watershed, there are a number of drivers acting simultaneously to influence adaptation actions. These drivers include regulations and standards, economics, voluntary mechanisms, and experience with climate stressors. It can be difficult in some cases to fully identify and articulate the causal mechanisms linking specific drivers with specific actions. Rather, the drivers are discussed below in relation to their broad influence on climate change adaptation in the potash industry.

Regulations and standards

Saskatchewan's Environmental Assessment Act provides the main regulatory framework used to guide the development of potash projects in the province. The Act requires that each greenfield development or brownfield expansion undertake an EA. As mentioned earlier, there are two design standards for excessive moisture typically used in the EA: the 1/100 year precipitation event for the mine site and the industry standard design storm of 300 mm to 320 mm in 24 hours, depending on the location of the mine. Subsequent analysis using these two design standards is used to inform infrastructure design and development. Most importantly, these design standards are typically applied to infrastructure within the Tailings Management Areas of the mines. These two scenarios cover a wide range of possibilities for extreme precipitation events and are considered to be representative of very severe events. However, they are based on

extremes value analysis of, and calculations of Probable Maximum Precipitation³ from observed precipitation (Hogg and Carr 1985) and do not explicitly include climate change projections.

Building codes also influence climate change adaptation decision making. Buildings are developed largely based on existing codes, which are viewed as providing adequate protection in terms of existing extreme storms and extreme temperatures. But again, current building codes in Canada and Saskatchewan are based largely on observed climate normals and do not explicitly take climate change projections into account. Further research is required to understand the robustness of existing building codes under climate change.

Economics

Economics influence most adaptation decisions, especially those requiring significant investment. The costs and benefits of different actions are important decision points. In the context of climate change, the added economic uncertainty surrounding different measures is especially difficult to confront and can add an extra barrier to adaptation. In addition, economics can also hinder action when it means replacing existing infrastructure that is still functional and operational. As such, costs and benefits can be more in favour of infrastructure-related adaptation measures during the development of the mine.

Experience

Many climate adaptations are based on previous or recent experience with and observations of climate stressors and conditions. Climate and weather are typically monitored during the design and operations phases of mines, and some infrastructure designs are roughly based on this monitoring (e.g. onsite 1/100 year precipitation events). This information, along with past operational experiences with extreme events, influences how current decisions are made. The types of decisions that have been influenced by recent experience are related to the design of tailings management ponds, brine injection well capacity, fresh water bypass channels, and brine pond freeboard.

Voluntary mechanisms

There are a number of adaptation actions that appear to be voluntary and driven by the general will to do things better, more efficiently, and more sustainably. Many of the water recycling measures seem to be at least partially voluntary. Also, some companies have enhanced environmental monitoring programs that exceed regulators' requirements.

³ Probable Maximum Precipitation refers to the most likely depth of precipitation over certain duration, and is calculated for specific locations and times of year (WMO 1986).

How are companies tracking success of adaptation actions?

There are a number of indicators already used by mining companies that could track success of adaptation actions. These indicators are typically not monitored explicitly for climate change adaptation, but rather sustainability in general. That said, these indicators provide insights into the success of adaptation actions.

The Global Reporting Initiative (GRI) framework (GRI 2013) is commonly used by potash mining companies in the Qu'Appelle River Watershed to track their progress towards sustainability. There are three main indicators used in the GRI framework that could potentially be used to track the success of climate change adaptation actions. Specifically, these indicators could be used to track progress towards reducing the companies' sensitivity to water scarcity. The first indicator is total water withdrawal by source (EN8 in the GRI framework). This indicator allows companies to track what percentage of their water comes from different sources. The second is water sources significantly affected by withdrawal of water (EN9). This indicator allows companies to assess whether or not their withdrawals are significant in relation to the abundance or sustainability of the source. And the third is percentage and total volume of water recycled and reused (EN10). This indicator, probably the most useful in terms of monitoring adaptation, allows companies to track their progress towards optimizing water recycling in their operations.

In addition to the GRI framework, some companies develop their own indicator frameworks for monitoring progress towards sustainability. Many of these indicator frameworks are designed to inform internal decision making processes. For example, K+S Potash Canada is developing Environmental Key Performance Indicators (KPIs) for their Legacy Project. This process begins by establishing an environmental baseline and targets for optimization. The KPIs will then be monitored to assess the efficacy of actions aimed at meeting the targets. These types of monitoring programs, which are used by most mines, are an entry point for programs specifically aimed at monitoring climate change adaptation.



LEFT: Flooded road near Saskatoon. RIGHT: Entering the Qu-Appelle Valley. Photos taken by Jeremy Pittman.

Adaptation lessons from the frontlines

This section provides an overview of key lessons in climate change adaptation for Saskatchewan's potash industry that were provided by the interview respondents.

Expect the unexpected

Recent excess moisture and extreme precipitation in the province have created awareness around the need to be prepared for 'surprises' or for events that exceed those previously experienced. This includes ensuring preparedness for events of both increased magnitude and frequency.

Consider cumulative impacts

A particular challenge associated with the recent wet period has been the cumulative impacts of back-to-back wet years. Single wet years can be problematic, but typically mine operations are able to cope fairly well with them. Back-to-back wet years do not allow mining companies to 'catch-up' in terms of dealing with brine volumes and excess surface water. As such, the need to consider the cumulative impacts of multiple events was highlighted by participants.

The importance of collaboration

The importance of collaboration between industry and government was stressed during the interviews. Current regulatory mechanisms (e.g. offsite water discharge approvals) were positively perceived due to the high degrees of collaboration between the different regulators (i.e. the Saskatchewan Water Security Agency, Saskatchewan Ministry of Environment, Saskatchewan Ministry of Economy, and Department of Fisheries and Oceans Canada). The established working relationships and precedents for collaboration between various regulators and industry have been successful. Information dissemination and communication between regulators and industry has been integral to effective adaptation to extreme precipitation events. Communication and information dissemination has been facilitated by recent developments of online information sites (e.g. Saskatchewan Water Security Agency's new website - <https://www.wsask.ca/>) and ongoing accessibility of regulators' staff. There is considerable interaction between regulators and a general willingness to work with potash companies to address climate-related impacts in a timely manner. Respondents noted the need to build upon and expand this collaboration to increase adaptive capacity for climate change.

How could governments help support climate change adaptation?

The interview respondents identified a number of ways that governments could help the potash industry adapt to climate change. These approaches could enhance the adaptive capacity of the industry and improve its competitiveness in a changing climate. The approaches, discussed in detail below, include enhancing research capacity, bridging science and industry, and promoting effective communication of climate change risks.

Enhance research capacity

Interview respondents noted the need to enhance research capacity in three main areas. First, they saw a need to improve climate and weather monitoring to address current data gaps. Companies need high resolution climate and weather information to feed into their decision making and risk analysis processes. Often, these information needs are not met by current climate and weather monitoring programs. Second, respondents saw the need for improved climate models for the potash producing region. And finally, respondents believed that better climate information and models could be used to develop plausible scenarios for future conditions that also take into account expected economic growth, water demand and other key factors. These scenarios could then be used to facilitate long-term strategy development for addressing climate and other types of change in the potash industry.

Bridge science and industry

Respondents viewed different levels of government as having a strong role in bridging science and industry for climate change adaptation. This role in bridging contains three main functions. First, government could contribute to the development of decision support systems to aid industry when making climate-related decisions. These systems could take many forms, but would generally serve to provide the best possible climate science in ways that meet the needs of industry's decision making. Second, government could play a role in screening and translating climate risks for industry. Third, government could foster strong working relationships between industry and climate scientists to collaboratively identify relevant climate change risks and incorporate these into management plans.

Effective communication

Government could play a role in communicating climate change risks and information to the industry. Communication could include climate change scenarios and risk assessments, adaptation options, and information on the different regulatory processes that would be involved. 'One-stop-shops' or clearing houses

for this information were viewed favourably by respondents. Respondents believed that government had a role in both creating and maintaining such communication channels. It is important to note that some respondents perceive an incoherent message regarding the importance of adapting to climate change coming from different government agencies. This incoherence leads to inaction in terms of adaptation.

Conclusion

This research provides empirical insights into climate change vulnerability and adaptation in Saskatchewan's potash industry. It demonstrates, via a case study of the southern Qu'Appelle River Watershed, that potash companies undertake a number of innovative strategies for addressing climate risks, such as investing in infrastructure, water reuse and recycling, alternative water sourcing, and proactive planning. The presence of these strategies is indicative of a certain level of adaptive capacity for dealing with climate change. These adaptive strategies are driven by regulations and standards, economics, voluntary mechanisms and experience with climate stressors. Progress towards climate change adaptation could be tracked to some degree with existing monitoring programs, such as GRI and other internal monitoring programs. Additional indicators could be integrated into these existing programs in relation to specific adaptation actions.

There were three main lessons for climate adaptation from this case study. The first is related to the need to prepare for 'surprise' events and climate impacts that go beyond those previously experienced. The second is the need to consider cumulative impacts of multiple events when conducting preparedness planning, as opposed to considering the impacts of single events in isolation. And the third is the importance of collaboration between industry, government and scientists in preparing for and adapting to climate change.

Enhancing adaptive capacity in the industry could occur through a number of avenues. In terms of government support in fostering adaptive capacity, this case study highlights the role of government as a bridge between science and industry. Government can support industry adaptation by ensuring practitioners have access to quality climate information and tools to help integrate this information into decision making processes. In addition, government was viewed as having a role in providing collaborative forums for identifying relevant climate risks and related adaptation strategies through engagement of different industry representatives, government policy makers and expert climate scientists.

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Appendix 1: Interview Guide

Introduction

This work is funded by NRCan and is being conducted to document experiences dealing with climate and weather in Canada's mining sector.

We are undertaking this work in collaboration with the Water Security Agency of Saskatchewan and the Saskatchewan Research Council

The information provided will be used to prepare policy briefs and academic publications.

Do you consent to the interview?

Do you consent to recording audio of this interview?

How would you like to be acknowledged for the information? Remain anonymous, company name, individual name/position?

Would you like to be kept up to date with the status of the project?

Would you like a copy of the final report?

What is your contact information?

Part 1 Setting the stage

1. What is your position? Please describe your responsibilities.
2. What are the main ways that climate or weather influence (positive and negative) operations in your position? If responses are limited, prompt with questions from Part 2 or with recent events (e.g. flooding, snow storms).
3. How do you deal with these influences? What are the main actions you have undertaken to deal with this? What are the strengths and weaknesses of these actions?
4. What are the main barriers/enablers of actions? If nothing has been done, why not?
5. How do you measure or track progress?
6. What would you do differently and why?
7. Do you have management or operating plans to deal with these influences?
8. How often are plans reviewed or tested?
9. How successful are the plans? What if things do not go as planned?
10. Have there been any climate vulnerability/risk assessments completed? How have these informed operations?

11. Has climate change been considered in any operating or risk management plans? If so, how? What climate risks are included?
12. Has climate change been considered in any infrastructure investments or decisions? If so, how? What climate risks are included?
13. Do you work with other internal departments or groups in managing these risks? If so, which ones and how?
14. Do you work with other external groups in managing these risks? If so, which ones and how? (Prompt for watershed stewardship group, Saskatchewan Mining Association, other community groups, other companies)
15. Do you work with government (municipal, provincial, federal) in managing these risks? If so, which departments/ministries and how?
16. Ideally, how could government (municipal, provincial, federal) help you deal with these influences?
17. If you could summarize three lessons you've learned for dealing with climate and weather, what would they be?

Part 2 Ensuring coverage of key issues

Based on the responses to Part 1, ask about any of the following issues that WERE NOT already discussed. Only ask about issues that are relevant to the individuals' position and responsibilities. Follow up and probe about key issues as necessary.

- How do climate/weather influence?
- Safety/Health of workers
- Fire and emergency management
- Tailings management
- Waste management
- Commodity management
- Business management
- Transportation of commodity and workers
- Power infrastructure
- Other infrastructure
- Markets
- Insurance
-

How do the following climate- and weather-related risks affect your operations?

- Flood and excessive moisture/precipitation

- Blizzards or extreme snowfall
- Water availability (quantity and quality) and drought
- Water use
- Tornadoes and strong winds
- Heat waves or extreme heat
- Cold snaps or extreme cold
- High or low humidity
- Fire
- Hail
- Lightning
- Inclement weather where product is sold or other regions where it is produced

Part 3 Unpacking specific risks and events

Based on the responses to Parts 1 and 2, identify 1-3 key climate- or weather-related events to discuss further in terms of exposure, sensitivity and adaptive capacity.

1. What are the key climatic/meteorological characteristics that made the event particularly noteworthy?
Probe: frequency, severity, magnitude, intensity, timing, area of coverage, seasonality.
2. Why were your operations particularly (not) sensitive to this event?
3. In your opinion, were you able to respond or deal with this event effectively? Why/why not? What do you recommend be done differently next time?
4. What were the main constraints/opportunities that hindered/enabled your ability to deal with this event?

Part 4 Future risk scenarios

1. What if heavy precipitation events became more intense and frequent, increasing risk of flooding? How would you prepare?
2. How do you think your company would respond to an extended drought (i.e. 5-10 years)?
3. Do you see any specific opportunities or challenges if extreme dry and wet events start occurring more frequently and closer together?



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