Bridging the Water Adaptation Gap (BWAG) - Pathways to Adaptation

Canada Team's Objective Two Summary Report for Partners

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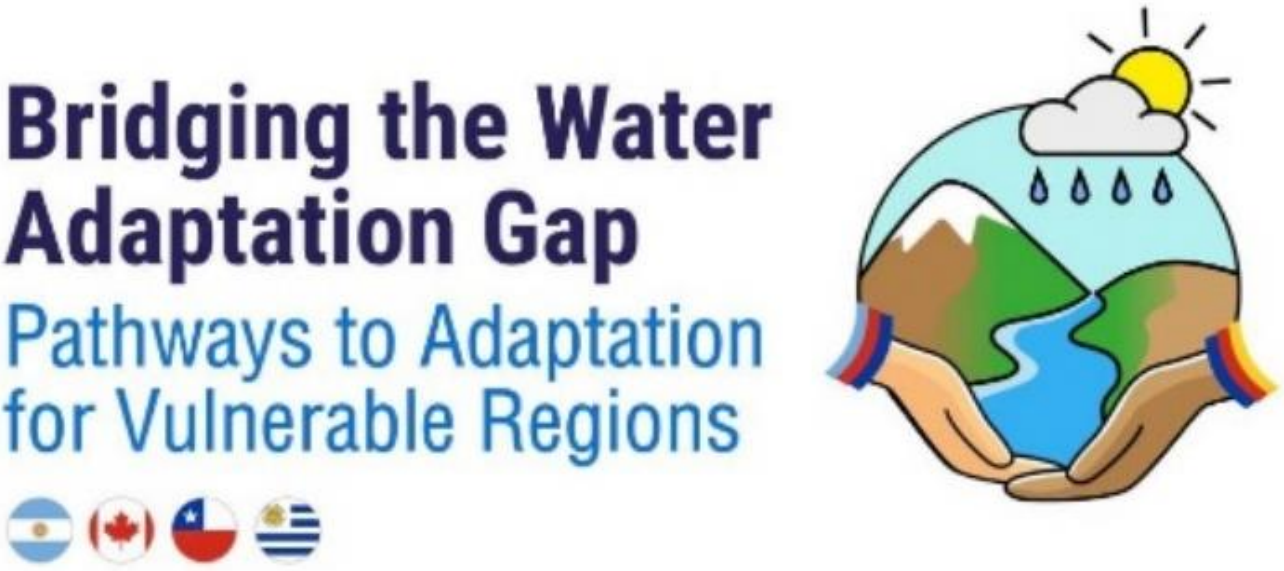

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Contents

1. Executive Summary

This report is an update for our Canadian partners on the key insights and achievements for Objective Two of the Bridging the Water Adaptation Gap (BWAG) project. The **Introduction** explains how Objective Two, which was to identify the main hydroclimatic and water security risks in our study areas, was accomplished through two main activities. The first activity was completing the Objective Two Risk Report, which is a literature review of these risks in Southern Saskatchewan and is summarized in the **Hazards** section. The second activity was conducting focus groups to identify the impacts of these risks on four regional sectors: infrastructure, ecosystems, livelihoods, and primary economic activities. The contents of these focus groups are summarized in the **Focus Groups Results: Impacts on the Sectors** section and briefly touched on below.

In the **Ecosystems** focus groups (**Section 4.1**), the impacts of non-climatic risks on ecosystems were discussed the most, particularly the impacts from conflict, governance issues, and changes in land use. The second most discussed type of impact was the impact of combined hazards (climatic and non-climatic), one example being how increased drought frequency, windstorms, and a lack of financial resources to reduce vegetation contribute to more grass fires.

In the **Livelihoods** focus groups (**Section 4.2**), the impact of water scarcity on the livelihoods of both crop and livestock farmers were highlighted as key concern. Conversely, the increasing occurrence and expansion of floods was highlighted as also impacting the agriculture sector and the livelihoods of many who depend on their farms. Change in water quality was also underlined in the discussion as an impact on the livelihoods of households.

In the **Primary Economic Activities** focus group (**Section 4.3**) the discussion largely centred on the impact of droughts on agriculture and tourism, including the increased development of irrigation systems in the province and the additional pressure placed on provincial support programs. Furthermore, non-climatic factors such as the pandemic, interest rates, policies, inflation, and the lack of available insurance were also discussed.

In the **Infrastructure** focus groups (**Section 4.4**), the impacts of excess water i.e. flooding was discussed in detail- especially how certain rural municipalities have been affected the worst. This was due to a disparity of access to grants for management and repairs, often resulting in permanent damage. “Dry seasons” were said to impact built green infrastructure in cities; there was a consensus on the importance and use of green infrastructure for proactive planning in the RMs. Compound and non-climatic impacts like COVID-19, the wars and a change in policy makers were discussed for their respective impacts on costs, establishments, and administration of infrastructure.

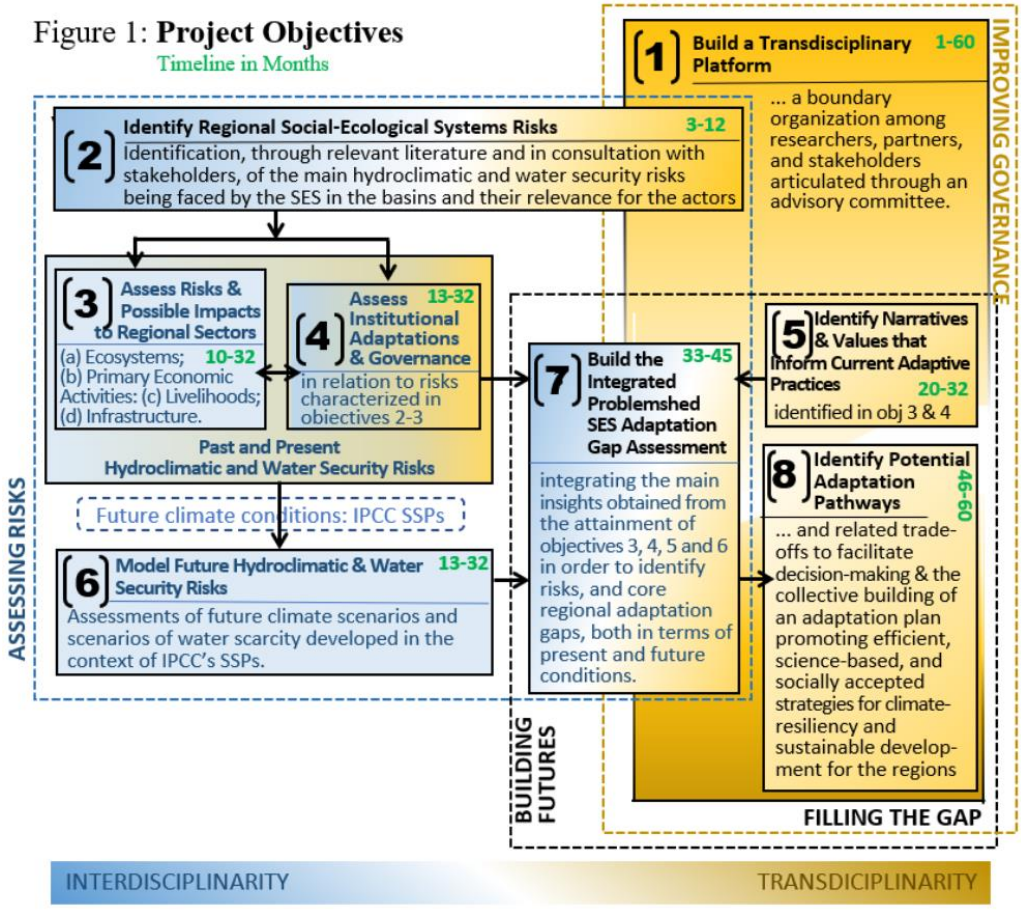
Finally, the **Next Steps** section of this report outlines how the risks identified in Objective Two are enabling us to shape the interview guides for our next objectives (Objectives Three and Four).

2. Introduction

Bridging the Water Adaptation Gap (BWAG) is a five-year transdisciplinary, international project funded by the Social Sciences and Humanities Research Council of Canada (SSHRC). This project investigates how agricultural regions affected by climate hazards and how research participants and partners may develop regional sustainable adaptation strategies to address water security issues exacerbated by climate change in four countries: Canada, Uruguay, Chile, and Argentina. This project is focused on the concept of risk. In relation to climate change, risk is defined as “the potential for adverse consequences for human or ecological systems recognizing the diversity of values and objectives associated with such systems “(Hurlbert et al. 2019, 680). Risk is a function of climatic hazards as well as “the exposure and vulnerability of the affected human or ecological system to the hazards” (Hurlbert et al. 2019, 680). Adaptation then seeks to reduce risks by reducing exposure and vulnerability to climate hazards. Compound risks arise from the interaction of multiple climate hazards, while

cascading risks refer to a trend where one risk triggers others, like a domino or contagion effect (Hurlbert et al. 2020). More details and references on the concept of climate change risks and how it influences our project are found in Chapter 1 of the Objective Two Risk Report.

Objective Two of the BWAG project was to identify, through relevant literature and in consultation with stakeholders and our partners, the main hydroclimatic and water security risks facing socio-ecological systems in our study areas and their relevance for the actors. (See **Figure 1** for all the objectives of this project). Two activities were implemented in relation to



Objective Two. The first activity was a review of documents and secondary data (see the Objective Two Risk Report) oriented to develop a systematic picture of the regional distribution of climate and water risks during the last 30 years. The second activity involved several focus groups with partners and stakeholders to identify the relevance and the impacts of the risks on four regional sectors: infrastructure, ecosystems, livelihoods, and primary economic activities.

This section of the report introduces the project and explains the goals of Objective Two. Section 3 (**Hazards**) summarizes the background information established in the Objective Two Risk Report. Section 4 **(Focus Groups Results: Impacts on the Sectors)** summarizes the results from the Objective Two Focus Group Reports and Section 5 **(Next Steps)** outlines how the next objectives of our project will build on Objective Two. The current report is intended to update our partners on what we have achieved for Objective Two and our 'key insights'.

3. Hazards

Our Canadian BWAG team of researchers and partners first met in September of 2022, where our partners provided initial feedback on the main hydroclimatic and water security risks facing socio-ecological systems in Southern Saskatchewan. Our researchers then conducted a review of academic and grey literature, titled the Objective Two Risk Report, to support and build on this risk identification process. This report consisted of five chapters. Chapter 1 defined and explained climate change risk and water security. The highlights from Chapter 2, which reviewed hydro-climatic variability in the prairie provinces, are shown below. The purpose of this chapter was to document recent findings regarding the nature of past and possible future drought and excessive moisture events. The roles of the strong hydro-climatic variability of the Canadian Prairies and projected climate change were considered.

- Drought can be defined in various ways, but the essence of the meaning is a prolonged period of abnormally dry weather resulting in insufficient water resources for the economy, environment and society. Drought is one of the worst hazards for the economy, environment and society.
- New findings about the characteristics of drought included the evaluation of its life stages, of sudden onset droughts, switches of wet and dry conditions, snow droughts and spatial evolutions.
- Hydro-climatic variability is especially strong in the Canadian Prairies and decadal variability tends to characterize droughts and excessive moisture events. Multi-decadal variability and decades-long drought are also supported by paleo-climatic research.
- Droughts are having more impacts now because of the compounding effects of other hazards including heat waves and intense precipitation, which are becoming more frequent.
- Climate change is a critical driver of the changing nature of hydro-climatic variability. Human-driven climate change is documented as worsening various characteristics of drought and excessive moisture now and into the future.
- Understanding changing characteristics of drought, such as life stages of drought and excessive moisture linkages, are important to improve the fit with planning and preparedness that help reduce impacts.
- Improved understanding of drought impacts to the economy, ecosystems, livelihoods and infrastructure, as well as interactions of risks is required. Enhanced understanding of the risks of drought and excessive moisture is required for improved adaptation. Reducing vulnerabilities to this hydro-climatic variability requires many vital components such as awareness, monitoring, research, outlooks, planning, management and preparedness.

Chapter 3 reviewed water quality in prairie lakes and agricultural ponds; Chapter 4 considered water security risks to primary economic sectors, and Chapter 5 focused on impacts from land use changes in Saskatchewan.

Table A in the Objective Two Risk Report (see **Table 1** below) considered the impacts of water security risks on four sectors: **ecosystems**, **livelihoods, primary economic activities**, and **infrastructure**. These sectors are defined as follows: an **ecosystem** refers to the interaction of living resources (ex. plants, animals, algae, and bacteria) and non-living resources (ex. water, soil, nutrients, and temperature) in a certain area. **Livelihoods** addresses how water challenges like flooding and drought affect people's means of making a living and securing the necessities of life. **Primary economic activities** address how water resources are used to produce goods and services, and how events related to water, such as floods and droughts, affect different economic sectors like agriculture, water supplies, energy production, industry, mining, forestry, recreation, human health, and society**.** Finally, **infrastructure** refers to built facilities that advance the other sectors including drinking water, irrigation, water pipelines, wastewater, and transportation equipment, including (built) green infrastructure.

Table 1: Impacts of water security risks on four sectors (livelihoods, primary economic activities, ecosystems, and infrastructure) in Southern Saskatchewan. This is Table A in the Objective Two Risk Report. See Appendix A in the linked report for more details and references for this table.

Risk categories	Livelihoods	Primary economic activities	Ecosystems	Infrastructure
Risk related to water scarcity	*Droughts tend to cause more damage, last longer and cover larger areas than other weather extremes, which makes impacts worse and adaptation more challenging. *Crop insurance dependency and coverage are expected to grow as climate change progresses. *Decreased fish populations.	*Droughts impact many economic sectors, including agriculture, water supplies, energy production, industry, mining, forestry, recreation, human health, and society. * Impacts on agriculture are particularly important due to its prominence in Saskatchewan's economy.	*Environmental impacts from major drought include reduced water quality, wetland loss, soil erosion and degradation, and ecological habitat destruction. * Future warming projects a decrease in summer streamflow and an increase in winter streamflow.	*Water is needed for other critical infrastructure (e.g., education, health).
Risks related to excessive moisture	*Loss and damage of household assets (mainly rural) due to heavy rains and floods. * Floods make up most of the Federal Disaster Financial Assistance Arrangements (DFAA) payments in the Prairies Provinces. *Projected extreme precipitation are expected to increase the potential for future urban flooding.	*Loss & damage in productive agriculture, mining and hydroelectricity, crop/livestock production, farm infrastructure, local government and infrastructure upgrades and net farm income.	* Higher runoff into aquatic ecosystems could potentially load more nutrients and contaminants into these systems, raising nutrient concentrations, increasing pH, and elevating the salinity of the systems.	*Loss & damage to water infrastructure, including wastewater treatment plants, and roads.
Risks related to climatic variability	* Rapid changes between extreme weather affect many aspects of people's livelihoods, including plants, animals, energy systems,	*Changing diseases affect agricultural production of crops and livestock.	* Rapid changes from drought to flood (and vice versa) can damage ecosystems and increase risk of pollution. *Changes in climate systems	* Cascading infrastructure risks from extreme conditions affect various types of

Risk categories	Livelihoods	Primary economic activities	Ecosystems	Infrastructure
	transportation, etc. * Human health risks from changing diseases.		(such as the El Niño–Southern Oscillation) can affect lake dynamics.	infrastructure.
Risks related to water quality	*High levels of cyanotoxins. *Poor source water quality affects drinking water quality, particularly in remote and Indigenous communities and non-Indigenous communities in Saskatchewan. *Late-season cyanobacterial blooms.	*Cyanobacterial blooms have led to drinking water advisories and negative impacts on tourism. *Decreased property values for lakeside properties. *Cyanobacterial toxins have killed cattle in all the prairie provinces. *Sulfate concentrations in agricultural ponds are also a concern.	*Negative impacts of cyanobacterial blooms include increased turbidity, oxygen depletion, and cyanotoxins which can cause “liver, digestive and neurological diseases when ingested”. *Nutrients and warm temperatures can combine to have synergistic effects on cyanobacterial growth in shallow water bodies. *Late-season cyanobacterial blooms freeze into the fall’s ice and release blue-coloured pigments in the winter. *Metal pollution of water. *Plastic pollution (microplastics and microfibers).	*Water treatment plants. *Wastewater treatment plants also often require expensive upgrades to meet governmental regulations and improve the removal of nutrients such as P and N that negatively impact downstream water quality.
Risks related to warming air temperatures	*Effects of increased temperature on urban areas prone to heat. *Summer fish kills which negatively affected the low oxygen caused by high temperatures and/or decomposition of algal blooms. *Warmer water temperatures contributed to increased concentrations of the toxin microcystin that are harmful to public health.	*Warmer water temperatures are reducing oxygen concentrations in lakes, which may reduce fish habitat. *Reduction of fish habitat noted above could negatively affect Saskatchewan's recreational fishing tourism industry.	*Warmer surface waters will lead to changes in lake thermal stratification. *Changes in nutrient availability. *Lower oxygen is detrimental for fish and invertebrates, alters nutrient availability, and increases metals' toxicity. *Cyanobacteria often reach maximum growth rates at warmer water temperatures.	*Shorter periods of ice cover: ice roads are open for a shorter period of time, which may reduce transportation in northern areas of the province.

Risk categories	Livelihoods	Primary economic activities	Ecosystems	Infrastructure
Risks from invasive species	*Invasive species may negatively impact subsistence fishing	* Invasive species such as dreissenid mussels, smallmouth bass and Prussian carp may negatively impact native fish populations, which could impact the recreational fishing industry. *The Northern Pine Beetle has impacted forestry.	*Warmer water temperatures and changes in precipitation may favour the spread of invasive species from south to north. *Increasing frequency of extreme events may make ecosystems more vulnerable to the invasion of new species. *Zebra and quagga mussels can drastically change many aspects of a lake, including nutrient cycling, the underwater light climate, and food web interactions, which can negatively affect fish at the top of the food web.	*Invasive dreissenid (zebra and quagga) mussels can severely impede the function of a variety of infrastructure, including facilities with water intake pipes.
Risks from land use changes	* Draining wetlands reduces flood and drought protection and recreational opportunities.	* Draining wetlands reduces flood and drought protection, increasing economic risks. However, drainage also increases net economic accruals from crop production	* Agricultural drainage removes many benefits (or ecosystem services) provided by wetlands.	* Wetlands may be considered 'natural infrastructure' since they reduce the severity of floods.

4. Focus Groups Results: Impacts on the Sectors

To expand on the water security risks impacting the four sectors identified in the Objective 2 Risk Report, BWAG's Canada team conducted six sector-specific focus groups from June to September of 2023. The number of focus groups and participants for each sector are shown in **Table 2**. The participants included academics, policy makers, agricultural producers, and representatives from rural municipalities, the local community, tribal councils, watershed and water quality groups, farm organizations, government agencies (provincial and federal), and non-profit organizations.

The focus groups were conducted after obtaining approval from the Research Ethics Board at the University of Regina and recorded after being consented to by all the participants. These audio files were then transcribed by research assistants, reviewed by the sector and project lead/s before being analysed using NVivo software. The following sections will summarize the main impacts, both climatic and non-climatic, that were discussed in the focus groups for each of the four sectors.

Table 2: Number of focus groups and participants for each sector in Objective Two.

Sector	Date	No. of participants	Focus Group Delivery
Ecosystems	September 14th, 2023	9	Zoom
Ecosystems	September 28th, 2023	9	Zoom
Infrastructure	June 28th, 2023	9	Hybrid (zoom and in-person)
Infrastructure	June 29th, 2023	11	Hybrid (zoom and in-person)
Primary Economic Activities	September 13th, 2023	10	Zoom
Livelihoods	September 19th, 2023	10	Zoom

4.1. Ecosystems

Impacts from non-climatic hazards were discussed more often than climatic hazards at the two ecosystems focus groups. Impacts from current and/or potential conflicts, which were often connected with governance issues, came up very often. Examples included conflict over poor water quality and the cost required to rehabilitate lakes with harmful algal blooms; the need for a better system to enforce drainage legislation; the need for a wetland policy in Saskatchewan; and the difficulty for First Nations to navigate policies, laws, and systems that were created in their absence. The participant below talked about how climate change and a lack of policy contribute to conflict over water.

"Oh, water conflict, woof, that's a big one. What I wanna share, [Facilitator], is that we have a great deal of conflict in this province, and I think there's two colliding forces here. One is the change, the changing of our weather due to climate change. And then the other one, is we lack policy. And what that is created is this psychology of pointing fingers and blaming the other guy. And that's where the conflict comes. And, and it was mentioned by one other person here like, we only have, like 1.3 million people, we're really small. And we cannot, we have to work together to make sure that all our industries are set up for success. But when we don't have policy, and then we're fighting these droughts and floods, when we get the super droughts and the super floods, we, we won't have a chance. Our businesses will not be successful."

Other governance issues that came up included a need for better assessment of groundwater resources to support permitting and better transparency from the provincial government on how much agricultural drainage (illegal or approved) occurs.

Another non-climatic hazard that came up as often as conflict and governance was impacts from land use changes, which expanded on those already mentioned in Chapter 5 and Appendix A of the Objective Two Risk Report. These included the impacts of wetland drainage, which reduces habitat for migrating birds, reduces groundwater recharge, and reduces the capacity of wetlands to store nutrients; impacts from the conversion of native grassland and other native habitat into farmland; and the impact of pollutants (such as herbicides, pesticides, and nutrients from fertilizers) in urban and agricultural runoff.

Other non-climatic hazards included impacts from industry, current adaptations, and water structures. Some participants were concerned about large industrial users of water, including irrigators and potash solution mines, using a lot of water and contributing to water allocation conflicts in the future as water resources become scarcer. The Husky oil spill, which shut down access to the North Saskatchewan River, was also referenced as a hazard from the oil industry to aquatic ecosystems. While current adaptations were often mentioned as being beneficial, several participants also pointed out that adaptations on farms in Southern Saskatchewan may have negative impacts. For example, the participant below talked about the inability of buffer strips to capture nutrients in spring runoff.

"And so, regardless of how well a farmer manages his nitrogen and his phosphorus, it's still gonna run off his land or her land in the spring when the snow melts. And so if that's not being captured anywhere, it's going into our water bodies. And so as we increase the amount of cultivation, we're gonna see more phosphorus and some nitrogen moving into our lakes and rivers. And it's just it's a natural part of the breakdown of straw. And so, and I know there was lots of research that was done previously under the I believe it was the WEBS program, you know. And they, they said, basically even buffer strips that you can put around to try to capture those nutrients don't work in the spring because the ground is frozen and the water and the nutrients just flow right through."

Impacts from water structures included dams acting as barriers to fish passage and the loss of habitat that may occur if structures are decommissioned. Other less-discussed non-climatic hazards included impacts from cottage development; finances ("*lots of times it comes down to the dollar*"); aging infrastructure; potential or current invasive species including quagga and zebra mussels, Prussian Carp, and aquatic vegetation such as purple loosestrife; a lack of human resources or knowledge, and misinformation. (See Table 3a of the Ecosystems Sector: Focus Group Report for Canada for more details on these non-climatic hazards).

After non-climatic hazards, the impacts of combined hazards (climatic and non-climatic) were the second most discussed type of hazard. Some examples of these combinations and the resulting impacts on ecosystems are listed below:

- Climate change (decrease in glaciers and water supply) + lack of groundwater knowledge + multiple water users → increased pressure on limited water resources, which stresses aquatic ecosystems.
- Intense rain events + changes in drainage structures (larger culverts)→ increased speed of transport of nutrients and silt into lakes.
- Warmer temperatures + nutrients → toxic algae blooms.
- Cumulative effects (ex. climate change + land use change + agriculture + urbanization + industry) negatively impact ecosystems. Many of these effects are increasing in intensity.
- Increased drought frequency + windstorms + lack of financial resources to reduce vegetation → more grassland fires.
- Reduced water flow due to drought + old dams and water structures → barriers to fish movement.

One participant also mentioned how the cumulative effects from industry, land use changes and climate change can lead to a breach of treaty if First Nations are not able to engage in practices within their culture including hunting, fishing, and accessing their land.

Hazards from drought came up often and included concerns about glacier reduction; decreased river flow and water levels in wetlands, lakes, and deltas; changes in ecosystem type due to increased aridity; how an increasing growing season increases algal growth; and the effect of increased drought frequency on forest and grassland fire management. Hazards related to flooding were also discussed, although not as often as the other hazards. These included the impact of intense rain events (including forcing cities to discharge raw sewage into water bodies); the larger impact of flooding on terminal (closed) water bodies such as the Quill Lakes; and an increasing change in the timing of water where the spring melt is smaller and there are more intense rain events in the summer.

4.2 Livelihoods

Partners from the focus group discussion highlighted drought and water scarcity as significant factors impacting livelihoods, especially in the context of agriculture and rural communities, which is consistent with the key findings in the Objective Two Risk Report. In relation to agriculture, several participants mentioned how water scarcity impacts the ability of farmers to grow their crops which, in effect, impacts harvest. One participant highlighted this by saying:

"You look at, say, a grain producer and their ability to even get a crop in the ground, and if they did, you know it might not do all that well in terms of production, you know the delay and harvest."

Dry conditions also affect farm inputs, making the application of fertilizer less effective in some situations. Increasing drought was highlighted as a key driver putting higher demand on irrigation. Animal production was also highlighted as being impacted by water scarcity as farmers are faced with inadequate water supply which impacts pasture, thus necessitating sourcing of feed from other areas. This increases their cost of production and was highlighted by a participant who said:

"So you know, the whole cattle animal production is, you know, dependent upon the pasture, water, etc., etc. on a daily basis. So when you have longer periods of drought or longer periods without them moisture it just keeps amplifying and increasing the expenses and additional work goes along with that."

For communities, water scarcity was mainly highlighted as an issue that impacts water quality. In the case of some First Nations, this impacts their ability to obtain medicines and traditional species which are important to them.

"I guess, for me just to speak kind of collectively, we have Nations, shoreline Nations again on these basins in reference. I guess it's about the exercising of our rights, and that being

livelihood, so whether that is drought affecting the shoreline. Whether that's affecting the habitats where we, cultivate our medicines and those kind of traditional species."

Additionally, participants emphasized the importance of water availability and quality in sustaining livelihoods, highlighting the need for effective water management strategies to mitigate these challenges.

Focus group participants also highlighted risks related to excessive moisture and flooding that are consistent with findings from the literature review of the Objective Two Risk Report. There were concerns about the impacts of floods getting worse every year with more damage to infrastructure. The agriculture sector was mentioned as being heavily impacted as farmers are burdened with extra costs as their farms get flooded, and while they try to get the water off the farm, they still have to pay for rent on the land. As captured by one of the participants, they said:

"So, they are looking at, you know, upwards of a $150 per acre return if they can manage their excess water and that relates back to, you know, all different crop inputs and land efficiency, equipment efficiency, etc. So, when it comes to flooding on livelihoods, I think you know, in excess water regions, again, that adaptability to manage, for you know, excess or drought, water is one of the most important impacts on farm business."

Also related to this is the impact on some First Nations who rent out their lands to farmers and are unable to receive payments when these farmlands get flooded. Participants also highlighted the impacts of flooding on communities as it disrupts people's ability to move and access basic services or go to work. The discussion also highlighted how areas that were in the past not considered as prone to flooding are now being flooded. There were also calls for the need to provide more insights into the challenges and impacts of flooding on livelihoods for anticipatory action. This was highlighted by a participant who said:

"As we redo these maps and some of these maps, we do have maps for communities that are in some cases [are] 30 years or more older. And as we are redoing them, the flood lines are starting to change. So, there's the impact that the hydrology, that the water regime is actually changed in some of these areas. And it's actually cause, you know, maybe in some cases more flooding hazard than people expected."

Participants also highlighted the impact of water quality issues on livelihoods, particularly in the context of agriculture and consumption for communities. Participants highlighted climate variability as impacting water levels and as the water depletes, the quality also depletes which impacts crop and animal farms extensively. The quality of water for spraying crops or growing pasture to feed animals becomes a concern as water depletes in dry conditions. One participant said:

"So, I guess, on the cropland end of it one of the things that probably you don't think too much about, and that is good quality water for spraying of crop, or whether it be for weed control or insect control... You have germination problems, it goes on and on."

Participants also highlighted the tremendous impact of water quality on livelihoods as communities as there are increasing cases of algae blooms which are sometimes toxic.

4.3 Primary Economic Activities

The key economic sectors/activities identified in the region by focus group participants included agriculture (farming, ranching, and food processing), the energy industry (including oil, gas, and biomass), forestry, manufacturing, mining industries, recreational activities (such as tourism, fishing, and hunting), and transportation.

The impact that droughts have on these economic sectors/activities was the topic most discussed during the PEA focus group. These included the increased development of irrigation systems in the province. A participant who talked about this said:

"There's been records about the amount of new irrigation systems being installed, utilizing different water sources to help provide more resilience against droughts for cropping systems."

Participants also highlighted that drought had a significant impact on agriculture, forestry, and cattle production, affecting both short-term and long-term outcomes. This placed additional pressure on provincial support programs, such as crop insurance. Additionally, droughts had adverse effects on tourism and business opportunities in communities focusing on eco-tourism. Moreover, participants highlighted that excess water, such as flooding, significantly impacted crop production and grain quality, and increased the risk of insurance denial for all types of businesses.

Non-climatic impacts on economic activities included current water policies. Participants noted that policies often fail to address water issues adequately. For example, policies classify cities solely for domestic water use, resulting in no charges for industrial or business water use within city limits. Participants below discussed the necessity for a shift in water management practices and emphasized the importance of enhancing awareness to protect water sources:

"We've got to move much more to what one might call a passive system rather than necessarily an active system."

"What we've seen across the provinces is a first of all a lack of understanding of what threats are there in regard to groundwater sources as well as even surface water sources."

They also emphasized the role of policies, noting that while some policies may be effective province-wide, others may vary in effectiveness across regions. Factors such as the pandemic, interest rates, inflation, and the uncertainty of insurance availability in the economic sector were also discussed. Furthermore, participants mentioned compounded hazards affecting the economic sector, such as irrigation, conservation drainage practices, AI technology, and land use management. Participants agreed that concerted efforts to enhance water use efficiency across all sectors will enhance resilience and should be a political priority. I AGREE MORE DETAIL/ CUT AND PASTE FROM EALIER REPORT? IF POSSIBLE

4.4 Infrastructure

The key findings from the infrastructure focus groups were as follows. Excess water (i.e. flooding) has resulted in permanent damage on infrastructure such as roads. This is especially true in certain rural municipalities (RM) which are affected the worst due to a disparity in access to grants for management. One participant said:

"Two of the- two of the three highways were overtopped. Luckily, they didn't lose any. During that same time, we had highway sixteen, which is a major highway through Saskatchewan, overtopped and get part of it taken out. So that was major infrastructure damage. We saw at the Quill Lake's threats to rail lines and highways, RM roads completely taken out."

Grants relating to flood damage reduction and adaptation planning programs were explained as complex processes which require certain internal resources that may make the process of acquiring them challenging for smaller communities in RMs. A participant said:

"*Yeah, I'll I I guess a second to number 11 said there, both the funding availability and small communities. I would definitely see that a lot. And and sometimes there are barriers as well to provincial or federal particularly, I would say Federal funding with the infrastructure. Certainly. there are some programs available. sometimes. you know, the minimum buy-in from a community is pretty substantial. they're really not targeting small communities. the timelines imposed are are kind of based off of budget cycles, so that really makes it makes it challenging as well for for particularly the smaller communities that maybe don't have all the internal resources in their community like Regina Saskatoon would. So yeah, that's definitely a a challenge."*

Beyond the impact on highways known to isolate communities in the past, flooding has also damaged natural infrastructure and built green infrastructure along with damages to commercial, private, and agricultural properties in both rural and urban communities.

There was some support for responsible drainage to mitigate the impacts of excessive water, which elaborated upon the trade-offs between environmental sustainability vs economic sustainability. A participant said:

"*I guess from the farmer point-of-view and [.....]Be politically correct, I guess in a way, but lot of people like the point fingers that ag drainage and doing nothing is not an answer. And there's certain groups that like to hold water back. That does just as much damage to our infrastructure as draining it. [.....] Also drainage. When people, you have a hundred and sixty acres that's naturally drained, that's okay. Then the road across the road has like a little corner, say two point three acres, and the guy puts a scraper in there and drains it. Everyone driving by that guy thinks he's just a criminal..... But yet they develop a whole corner of the city. pave it put up houses,* [.....] *everybody has weeping tile they have a hundred percent drainage surface and exactly. But if a farmer does it, everyone's pointing the finger and all these individuals need to be controlled. And the thing is what they're trying to do is soil health. Most guys aren't doing it because of a hate of wetland, they're farming land, and thats*

why they're doing it. [.....] *So the big thing I just have: drainage is a good thing.*[.....]*You can mitigate the floods too because just letting it hold up and saving it doesn't do anything."*

A tendency of being short sighted (reactive short-term plans) was discussed with a consensus around the need for more proactive planning (for long-termed and better preparedness for natural hazards) to mitigate potential losses. This proactive planning detailed the need to use "dry periods" to "do the work" in preparation of wet periods. A need for more water storage infrastructure was considered along with plans for placement. A participant said:

"So, you just spent forty million dollars and then it floods again and the residents, or you know of the municipality or the urban center, you know, start to question the experts and that sort of thing on, on what is the right thing and trying to be proactive versus being reactive"

Adding to it, another participant said:

"The drought does have a plus side where you can get in. You can clean out those creeks and those spots where you can't get in normally, and that's one of the things that happens a lot. You have wet, wet- wet and then it gets dry and everyone just forgets about it."

Dry periods which often result in extreme heat events were explained to adversely impact built green infrastructure in major cities. They also impact livelihoods and economic activities reliant on agriculture.

Certain compound impacts were also discussed in detail wherein there were impacts due to a change in community priorities and policies. For example, when political leadership changes, the adaptation/ mitigation responses change or are even lost. A participant gives an example below:

"One, of the things that they planned on doing was to replace a bunch of culverts throughout town along the highway to help drain the highway, and then it never got done. Ran into another election, and in the in the fall and the next summer, well, I mean, we still have the culverts sitting in our yard."

The impacts of COVID19 and the war in Ukraine were also discussed; see the participant below for impacts from COVID19 on getting supplies:

"The COVID. We're seeing it delays on products and we're still seeing that we've changed suppliers. We've changed suppliers again, we're trying to get different products, switching products."

Forest fires and ice storms were also said to have impacted built infrastructure by causing power-grid issues. Extreme shifts in the province have resulted in intersectional impact on all sectors- infrastructure, livelihoods, primary economic activities, and ecosystems.

"I mean wildfires, grass fires in this region. That seems kind of unheard-of but major disaster, you know, around the lake a couple of years ago as well we had a major ice storm tied into the.

Our concern with that is the power in the grid system. So I mean we were. We are basically well, screwed. If we have no power, you know, if we're down for three days, I mean we'd come to a pretty devastating halt. As for our infrastructure and supplying water to residents through the water treatment plant process, we're actually installing two backup generators now: natural gas, in case of those power outages stemming from the ice storms we've seen."

5. Next Steps

These risks identified in Objective Two are now enabling us to shape the interview guides and interviewee list for the next objectives in this project, which are to further assess the risks and their possible impacts to each sector (Objective Three) and then assess the institutional adaptations and governance in relation to these risks (Objective Four; see Figure 1 for project objectives).

6. References

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