Weathering What's Ahead:

Appendices

NOVA SCOTIA

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Appendix 1: Glossary

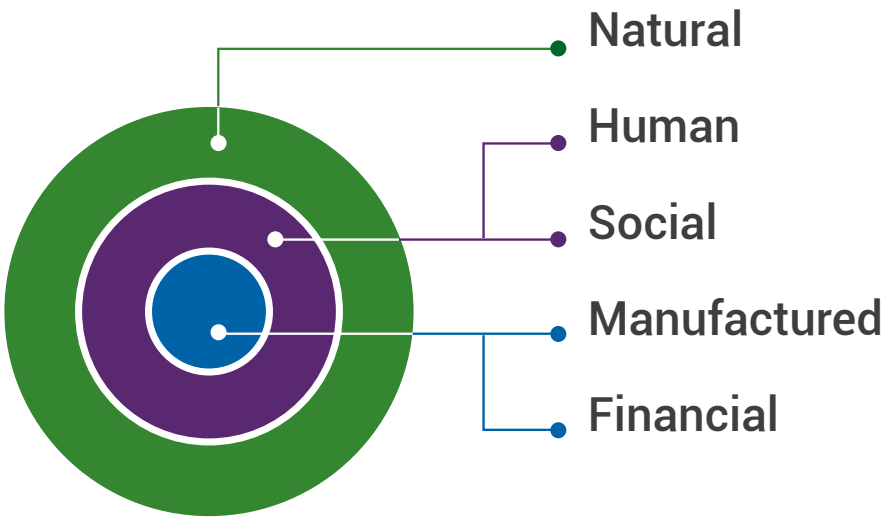
Adaptation	Adaptation is defined, in human systems, as the process of adjustment to actual or expected climate and its effects in order to moderate harm or take advantage of beneficial opportunities. In natural systems, adaptation is the process of adjustment to actual climate and its effects; human intervention may facilitate this[2].
Adaptive capacity	The ability of people, institutions, and systems to adjust and adapt to potential damage, to take advantage of opportunities, or to respond to consequences[5, 70]. This term differs from coping capacity (below), in that it takes a medium- to long-term perspective. Adaptive capacity can be viewed as the 'room to move' for adaptation—i.e., the capacity to increase future coping capacity and to reduce sensitivity and exposure to hazards.
Coping capacity	The ability of people, institutions, and systems to successfully accommodate, and manage adverse conditions in the short- to medium-term, using available skills, values, beliefs, and resources.
Climate opportunity (or benefit)	An impact of climate change with the potential for environmental, social, or economic benefit. Adaptation is required to realize the potential benefit.
Climate hazard (or threat)	The potential occurrence of a climate-related event or stress that may cause loss of life, injury, or other impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources[5,70].
Climate impact	A climatic event or trend that may have an impact on well-being. If the consequences are predominantly negative, we refer to the climatic event or trend as a climate hazard. If the consequences are predominantly positive, we refer to the climatic event or trend as a climate opportunity.

Cultural Services	Non-physical benefits humans derive from ecosystems through spiritual, cognitive, and experiential enrichment. Examples include opportunities for spiritual and religious inspiration/expression, recreation opportunities, aesthetic appeal, artistic inspiration, and education opportunities[71]. See Ecosystem services below.
Ecosystem Services	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth[71].
Exposure	The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected by a climate hazard[5,70] or positively affected by a climate opportunity.
Financial capital	Money that facilitates the interaction of other forms of capital by funding the activities that might be required for the services flowing from those capitals to be acquired, realized, managed, or improved[72].
Flows (of capital)	Movement of materials or information to and from existing stocks, often measured as a volume or a rate (e.g., volume per unit of time)[72]. This movement moderates the supply of services from which people derive well-being. Examples include net flows of water, weathering rates of rocks/minerals, and coastal erosion rates (natural capital), attrition rates of individuals from volunteer organizations (social capital), deterioration of roads, bridges, buildings, equipment, etc. (manufactured capital), frequency and volume of consumption, savings, and investment (financial capital).
Foundational (or supporting services)	Ecosystem services that generate the habitat and biodiversity needed to support plant and animal species. Examples include soil formation, nutrient cycling, and primary productivity[71,73].

Human capital	The productive capacity of human beings, including the stock of capabilities held by individuals such as knowledge, education, training, skills as well as physical and mental characteristics like behavioural habits and physical and mental health[72].
Manufactured capital	Manufactured assets, such as roads, vehicles, houses, machinery[72] that are built from inputs of materials (natural capital) using energy, labour, and production technologies that rely on human and financial capital[74].
Natural capital	The stock of physical assets in the environment, the processes from which humans obtain benefits[74] and that sustain life on the planet. Examples of physical assets include water, trees, minerals, and species. Examples of natural processes include water purification and climate regulation. The term natural asset is also used to refer to specific physical assets that provide ecosystem services.
Provisioning services	Ecosystem services that provide humans with physical, living and non-living resources. Examples include food production, fresh water supply, fuelwood production, fibre production, biochemical production, and genetic resources[71].
Regulating services	Ecosystem services that benefit humans through regulating natural processes. Examples include climate regulation, disease control, water quality regulation, and air/water purification[71].
Risk	Climate risk is often used to refer to the potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard, on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Risk results from the interaction of vulnerability (i.e., the combination of sensitivity and adaptive or coping capacity of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence[5,70].

Sensitivity	The degree to which a system is affected, either adversely or beneficially, by climate variability or change[5,70]. The term refers to the susceptibility of natural capital, manufactured capital, people, etc. to adverse or beneficial effects when exposed to a climate impact. For example, underground electricity cables are less susceptible to damage from ice storms than above-ground wires.
Social capital	The stock of contacts, trust, reciprocity, and mutual understanding associated with social networks[72]. Examples of social capital in action include civic engagement, volunteerism, political engagement, club affiliations, family stability, and trust for institutions[74]. Social capital can be eroded by inequitable distribution of other capitals.
Socioeconomic determinants (of climate change vulnerability)	Adaptive and coping capacity, exposure and sensitivity are shaped by many non-climatic, socioeconomic factors, including access to and control over social capital, human capital, financial capital, manufactured capital, and natural capital. In turn, socioeconomic determinants – social, political, and economic conditions and institutions at local to global levels— shape people's access to these capitals, creating inequities in climate change vulnerability[75].
Stocks (of capital)	Quantifiable amounts of material or information available to a system or a set of users. Examples include volumes of soil/organic matter and water (natural capital), the number of individuals in a social network (social capital), knowledge held by fishers about the best gear and fishing locations (human capital), and the amount of liquid assets in a region (financial capital).
Well-being	Well-being characterizes "how we are doing" as individuals, households, and communities. It captures outcomes relating to material conditions that shape people's economic options and living standards; quality of life factors that encompass how healthy people are, what they know and can do, and the quality and safety of their places of living; and social connections that reflect how integrated and engaged people are in their communities, and with whom they spend their time. Capitals (e.g., natural, social, human, financial, and manufactured) are the necessary resources from which well-being is derived in the present and from which long-term sustainable well-being is derived for the future.

Appendix 2: What is Well-being?



Natural: All aspects of the natural environment that support and sustain life and human activity and fulfillment. This includes healthy ecosystems and biodiversity, food, clean air, water, the ability to earn a living from natural resources, and enjoy nature.

Human: Resources needed for people to live healthy and fulfilling lives and to participate in society. This includes physical and mental health, knowledge, skills, and education to learn, play, and work.

Social: The quality of relationships and institutions that support how we care for each other and live and work together. This includes friends and family, neighbours, community organizations, governments, and other institutions that provide a sense of community and safety.

Manufactured: Human-made goods, services, and infrastructure needed for well-being. These include homes, hospitals, roads, and utilities like drinking water and wastewater systems and telephone, internet, and electrical services.

Financial: All aspects of the economy and financial systems. This includes money, household incomes, economic security, and living standards.

Appendix 3: Methods Summary

Please refer to the technical report for detailed methods and results: Understanding Climate Change Impacts in Relation to Wellbeing for Nova Scotia – Synthesis Report available at http://climatechange.novascotia.ca.

Overview

The climate change risk assessment was completed over several phases between March 2020 and February 2022. It combines existing research with the development of a Well-being-at-Risk Index for Nova Scotia. An index-based approach was selected to rapidly screen:

- Priorities for action by revealing relative risks and potential benefits to the well-being of Nova Scotians.
- What might change under different climate futures.
- Why differences exist between regions or types of climate impacts.

Background Research

The first step involved research into the concept of well-being, as there is no universally accepted definition. Slightly different well-being frameworks are used by national governments, international organizations, and researchers to understand "how we are doing" as individuals, households, and communities. Reports and peer-reviewed literature were reviewed for perspectives of the different frameworks and suitability for use in a climate change risk assessment.

This assessment draws on three well-established well-being frameworks: OECD's Better Life Initiative, New Zealand's Living Standards Framework (2018), and Forum for the Future's five capitals model.

The well-being framework selected includes five building blocks (or capitals) of well-being that serve as resources for quality of life now and are needed for long-term sustainability: natural, human, social, manufactured, and financial. Resources that contribute to well-being can be thought of in terms of stocks and flows of the five types of capital. A wetland is an example of a natural capital stock that contributes to well-being by providing opportunities for recreation, protects shorelines from flooding, and filters water (flow).

Effective and equitable climate change adaptation involves understanding which capital stocks and flows are at risk, where and to what extent, and which losses and disruptions are most likely to affect people's lives and well-being.

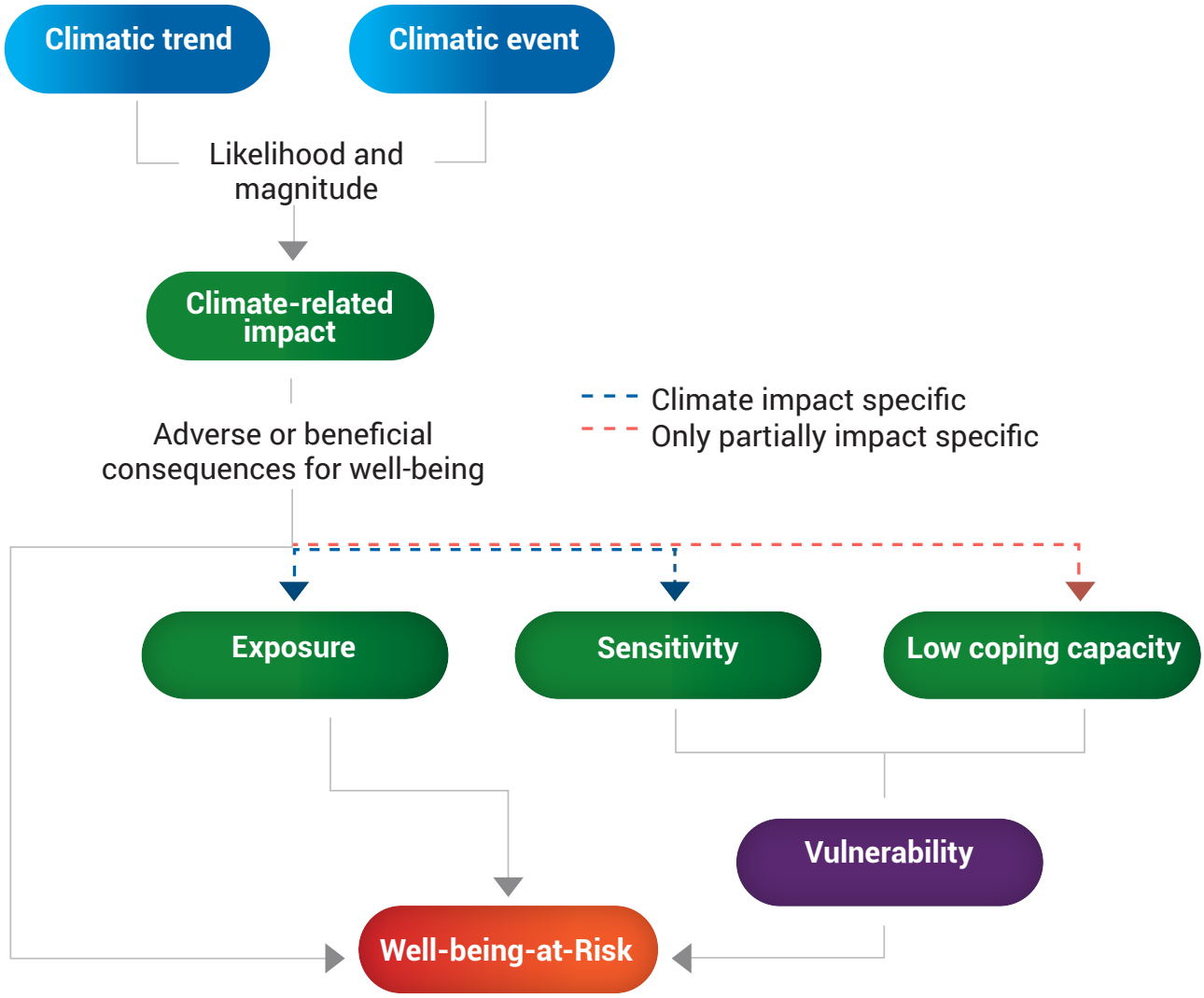
In addition, there are twelve dimensions that characterize well-being and quality of life: jobs and earnings, income wealth and consumption, knowledge and skills, physical and mental health, personal safety and security, work-life balance, social connections and relationships, civic engagement and governance, environmental quality, housing, life satisfaction, and spiritual and cultural fulfillment.

This assessment drew on all five capitals and twelve dimensions to develop the Well-being-at-Risk Index (WRI). Additional evidence was reviewed to:

- Further define key concepts and terms.
- Identify potential indicators of well-being that could be used to develop the WRI.
- Describe the current state of knowledge of climate impacts for Nova Scotia.
- Understand how inequities shape the well-being of marginalized and racialized groups and the implications for climate risk.

Creating the Well-being-at-Risk Index (WRI)

Developing the WRI builds upon a project by the European Spatial Planning Observation Network (ESPON) called "ESPON-Climate: Climate Change and Territorial Effects on Regions and Local Economies in Europe" (https://www.espon.eu/climate), which was adapted to reflect the latest climate risk terminology used by the IPCC. The diagram below shows the relationship between climatic changes, exposure, sensitivity, and low coping capacity in the development of the WRI.



Census Divisions

The assessment used the 18 census divisions for Nova Scotia (aligned with the boundaries of the province's 18 counties) as the spatial scale for analysis. This scale allowed for manageable data sets and offered enough resolution to explore regional differences in climate.

Exposure, Sensitivity, and Low Coping Capacity Data

539 potential socio-economic, physical, and environmental indicators were identified from the background research, but this was too many to include due to complexity and time. An indicator short-list was created by assessing data quality, feasibility, and strength of evidence to well-being and climate change.

The final WRI includes 175 indicators across the five capitals and twelve dimensions of well-being and linked to Exposure, Sensitivity, and Coping Capacity. These data were treated using several statistical steps. For example, data are measured in different units (kilometres of roads vs. number of people), so they must be converted to numbers that can be compared.

Climate Projections

51 climate variables and indices were generated for use in the WRI for two emissions scenarios (RCP4.5 and RCP8.5 median values or 50th percentile) and four 30-year time periods: baseline (1981-2010), 2030s (2015-2045), 2050s (2035-2065), and 2080s (2065-2095). Please see data sources below for more information.

Climate Impact Chains

19 climate impact chains were developed that connect specific climate impacts with indicators of what is exposed to the specific climate impact, how sensitive it is to the specific impact, and the generalized capacity to cope.

Starting with a subset of relevant climate impacts identified by the IPCC, additional expert opinion and evidence was used to assess whether the extent of projected climatic change meets the threshold for harm (for a climate hazard) or benefit (for a climate opportunity). For example, four different climate hazards relating to heat extremes were included, because the climatic changes and effects on well-being are different for each. The effects of heat extremes on agricultural production are different than on human health and each have a different threshold to consider for harm.

The 19 impact chains were divided into four categories as shown in the figure below. Two of the four categories could improve well-being and two could decrease well-being. The WRI scores are ranked within each of the four categories, as climate hazards and opportunities are not directly comparable.

Increasingly Negative Effects
DECREASE WELL-BEING

- Drought
- Pluvial flooding
- Fluvial flooding
- Heat extreme:
  - agriculture
  - ecosystems
  - human health
  - transportation infrastructure
- Cooling demand (buildings)
- Pests and diseases (agriculture)
- Shifting ecoregions
- Vector-borne diseases (human)
- Sea level rise and coastal flooding
- Wildfire

Increasing Beneficial Effects
INCREASE WELL-BEING

- Summer tourism & recreation
- Growing season

Decreasing Negative Effects
INCREASE WELL-BEING

- Heavy snowfall
- Freeze-thaw cycles
- Heating demand (buildings)

Decreasing Beneficial Effects
DECREASE WELL-BEING

- Winter tourism / recreation

Most indicators for Low Coping Capacity reflect the general coping capacity (or lack thereof) of Nova Scotians to shocks and stresses, but some are specific to a climate-related hazard or opportunity. For climate opportunities, coping capacity is not low capacity (which increases risk), but capacity to realize a benefit.

Creating the climate impact chains also allows the WRI to include the ripple—or cascading— effects across society. For example, human health will be directly affected by high and extreme high temperatures, but the resulting strain on emergency services and hospitals is considered part of the cascading effect.

The WRI can also shed light on the risk implications for well-being when climate hazards occur close together by aggregating scores from different climate impact chains (e.g., drought and wildfire). Compounding effects can strike the same region, same group of people, or the same stock or flow of well-being, like a specific piece of critical infrastructure. For example, in 2021, droughts in British Columbia increased the severity of wildfires. The loss of trees from the wildfires then worsened the effects of flooding from extremely intense rainfall. Please see the technical Synthesis Report for more information available at http://climatechange.novascotia.ca.

1) Analysis

The Well-being-at-Risk Index was used to address the following questions:

- Which climate-related impacts are the largest relative source of potential losses and improvements in well-being and how these change over time?
- Which capitals and dimensions of well-being important to Nova Scotians are most exposed and contributing to vulnerability (sensitivity and coping capacity)?
- Which regions are impacted relatively more by climate change—both positively and negatively? What climate-related impacts are relatively more impactful in each region and why?

The WRI produces a score that is ranked for each region and across all impacts for the province. The analysis was conducted for baseline (1981-2010), 2030s (2015-2045), 2050s (2035-2065), and 2080s (2065-2095). RCP4.5 and RCP8.5 emissions scenarios are both reflected.

The WRI is calculated based on the scores for each sub-Index (Climate Impact, Exposure, Sensitivity, and Low Coping Capacity), which are equally weighted as informed by the IPCC's conceptualization of risk.

- Climate Impact scores are calculated based on the extent of climatic change, representing the difference between the projected climate value in each future time frame when compared to the baseline.
- Exposure, Sensitivity, and Low Coping Capacity scores are calculated based on socio-economic, physical, and environmental data and don't vary over time, i.e., what Nova Scotia looks like now.

It's important to note that these scores are relative. **Low WRI values should not be interpreted as implying the absolute risk to well-being from a specific climate impact is minor or insignificant.** For example, sea level rise and coastal flooding are very impactful for Nova Scotians now, and sea level rise will continue to increase this century. However, the relative risk to well-being from heat extremes by the end of the century will be greater than that of sea level rise. This is based on the extent of projected climatic change, what and how much is exposed, how sensitive those things are each climate impact, and the general capacity to cope.

Additional analysis explored the statistical differences between groups disproportionately affected by climate change and tested opportunities to reduce climate vulnerabilities.

A complementary study was conducted by MQO Research on behalf of the Province of Nova Scotia in March 2021. This research explored what is important to the quality of life and well-being of Nova Scotians through telephone surveys, interviews with municipalities, business sectors, and community agencies, and two First Nation sharing sessions. The results of this assessment were cross-referenced with the WRI results to identify areas at high risk of climate change and important to the well-being of Nova Scotians.

Data Sources

There are four main data sources used in this assessment.

1. Climate Projections

Climate projection data were downloaded from Pacific Climate Impacts Consortium in December 2019. The data are based on outputs from an ensemble of 27 statistically downscaled General Circulation Model projections from the Coupled Model Intercomparison Project Phase 5:

ACCESS1-0	CNRM-CM5	HadGEM2-CC	MIROC5
bcc-csm1-1	CSIRO-Mk3-6-0	HadGEM2-ES	MPI-ESM-LR
bcc-csm1-1-m	FGOALS-g2	inmcm4	MPI-ESM-MR
BNU-ESM	GFDL-CM3	IPSL-CM5A-LR	MRI-CGCM3
CanESM2	GFDL-ESM2G	IPSL-CM5A-MR	NorESM1-M
CCSM4	GFDL-ESM2M	MIROC-ESM	NorESM1-ME
CESM1-CAM5	HadGEM2-AO	MIROC-ESM-CHEM	

The projections are downscaled for Nova Scotia (300 arc-seconds or approximately 10 km by 10 km) using Bias Correction (v2) models for RCP8.5 and RCP4.5. The analysis uses the median (50th percentile) values for the climate projections. Additional calculations were necessary for some climate indices. Where possible, the exact definitions and methods for calculating indices used in this model were drawn from the Climpact2 tool.

The Sixth Assessment Report by the IPCC uses the latest modelled projections (Coupled Model Intercomparison Project Phase 6), but these climate data were not available downscaled for Nova Scotia during the timeframe of this assessment.

Wildfire Projections

Modelled climate data and publicly available source code (see Wang et al. 2015) were used to develop wildfire indices following the same approach used by the Canadian Forest Fire Weather Index System (see Van Wagner 1987) and the Province of Nova Scotia. These indices are not designed for climate projections, but were used with certain assumptions based on data availability.

Sea level Rise

CanCoast 2.0: data and indices to describe the sensitive of Canada's marine coasts to the changing climate (see Manson 2019) combines climate projections for sea level rise with other factors for coastal erosion and flooding (e.g., storm surges, land subsidence, coastal material, etc.). Linear regression was used to interpolate results for the years 2030, 2050, and 2080. A ten metre "coastal zone" was assumed to estimate potential exposed area for coastal flooding (see Manuel et al. 2016).

These projections data are consistent with James et al. (2021).

2. Statistics Canada

Statistics Canada data were used for several socio-economic indicators.

3. Engage Nova Scotia

This research was made possible using data from the Quality of Life Initiative led by Engage Nova Scotia in partnership with the Canadian Index of Well-Being framework developed by Dr Bryan Smale of the University of Waterloo (2018).

The Engage Nova Scotia data set includes a range of indicators for well-being and quality of life for Nova Scotians. The Engage Nova Scotia data set did not include values for the Lunenburg, Queens, and Yarmouth census divisions; the missing data for these census divisions were imputed using multivariate regression analysis.

4. Government Inventories

A range of provincial databases on natural resources were used as data sources, such as the Nova Scotia Forest Inventory for forests, dunes and beaches, wetlands, and salt marshes, and Nova Scotia Significant Species and Habitats, as well as Environment and Climate Change Canada's Atlantic Canada Critical Habitat.

Appendix 4: Detailed Findings

The following section presents additional details of the WRI results and analysis described in the main section of this report. Some of the results are presented in tables. Please refer to the guide below as an aid to navigating the information.

Example table of WRI results

Find the climate impact or census division of interest

Which time period are you interested in?

How do Climate Impacts, Exposure, Sensitivity, and Low Coping Capacity influence the final risk score?

Decreases to Well-being through Climate Change	2030s: Early century (2015-2045)			Nova Scotia Today		
	Well-being-at-Risk Index	Climate impact		Exposure	Sensitivity	Low coping capacity
Increasingly negative effects						
Drought	8	5		9	12	6
Pluvial Flooding	1	4		2	2	3
Fluvial Flooding	2	1		7	3	3
Heat extreme - agriculture	6	10		4	8	5

The values in each column are the ranks of the scores within each of the four categories of climate impact. For example, a "1" in any column means that score is the highest in that column in that category. The WRI scores are calculated by averaging the Climate Impact, Exposure, Sensitivity, and Low Coping Capacity scores.

Climate Risks

Table 1 shows the ranking for the 13 climate hazards with increasingly negative effects on well-being across Nova Scotia under a high emissions scenario (RCP8.5). Winter tourism and recreation is in a category of its own, offering benefit now that will decline as the climate changes. As a result, both categories will decrease well-being. However, the climate impacts are ranked within each category because the direction of climatic change and corresponding effect on well-being makes it inappropriate to compare them within the same category in an index-based approach.

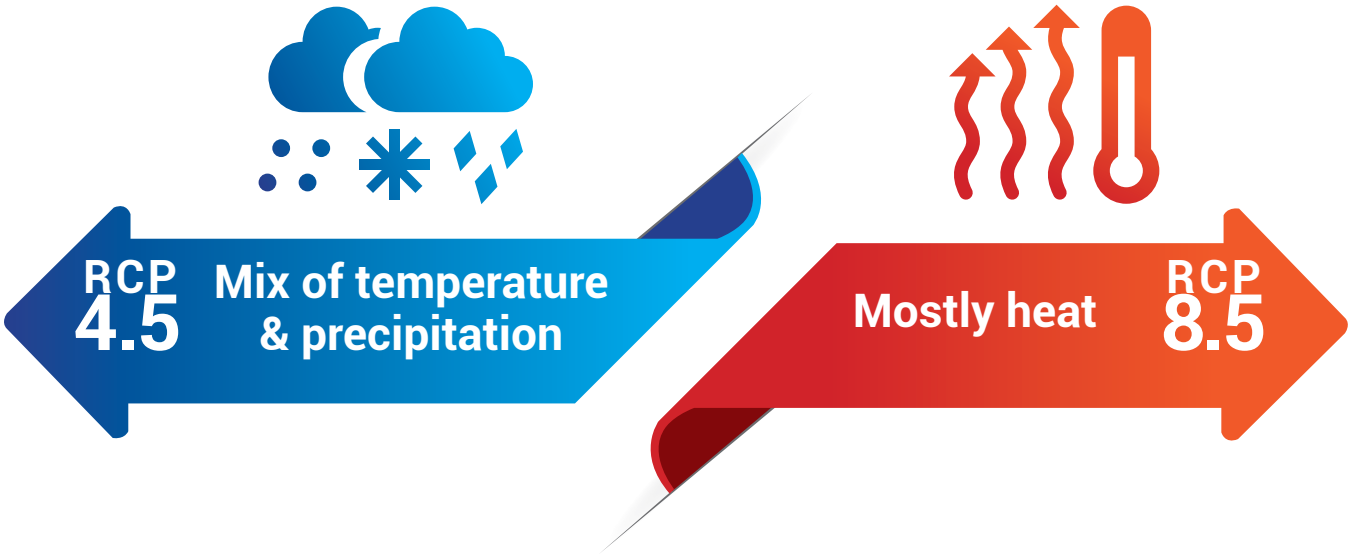
In Table 1 on the next page, the climate hazard "heat extremes for agriculture" is ranked 6 out of 12 for the WRI score in the 2030s. The corresponding Climate Impact score is ranked 10 out of 12 for 2030s, indicating not much projected climatic change between the baseline (1981-2010) and the 2030s. However, by the 2080s, the Climate Impact score is 2 out 12, which means there is a significant change between baseline and 2080s in comparison to the other climate hazards.

Table 1: Ranks of Well-being-at-Risk Index Scores for Both Categories of Climate Impacts that Decrease Well-being across Nova Scotia (RCP8.5, median)

Decreases to Well-being through Climate Change	2030s: Early century (2015-2045)		2050s: Mid century (2035-2065)		2080s: End century (2065-2095)		Nova Scotia Today		
	Well-being-at-Risk Index	Climate impact	Well-being-at-Risk Index	Climate impact	Wellbing-at-Risk Index	Climate impact	Exposure	Sensitivity	Low coping capacity
Increasingly negative effects									
Drought	8	5	13	9	11	6	9	12	6
Pluvial Flooding	1	4	4	13	8	13	2	2	3
Fluvial Flooding	2	1	2	4	9	10	7	3	3
Heat extreme - agriculture	6	10	6	10	1	2	4	8	5
Heat extreme - ecosystems	11	10	11	10	4	2	6	11	8
Heat extreme - human health	9	6	8	2	7	5	11	5	11
Heat extreme - transport infrastructure	13	12	12	12	2	1	13	4	7
Cooling demand	10	9	10	7	3	4	5	9	12
Agriculture pests and diseases	7	8	9	5	13	12	1	13	8
Shifting ecoregions	4	2	3	3	6	8	3	10	8
Vector-borne diseases	3	3	5	8	10	11	11	1	13
Sea level rise and coastal flooding	5	7	7	6	12	9	10	6	1
Wildfire	12	13	1	1	5	7	8	7	1
Decreasing beneficial effects									
Winter tourism & recreation	1	1	1	1	1	1	1	1	1

Risks Depend on Greenhouse Gas Emissions

Under a scenario where greenhouse gas emissions are rapidly and significantly reduced, the priority risks to the well-being of Nova Scotians would differ. A lower emissions scenario (RCP4.5) means that the more consequential climate hazards for well-being by the end of the century will represent a mix of temperature and precipitation related climate hazards. Under a high emissions scenario (RCP8.5), the hazards are mostly from temperature increases.



For example, under a low emissions scenario, flooding remains the top-ranked hazard during this century. Sea level rise and coastal flooding are projected to have a relatively bigger negative impact on well-being by the end of the century compared with other climate impacts. And, while increasing temperatures are a concern, heat extremes and wildfires will be less so relative to other climate impacts.

Table 2 on the next page ranks climate risks for Nova Scotia under a lower emissions scenario (RCP4.5, median or 50th percentile), where 1 represents the highest score value.

Table 2: Ranks of Well-being-at-Risk Index Scores for Both Categories of Climate Impacts that Decrease Well-being across Nova Scotia (RCP4.5, median)

Decreases to Well-being through Climate	2030s: Early century (2015-2045)		2050s: Mid century (2035-2065)		2080s: End century (2065-2095)		Nova Scotia Today		
	Well-being-at-Risk Index	Climate impact	Well-being-at-Risk Index	Climate impact	Well-being-at-Risk Index	Climate impact	Exposure	Sensitivity	Low coping capacity
Increasingly negative effects									
Drought	12	9	11	5	12	10	9	12	6
Pluvial Flooding	8	12	2	12	2	12	2	2	3
Fluvial Flooding	1	2	1	3	3	7	7	3	3
Heat extreme - agriculture	2	7	5	8	4	5	4	8	5
Heat extreme - ecosystems	10	7	10	8	9	5	6	11	8
Heat extreme - human health	5	1	6	1	7	1	11	5	11
Heat extreme - transport infrastructure	7	3	9	10	10	8	13	4	7
Cooling demand	6	4	8	7	8	3	5	9	12
Agriculture pests and diseases	11	10	12	11	11	11	1	13	8
Shifting ecoregions	3	6	4	2	1	2	3	10	8
Vector-borne diseases	9	11	3	6	5	9	11	1	13
SLR and costal flooding	4	5	7	4	6	4	10	6	1
Wildfire	13	13	13	13	13	13	8	7	1
Decreasing beneficial effects									
Winter tourism & recreation	1	1	1	1	1	1	1	1	1

Climate Opportunities

The following Table 3 shows the rank of the WRI scores for the three types of climate impacts with decreasing negative effects to well-being across Nova Scotia under RCP8.5. The two climate impacts that could offer increasing beneficial effects to well-being across Nova Scotia are also included. Both categories offer the potential for improvements to well-being. As with climate risks above, the climate opportunities are ranked within each category, because the direction of climatic change makes it inappropriate to compare them within the same category in an index-based approach.

For climate opportunities, the capacity to cope represents the ability to take advantage of the opportunity and realize the benefit. "1" is the highest rank offering the most relative benefit.

Table 3: Ranks of Well-being-at-Risk Index Scores for Both Categories of Climate Impacts that Improve Well-being across Nova Scotia (RCP8.5, median)

Improvements to Well-being through Climate Change	2030s: Early century (2015-2045)		2050s: Mid century (2035-2065)		2080s: End century (2065-2095)		Nova Scotia Today		
	Well-being-at-Risk Index	Climate impact	Well-being-at-Risk Index	Climate impact	Well-being-at-Risk Index	Climate impact	Exposure	Sensitivity	Coping capacity
Increasing beneficial effects									
Summer tourism & recreation	2	2	2	2	2	2	2	1	2
Growing season	1	1	1	1	1	1	1	2	1
Decreasing negative effects									
Heavy snowfall	2	3	3	3	2	3	3	2	1
Freeze-thaw Cycles	3	2	2	1	3	1	2	3	2
Heating demand	1	1	1	2	1	2	1	1	3

There are no changes to the ranks when comparing the lower greenhouse gas emissions scenario (RCP4.5) with the higher emissions scenario (RCP8.5).

Regional Differences

Detailed results for individual census divisions are available in the appendices of the technical Synthesis Report at climatechange.novascotia.ca. The assessment reviewed relative ranking for each census division based on aggregate WRI scores across 2030s, 2050s, and 2080s and within each of the four categories of impact.

The figure below shows the five highest ranked census divisions within each category. These are the census divisions that would be most impacted by climate impacts should they occur today, reflecting a need for adaptation either to reduce risks or take advantage of opportunities.

Increasingly Negative Effects

Cumberland
Halifax
Digby
Annapolis
Pictou

Increasing Beneficial Effects

Halifax
Kings
Cumberland
Colchester
Cape Breton

Decreasing Negative Effects

Cumberland
Halifax
Pictou
Cape Breton
Colchester

Decreasing Beneficial Effects

Halifax
Hants
Lunenburg
Cumberland
Pictou

These results were cross-referenced with a bottom-up approach that looked at the number of times the same result is found across all census divisions when compared between early and end century (RCP8.5, median). The results were almost identical, but Cape Breton and Pictou would be switched within the two beneficial effects categories.

In the 2030s, several census divisions will experience heat extremes affecting agriculture more than other impacts. This pattern holds to the end of the century. Second and third-ranked impacts shift between time periods, however. Shifting ecoregions and pluvial flooding will be replaced by agriculture pests & diseases, fluvial flooding and heat extremes affecting human health.

In the 2030s, more census divisions will experience less demand for heating in buildings (as temperatures warm) and fewer freeze-thaw cycles than heavy snow. By the 2080s, reduced heating demand will be relatively less important than reduced freeze thaw cycles for more census divisions.

A lengthened growing season is more important than summer tourism & recreation in providing increasing beneficial impacts to well-being for more census divisions.

Appendix 5: Research, Knowledge, and Data Gaps

The process of preparing this climate change risk assessment revealed research, knowledge, and data gaps. In some cases, partnerships between university and community researchers, community groups, governments, and Mi'kmaw organizations may be necessary to create a complete picture, particularly for topics that are broad in scope. Some gaps will help to improve data available for future climate change risk assessments and to further scale information for local or organizational planning and decisions.

Intersectional Analysis and Inequities

There is a significant lack of data and research across Nova Scotia and at the regional level to enable robust analysis that considers intersectional experiences within marginalized and racialized communities. This includes qualitative information about experiences of climate impacts and inequities, as well as demographic and socio-economic data. Significant gaps exist for women, individuals living on low-incomes, individuals living with disabilities, recent immigrants, African Nova Scotians, and LGBTQTS+ communities. Gaps in knowledge within Mi'kmaw communities may exist but would need further exploration to identify what communities would find most helpful.

Severity and Damage

More information is needed to better understand the magnitude and severity of impacts and how climate hazards interact in Nova Scotia (compounding effects). This includes estimates of the damage to well-being and tracking the full economic costs of climate change.

Climate Opportunities

There is little information about the potential climate opportunities for Nova Scotia. While this is not unique to Nova Scotia, better understanding potential opportunities will help us adapt.

Social Impacts from Climate Change

Less is known about social impacts from climate change compared with environmental or economic impacts, including how the changing climate affects work-life balance and the possibility of climate-disrupted work. There is also little understanding of the impacts to cultural practices from climate change.

Business Sector

Nova Scotia's economy has a lot of small and medium-sized businesses in urban and rural communities, such as tourism, smaller retail and service businesses, cultural services, and real estate. The impacts of the changing climate, risks, and opportunities for small and medium-sized businesses is not well understood. Mining is a resource-based sector for which there is little information on climate risks or opportunities in Nova Scotia.

Education and Learning

Nova Scotia has a high number of post-secondary educational institutions for its size. However, there is little information about how climate change could affect university and college facilities and student populations.

The field of adaptation is growing, with a need for individuals who specialize in adapting to climate change. There is an opportunity to explore how Nova Scotian educational systems can more intentionally advance formal and informal learning that helps build the skills and knowledge needed to adapt and creates green jobs.

Transboundary Impacts

Increasingly, jurisdictions are beginning to explore climate risks that trace climate-related disruptions in other places to impacts at home. We are part of a global community. For example, the COVID-19 pandemic has disrupted supply chains around the world. Similar disruptions caused by climatic changes elsewhere could affect us. More research specific could identify vulnerabilities and opportunities for Nova Scotia that start in other parts of the world.

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